Oracle® Communications Cloud Native Core, Network Repository Function Benchmarking Guide





Oracle Communications Cloud Native Core, Network Repository Function Benchmarking Guide, Release 24.3.0

G17042-01

Copyright © 2023, 2024, Oracle and/or its affiliates.

This software and related documentation are provided under a license agreement containing restrictions on use and disclosure and are protected by intellectual property laws. Except as expressly permitted in your license agreement or allowed by law, you may not use, copy, reproduce, translate, broadcast, modify, license, transmit, distribute, exhibit, perform, publish, or display any part, in any form, or by any means. Reverse engineering, disassembly, or decompilation of this software, unless required by law for interoperability, is prohibited.

The information contained herein is subject to change without notice and is not warranted to be error-free. If you find any errors, please report them to us in writing.

If this is software, software documentation, data (as defined in the Federal Acquisition Regulation), or related documentation that is delivered to the U.S. Government or anyone licensing it on behalf of the U.S. Government, then the following notice is applicable:

U.S. GOVERNMENT END USERS: Oracle programs (including any operating system, integrated software, any programs embedded, installed, or activated on delivered hardware, and modifications of such programs) and Oracle computer documentation or other Oracle data delivered to or accessed by U.S. Government end users are "commercial computer software," "commercial computer software documentation," or "limited rights data" pursuant to the applicable Federal Acquisition Regulation and agency-specific supplemental regulations. As such, the use, reproduction, duplication, release, display, disclosure, modification, preparation of derivative works, and/or adaptation of i) Oracle programs (including any operating system, integrated software, any programs embedded, installed, or activated on delivered hardware, and modifications of such programs), ii) Oracle computer documentation and/or iii) other Oracle data, is subject to the rights and limitations specified in the license contained in the applicable contract. The terms governing the U.S. Government's use of Oracle cloud services are defined by the applicable contract for such services. No other rights are granted to the U.S. Government.

This software or hardware is developed for general use in a variety of information management applications. It is not developed or intended for use in any inherently dangerous applications, including applications that may create a risk of personal injury. If you use this software or hardware in dangerous applications, then you shall be responsible to take all appropriate fail-safe, backup, redundancy, and other measures to ensure its safe use. Oracle Corporation and its affiliates disclaim any liability for any damages caused by use of this software or hardware in dangerous applications.

Oracle®, Java, MySQL, and NetSuite are registered trademarks of Oracle and/or its affiliates. Other names may be trademarks of their respective owners.

Intel and Intel Inside are trademarks or registered trademarks of Intel Corporation. All SPARC trademarks are used under license and are trademarks or registered trademarks of SPARC International, Inc. AMD, Epyc, and the AMD logo are trademarks or registered trademarks of Advanced Micro Devices. UNIX is a registered trademark of The Open Group.

This software or hardware and documentation may provide access to or information about content, products, and services from third parties. Oracle Corporation and its affiliates are not responsible for and expressly disclaim all warranties of any kind with respect to third-party content, products, and services unless otherwise set forth in an applicable agreement between you and Oracle. Oracle Corporation and its affiliates will not be responsible for any loss, costs, or damages incurred due to your access to or use of third-party content, products, or services, except as set forth in an applicable agreement between you and Oracle.

Contents

Introduction	
1.1 Purpose and Scope	1
1.2 References	1
Deployment Environment	
2.1 Deployed Components	1
2.1.1 Hardware Details	1
2.1.2 Observability Services	1
2.1.3 System Software	1
2.2 Resource Requirements	2
2.2.1 CNE Common Applications	2
2.2.2 NRF Services	3
2.2.3 cnDBTier Services	4
Test Topology	
3.1 Single Set Test Topology	1
3.2 Multiset Test Topology (NRF Growth)	1
Benchmark Testing	
4.1 Overview	1
4.2 NRF Features	1
4.3 Software Test Constraints	4
4.4 Service Operations	4
4.5 CNE Common Services Resource Utilization	5
4.6 Observations for 38.17K TPS	5
4.6.1 NRF Services Resource Requirements	5
4.6.2 STATE Data Quantum at NRF before Performance Run Begins	7
4.6.3 Call-Mix	7
4.6.3.1 NF Count Per NF Types	8
4.6.3.2 Discovery TPS per NfType and Number of Profiles in Response	9
4.6.4 Test Observations	9

	4.6.5	NRF	Resource Utilization	10
	4.6.6	cnDE	BTier Services Resource Utilization	10
	4.6.7	Late	ncy Observations	11
4.7	Obse	ervatio	ons for 46.5K TPS	11
	4.7.1	Obse	ervations for 51.6K TPS	11
	4.7	7.1.1	NRF Services Resource Requirements	11
	4.7	7.1.2	STATE Data Quantum at NRF before Performance Run Begins	13
	4.7	7.1.3	Call-Mix	13
	4.7	7.1.4	Test Observations	15
	4.7	7.1.5	NRF Resource Utilization	15
	4.7	7.1.6	cnDBTier Services Resource Utilization	16
	4.7	7.1.7	Latency Observations	17
	4.7.2	Obse	ervations for 5K TPS	17
	4.7	7.2.1	NRF Services Resource Requirements	17
	4.7	7.2.2	Call-Mix	18
	4.7	7.2.3	Test Observations	20
	4.7	7.2.4	NRF Resource Utilization	20
	4.7	7.2.5	cnDBTier Services Resource Utilization	21
	17	726	Latency Observations	22

My Oracle Support

My Oracle Support (https://support.oracle.com) is your initial point of contact for all product support and training needs. A representative at Customer Access Support can assist you with My Oracle Support registration.

Call the Customer Access Support main number at 1-800-223-1711 (toll-free in the US), or call the Oracle Support hotline for your local country from the list at http://www.oracle.com/us/support/contact/index.html. When calling, make the selections in the sequence shown below on the Support telephone menu:

- For Technical issues such as creating a new Service Request (SR), select 1.
- For Non-technical issues such as registration or assistance with My Oracle Support, select
 2.
- For Hardware, Networking and Solaris Operating System Support, select 3.

You are connected to a live agent who can assist you with My Oracle Support registration and opening a support ticket.

My Oracle Support is available 24 hours a day, 7 days a week, 365 days a year.

Acronyms

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

Table Acronyms

Term	Definition	
ASM	Aspen Service Mesh	
В	Bytes	
CA	Certificate Authority	
CNE	Cloud Native Environment	
CPU	Central Processing Unit	
KB	Kilo Bytes	
LB	Load Balancer	
NF	Network Function	
NRF	Oracle Communications Cloud Native Core, Network Repository Function	
oso	Operations Services Overlay	
RAM	Random Access Memory	
RTT	Round Trip Time	
SBA	Service Based Architecture	
Set	A set comprises of multiple Georedundant NRF sites	
TLS	Transport Layer Security	
XFCC	x-forwarded-client-cert	

What's New in This Guide

This section lists the documentation updates for release 24.3.x.

Release 24.3.0- G17042-01, March 2025

Generic Updates

- Updated the Kyverno, Prometheus, and Jaeger versions in the <u>Observability Services</u> section.
- Updated the cnDBTier, CNE, and Kubernetes versions in the System Software section.
- Updated the NRF version test constraint in the <u>Software Test Constraints</u> section.

Benchmark Testing Updates

- Updated the values for latency parameters in the <u>Latency Observations</u> section for Observations for 38.17K TPS.
- Updated the following sections in the Observations for 46.5K TPS chapter:
 - Updated the NRF microservices resource utilization for benchmarking in the NRF Resource Utilization section for the following microservices:
 - * nfsubscription
 - * nrfauditor
 - * nrfconfiguration
 - * nfaccesstoken
 - * nrfartisan
 - nrfcachedata
 - * perf-info
 - * ingressgateway
 - * egressgateway
 - Corrected the value of SQL (ndbappmysqld) service pod count from 4 to 2 in the cnDBTier Services Resource Utilization section.
 - Updated the values for latency parameters in the <u>Latency Observations</u> section.

Introduction

Oracle Communications Cloud Native Core Network Repository Function (NRF) is one of the main components of the 5G Service Based Architecture (SBA). NRF maintains an updated repository of all the Network Functions (NFs) available in the operator's network along with the services provided by each NFs in the 5G core. NRF instantiates, scales, and terminates the services with minimal or no manual intervention.

For more information about NRF architecture, see *Oracle Communications Cloud Native Core, Network Repository Function User Guide.*

1.1 Purpose and Scope

This document describes the measurements that are used to perform the performance evaluation of NRF, microservices, and deployment environment setup software such as Aspen Service Mesh (ASM), Operations Services Overlay (OSO), Cloud Native Environment (CNE), and so on.

This document provides the following information:

- Benchmark NRF performance and capacity
- Benchmark data from our labs
- Key metrics used to manage NRF performance and capacity

Note

The performance and capacity of the NRF system may vary based on the call model, Feature or Interface configuration, and underlying CNE and hardware environment.

1.2 References

Following are the reference documents:

- Oracle Communications Cloud Native Core, Cloud Native Environment Installation, Upgrade, and Fault Recovery Guide
- Oracle Communications Cloud Native Core, Operations Services Overlay Installation and Upgrade Guide
- Oracle Communications Cloud Native Core, cnDBTier User Guide
- Oracle Communications Cloud Native Core, Network Repository Function User Guide
- Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide
- Oracle Communications Cloud Native Core, Network Repository Function Troubleshooting Guide
- Oracle Communications Cloud Native Core, Network Repository Function Network Impact Report



- Oracle Communications Cloud Native Configuration Console User Guide
- Oracle Communications 5G Automated Test Suite Guide
- Oracle Communication Cloud Native Core, Data Collector User Guide

Deployment Environment

This section provides information about the cloud native infrastructure used for Oracle Communications Cloud Native Core, Network Repository Function (NRF) benchmarking.

2.1 Deployed Components

This section provides details about the deployed components.

2.1.1 Hardware Details

This section describes the hardware details.

Table 2-1 Hardware Details

Nodes	Туре
Master Nodes	ORACLE SERVER X8-2
Top of Rack Switch	Cisco 93108TC-EX
Worker Nodes	ORACLE SERVER X8-2

2.1.2 Observability Services

This section describes the observability services used for NRF benchmarking.

Table 2-2 Observability Services

Service Name	Version
OpenSearch	2.11.0
OpenSearch Dashboard	2.11.0
FluentBit	1.9.4
Fluentd OpenSearch	1.16.2
Kyverno	1.12.5
Grafana	9.5.3
Prometheus	2.52.0
Jaeger	1.60.0

2.1.3 System Software

This section describes the system software details.



Table 2-3 System Software

System Software	Details		
Operating System (+Kernel Version)	5.15.0-105.125.6.2.2.el8uek.x86_64		
	Oracle Linux Server 8.8		
Hypervisor	BareMetal Server		
CNE	23.4.1		
oso	NA		
Kubernetes	1.27.x		
ASM	1.14.6		
cnDBTier	24.3.0		

2.2 Resource Requirements

The CPU and RAM resources that each service consumes are constrained, so that they do not consume excess resources that could be used by applications. Each service is initially allocated a CPU and RAM at the time of deployment and is allowed to grow to a specified upper limit of each resource while it continues to run. For services where little growth is expected, or where increasing the CPU or RAM underneath a running application might cause an unacceptable service disruption, the initial allocation and upper limit are set to the same value. The resource requests and limits are given below:



(i) Note

Max replica count of a service must be adjusted as per the target TPS.

2.2.1 CNE Common Applications

This section describes the CNE common applications.

Table 2-4 CNE Common Applications

Service	Pod replica #	CPU/Pod		Memory (Mi)	
		Requests	Limit	Requests	Limit
Prometheus	2	2000	2000	4096	4096
Prometheus Node Exporter	1 per node	800	800	512	512
Prometheus Operator	1	100	200	100	200
Prometheus AlertManager	2	20	20	64	64
Prometheus Kube State Metrics	1	20	20	32	100
Promxy	1	100	100	512	512
OpenSearch Master	3	1000	1000	2048	2048
OpenSearch Data	3	1000	1000	16384	16384



Table 2-4 (Cont.) CNE Common Applications

Service	Pod replica #	CPU/Pod		Memory (Mi)	
		Requests	Limit	Requests	Limit
OpenSearch Client	3	1000	1000	2048	2048
OpenSearch Dashboard	1	100	100	512	512
occne-metrics- server	1	100	100	200	200
occne- alertmanager- snmp-notifier	1	100	100	128	128
Fluentd OpenSearch	1 per worker node	500	500	1024	1024
Jaeger Agent	1 per worker node	256	500	128	512
Jaeger Collector	1	500	1250	512	1024
Jaeger query	1	256	500	128	512
MetalLB Controller	1	100	100	100	100
MetalLB Speaker	1 per worker node	100	100	100	100
LB Controller (vCNE only)	1	10	500	128	1024
Egress Controller (vCNE only)	1 per worker node	10	1000	200	500
Bastion Controller	1	10	200	128	256
Kyverno	3	100	200	256	512

2.2.2 NRF Services

Table 2-5 NRF Services Resource Requirements

Service Name	Min Pod Replica Count per NRF
Helm test	1
<helm-release-name>-nfregistration</helm-release-name>	2
<helm-release-name>-nfdiscovery</helm-release-name>	2
<helm-release-name>-nfsubscription</helm-release-name>	2
<helm-release-name>-nrfauditor</helm-release-name>	2
<helm-release-name>-nrfconfiguration</helm-release-name>	1
<helm-release-name>-nfaccesstoken</helm-release-name>	2
<helm-release-name>-nrfartisan</helm-release-name>	1
<helm-release-name>-nrfcachedata</helm-release-name>	2
<helm-release-name>-ingressgateway</helm-release-name>	2
<helm-release-name>-egressgateway</helm-release-name>	2
<helm-release-name>-alternate-route</helm-release-name>	2
<helm-release-name>-appinfo</helm-release-name>	2
<helm-release-name>-perfinfo</helm-release-name>	2



Where, <helm-release-name> is prefixed in each microservice name. For example, if helmrelease-name is "ocnrf", then nfregistration microservice name is "ocnrf-nfregistration".

For more information about other resource requirements, see Oracle Communications Cloud Native Core, Network Repository Function Installation, Upgrade, and Fault Recovery Guide.

2.2.3 cnDBTier Services

Table 2-6 cnDBTier Services Resource Requirements

Service Name	Min Pod Replica Count per cnDBTier
MGMT (ndbmgmd)	2
DB (ndbmtd)	4
SQL (ndbmysqld)	2
SQL (ndbappmysqld)	2
Monitor Service (db-monitor-svc)	1
Backup Manager Service (db-backup-manager-svc)	1
Replication Service - Leader	1
Replication Service - Other	0



(i) Note

There is a change in the Memory/Pod resource requirement for Monitor Service (dbmonitor-svc) and SQL (ndbappmysqld) services.

For more information about other resource requirements and recommended parameter values, see Oracle Communications Cloud Native Core, Network Repository Function Installation, Upgrade, and Fault Recovery Guide.

Test Topology

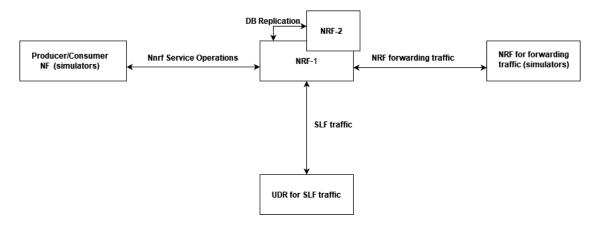
This section describes the topology used for testing Oracle Communications Cloud Native Core, Network Repository Function (NRF).

3.1 Single Set Test Topology

The following image represents the test topology consisting of the following components:

- Two-site NRF
- UDR for SLF traffic
- Producer/Consumer NF for Nnrf service operations (simulators)
- NRF for forwarding to a different segment (simulators)

Figure 3-1 Single Set Test Topology



- Producer NF sends NfRegister, NfHeartbeat, NfUpdate, and NfDeregister requests to NRF.
- Consumer NF sends NfStatusSubscribe, NfStatusSubscribe (PATCH), NfStatusUnsubscribe, NfDiscover, NfAccessToken, NfProfileRetrieval, and NfListRetrieval requests to NRF.
- 3. NRF sends request to UDR for processing SLF based discovery query.
- 4. NRF sends response to all service requests it receives.
- NRF triggers NfStatusNotify to all the Consumer NFs who have created subscription.
- 6. NRF forwards NfDiscovery requests to the NRF simulator.

3.2 Multiset Test Topology (NRF Growth)

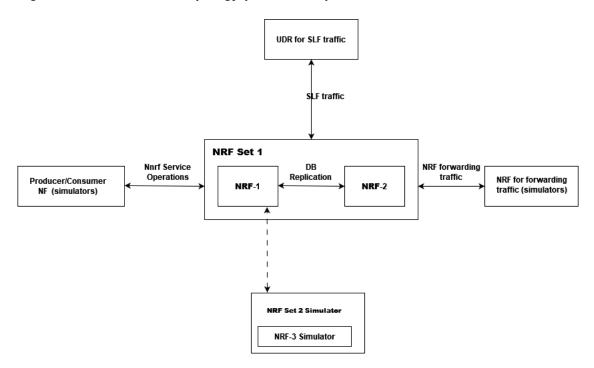
The following image represents the test topology consisting of the following components:

 Two NRF Sets with one NRF Set having two NRF sites and the other set with one NRF site.



- UDR for SLF traffic
- Producer/Consumer NF for Nnrf service operations (simulators)
- NRF for forwarding to a different segment (simulators)

Figure 3-2 Multiset Test Topology (NRF Growth)



- 1. Producer NF sends NfRegister, NfHeartbeat, NfUpdate, and NfDeregister requests to NRF.
- Consumer NF sends NfStatusSubscribe, NfStatusSubscribe (PATCH), NfStatusUnsubscribe, NfDiscover, NfAccessToken, NfProfileRetrieval, and NfListRetrieval requests to NRF.
- 3. NRF sends request to UDR for processing SLF based discovery query.
- 4. NRF sends response to all service requests it receives.
- 5. NRF triggers NfStatusNotify to all the Consumer NFs who have created subscription.
- 6. NRF forwards NfDiscovery requests to the NRF simulator.
- 7. NRF Set 1 retrieves the remote set state data from NRF Set 2 and vice versa.

Benchmark Testing

This section describes the environment used for benchmarking Oracle Communications Cloud Native Core, Network Repository Function (NRF). Benchmarking is performed with the settings described in this section.

The default values or recommendations for any required software or resource are available from third-party vendors. The operators may choose different values.

4.1 Overview

To qualify the test run, the following elements are considered:

- Pod restart
- · CPU and Memory utilization
- Error rate
- Ingress and egress traffic rate
- Success rate
- Message request and response processing time
- Infrastructure resource requirements and utilization

4.2 NRF Features

Table 4-1 NRF Features

NRF Features	Feature Status	Notes
Subscriber Location Function	ENABLED	SLF is enabled for 4 NfTypes in slfLookupConfig.
SLF Selection from Registered NF Profiles	ENABLED	Dynamic SLF feature is enabled.
Access Token Caching during SLF Query	ENABLED	For more information about the accessTokenCacheEnabled under slfOptions, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
Overload Control Based on Percentage Discards	ENABLED	For more information about the configuration, see <i>Oracle</i> <i>Communications Cloud</i> <i>Native Core, Network</i> <i>Repository Function Rest</i> <i>Specification Guide.</i>



Table 4-1 (Cont.) NRF Features

NRF Features	Feature Status	Notes
Preferred Locality Feature Set	ENABLED	Extended Preferred locality is
·		configured with 3 locationTypes, 2 locationMappings, 2 preferredLocationDetails.
NRF Forwarding per NF Type/Service Type	ENABLED for UDM	Forwarding is enabled for discovery services. 1 host is present in nrfHostConfig and 1 rule is present in forwardingRulesConfig.
EmptyList in Discovery Response	ENABLED	EmptyList feature is enabled and discoveryValidityPeriodCfg under nfDiscoveryOptions is configured with 5 rules.
Access Token Request Authorization	ENABLED	AuthFeature is enabled with 8 rules in authRulesConfig under nfAccessTokenOptions.
Pod Protection Support for NRF Subscription Microservice	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
Subscription Limit	ENABLED	Set the subscription limit to 1000. For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
User-Agent Header for Outgoing Requests	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
NRF to Pick Port from ipEndpoints and FQDN from the NF Service or NF level when Selecting SLF	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
Ingress Gateway Pod Protection	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.



Table 4-1 (Cont.) NRF Features

NRF Features	Feature Status	Notes
ASM Sidecar	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
Maximum Number of Profiles in Discovery Response	ENABLED	Set the value as 10 for this parameter. For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
NRF Georedundancy	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
NRF Growth	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide. Note: This feature is enabled only for 38.17K TPS Call-Mix.
SLF Routing using SCP	ENABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
Load Change Threshold for Notifications from NRF	ENABLED	This is nfNotifyLoadThreshold. This is set as 5%. For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.
NF Screening Feature (Rules)	DISABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.



Table 4-1 (Cont.) NRF Features

NRF Features	Feature Status	Notes
NRF Roaming support (hNRF + vNRF)	DISABLED	For more information about the configuration, see Oracle Communications Cloud Native Core, Network Repository Function Rest Specification Guide.

(i) Note

Apart from these features being enabled, rest of the feature configurations have been set to their default values. For more information about the feature configurations, see Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide. For more information about the features, see Oracle Communications Cloud Native Core, Network Repository Function User Guide.

4.3 Software Test Constraints

Table 4-2 Software Test Constraints

Test Constraint	Details
NRF Version	24.3.0
Ingress incoming connections	For more information on this, see
Ingress outgoing connections	Test Observations for 38.17K
Egress incoming connections	<u>Test Observations</u> for 46.5K
Egress outgoing connections	
Average HTTP Request Packet Size	~1-3 KB (Based on NfRegister Request)
Average HTTP Response Packet Size	~5-30 KB (Discovery Response with nfProfiles)
Average NF Heartbeats Timer per NF	30s
Average size of NF Profiles	~1-3 KB
Deployment with service mesh enabled	1.14.6

4.4 Service Operations

This section list the various service operations with the required query parameters.

NfDiscover Service Operation

The NfDiscover service operations are sent with the following guery parameters:

- Target-nf-type and requester-nf-type
- Target-nf-type, requester-nf-type, and supi
- Target-nf-type, requester-nf-type, and group-id-list
- Target-nf-type, requester-nf-type, and routing-indicator



- Target-nf-type, requester-nf-type, and service-names
- Target-nf-type, requester-nf-type, and requester-snssais
- Target-nf-type, requester-nf-type, requester-snssais, target-plmn-list, and requester-plmn-list
- Target-nf-type, requester-nf-type, and pgw
- Target-nf-type, requester-nf-type, and guami
- Target-nf-type, requester-nf-type, service-names, and group-id-list
- Target-nf-type, requester-nf-type, preferred-locality, and supi
- Target-nf-type, requester-nf-type, service-names, supi, and group-id-list
- Target-nf-type, requester-nf-type, preferred-locality, and group-id-list
- · Target-nf-type, requester-nf-type, service-names, supi, and data-set
- Target-nf-type, requester-nf-type, preferred-locality, supi, and group-id-list
- Target-nf-type, requester-nf-type, supi, and routing-indicator
- Target-nf-type, requester-nf-type, supi, routing-indicator, and service-names
- Target-nf-type, requester-nf-type, group-id-list, and service-names
- Target-nf-type, requester-nf-type, dnn, snssai, and tai
- Target-nf-type, requester-nf-type, dnn, snssai, and preferred-locality
- · Target-nf-type, requester-nf-type, supi, and data-set

4.5 CNE Common Services Resource Utilization

The following table describes CNE microservices and their utilization.

Table 4-3 CNE Common Services Resource Utilization

CNE Observability Services	Pod Count	СРИ	Memory
occne-prometheus-server-1	2	8.07%	64%
occne-elastic-elasticsearch-master-0	1	0.53%	65%
occne-elastic-elasticsearch-master-1	1	0.56%	68%
occne-elastic-elasticsearch-master-2	1	0.53%	65%
occne-elastic-elasticsearch-data-1	1	0.31%	53%
occne-elastic-elasticsearch-data-2	1	0.72%	93%
occne-prometheus-node-exporter	16	0.80%	8%

4.6 Observations for 38.17K TPS

This section provides the details of observations noticed for 38.17K TPS.

4.6.1 NRF Services Resource Requirements

This section provides the resource requirement for NRF deployment.



Table 4-4 NRF Services Resource Requirements

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/P od (in Gi)	Max Memory/P od (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>- nfregistration</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nfdiscovery</helm-release-name>	58	8	8	3	3	78.1	2
<helm-release-name>- nfsubscription</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfauditor</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfconfiguration</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nfaccesstoken</helm-release-name>	2	2	2	2	2	78.1	1
<helm-release-name>- nrfartisan</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nrfcachedata</helm-release-name>	2	4	4	3	3	78.1	1
<helm-release-name>- ingressgateway</helm-release-name>	26	4	4	4	4	78.1	1
<helm-release-name>- egressgateway</helm-release-name>	24	4	4	4	4	78.1	1
<helm-release-name>- alternate-route</helm-release-name>	2	2	2	4	4	78.1	1
<helm-release-name>-appinfo</helm-release-name>	2	1	1	1	1	78.1	1
<helm-release-name>- perfinfo</helm-release-name>	2	1	1	1	1	78.1	1



4.6.2 STATE Data Quantum at NRF before Performance Run Begins

Table 4-5 STATE Data Quantum at NRF before Performance Run Begins

		_
Parameters	Values	Details
Number of NF Profiles in DB	125*	Following are the NfTypes: AMF: 40 AUSF: 4 BSF: 2 CBCF: 5 CHF: 2 DRA: 3 GMLC: 3 LMF: 3 NEF: 3 PCF: 5
Number of Subscriptions in DB	500	 SMF: 40 SMSF: 3 UDM: 4 UDR: 10 Subscriptions are created with the below
·		 conditions: Subscription to a set of NF Instances identified by their NF Type. (NfTypeCond). NotificationCondition with monitored attributes set to "/priority" or "/load". reqNotifEvents set to NF_REGISTERED,NF_DEREGIST ERED, NF_PROFILE_CHANGE.

(i) Note

* indicates that Set1 hosts 125 NFs and Set 2 (simulator) hosts 125 NFs. When these two sets are combined together with NRF Growth feature enabled, we will have 250 NFs.

4.6.3 Call-Mix

The following table describes the various type of service requests with the required traffic distribution and targeted TPS.

Table 4-6 Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
Α	NF Register	0.00002	1
В	NF Update	0.00282	1
С	NF Heartbeat	Not considered	26



Table 4-6 (Cont.) Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
D	NF Subscribe + Update Subscription	0.01416	5
Е	NF Discover	98.45	33,900
F	NRF Forwarded Discovery (Incoming)	10% of Incoming discovery traffic	3,760
G	% of traffic forwarded to remote PLMN (case Visited NRF)	0%	Not included in this test.
Н	% of traffic received from remote PLMN (case Home NRF)	0%	Not included in this test.
I	SLF Query	49% of Discovery	18,605
J	NF Access Token for SLF	Extra	0.1
K	NF Profile Retrieval	0.00141	1
L	NF List Retrieval	0.00141	1
М	NF Status Notify	1.52328	480
N	NF Status UnSubscribe	0.00006	1
0	NF DeRegister	0.00002	1
Р	NF Access Token for Consumers	0.00141	1
Q	NRF Forwarding (Outgoing)	10% of discovery traffic	3,760

Table 4-7 Total Traffic

Traffic Type	Message Considered	Targeted TPS
	A+B+C+D+E+F+G+H+J+K+ L+N+O+P	37,698
Total Outgoing Traffic	I + M + Q	22,845

4.6.3.1 NF Count Per NF Types

The following table lists the NF count per NF type along with the NF profile size.

Table 4-8 NF Count Per NF Types

Target-NF Types	NF Count	Profile Size (with pretty printing) (in bytes)
AMF	58	8700-11300
AUSF	6	4640
BSF	3	1700
CHF	3	1800
GMLC	6	0630
LMF	6	2400
PCF	30	1500-2500
SMF	94	5700-7400
UDM	6	3200



Table 4-8 (Cont.) NF Count Per NF Types

Target-NF Types	NF Count	Profile Size (with pretty printing) (in bytes)
UDR	36	1700-2000
SLF	3	2100
SMSF	3	11300
NEF	3	11300
CBCF	3	11300

Total NF Count is 260.

4.6.3.2 Discovery TPS per NfType and Number of Profiles in Response

The following table indicates the discovery TPS per NfType and the number of profiles sent in the response.

Table 4-9 Discovery TPS per NfType and Number of Profiles in Response

Target-Nf Types	TPS (in %)	Absolute Discovery TPS	SLF Queries Posted	Number of Profiles in Response
AUSF	0.39	209	209	6
BSF	0.00	0	0	3
CBCF	0.00	0	0	3
CHF	0.077	42.3	0	3
GMLC	0.00	0	0	6
LMF	0.025	14.5	0	6
PCF	0.39	211	0	10
SMF	8.09	4368	0	10
UDM	85.5	46209	46209	6
UDR	1.21	652	652	12
SLF	0	0	0	3
NEF	0.026	14.1	0	3
SMSF	0.025	13.5	0	3

4.6.4 Test Observations

The following table provides the details of test duration and TPS used for the benchmarking test.

Table 4-10 Test Observations

Parameter	Values
Test Duration	60 hours
TPS Achieved	38.17K (considered all Ingress and NfStatusNotify traffic)
Ingress incoming connections	144
Ingress outgoing connections	1.440K
Egress incoming connections	144



Table 4-10 (Cont.) Test Observations

Parameter	Values
Egress outgoing connections	720

4.6.5 NRF Resource Utilization

The following table describes the list of NRF microservices and their utilization.

Table 4-11 NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory (in Gi)
nfregistration	2	7%	28.17%
nfdiscovery	44	64.65%	43.3%
nfsubscription	2	9.17%	36.33%
nrfauditor	2	0.48%	11.33%
nrfconfiguration	1	1%	16.25%
nfaccesstoken	2	0.75%	31.75%
nrfartisan	1	0%	0%
nrfcachedata	2	37%	30.75%
alternate-route	2	0%	9%
perf-info	2	4.5%	12.5%
appinfo	2	5.5%	12.5%
ingressgateway	18	45.26%	8.33%
egressgateway	18	34.2%	27.99%

(i) Note

The features enabled for this benchmarking testing does not utilize alternate-route service.

4.6.6 cnDBTier Services Resource Utilization

The following table provides observed values of cnDBTier services.

Table 4-12 cnDBTier Services Resource Utilization

	1		
Service Name	Pod Count	Average CPU	Memory
SQL (ndbappmysqld)	2	13.8%	35.33%
DB (ndbmtd)	4	5.1%	88.84%
SQL (ndbmysqld)	2	0.2%	1.5%
MGMT (ndbmgmd)	2	0.2%	0.35%
Monitor Service (db-monitor-svc)	1	0.2%	10.1 %
Backup Manager Service (db-backup-manager-svc)	1	0.5%	8.9%



Table 4-13 cnDBTier Statistics

DBTier Statistics	Value
Disk Write operations per second	98.4
Disk Read operations per second	439
Transaction rates on data nodes	230

4.6.7 Latency Observations

The following table lists the details of latency observations.

Table 4-14 Latency Observations

Latency Parameter	Details			
	99th Percentil e (ms)	95th Percentil e (ms)	90th Percentil e (ms)	50th Percentil e (ms)
Average Turnaround time at Ingress Gateway, Discovery Processing, and SLF Egress Transaction	101	089	084	071
Average Turnaround time for Discovery Processing and SLF Egress Transaction	235	195	180	161
Average Turnaround time for SLF Egress Transaction (see Note)	195	172	165	159

(i) Note

Following simulators are used for performance measurement and their induced latency:

- NF simulator to NRF: 50ms
- NRF to forwarding simulator and forwarding simulator to NRF: 150ms
- NRF to another remote set NRF: 150 ms
- NRF to SLF: 150 ms

4.7 Observations for 46.5K TPS

This section provides the details of observations noticed for 46.5K TPS.

4.7.1 Observations for 51.6K TPS

This section provides the details of observations noticed for 51.6K TPS.

4.7.1.1 NRF Services Resource Requirements

This section provides the resource requirement for NRF deployment.



Table 4-15 NRF Services Resource Requirements

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/P od (in Gi)	Max Memory/P od (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>- nfregistration</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nfdiscovery</helm-release-name>	58	8	8	3	3	78.1	2
<helm-release-name>- nfsubscription</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfauditor</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfconfiguration</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nfaccesstoken</helm-release-name>	2	2	2	2	2	78.1	1
<helm-release-name>- nrfartisan</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nrfcachedata</helm-release-name>	2	4	4	3	3	78.1	1
<helm-release-name>- ingressgateway</helm-release-name>	26	4	4	4	4	78.1	1
<helm-release-name>- egressgateway</helm-release-name>	24	4	4	4	4	78.1	1
<helm-release-name>- alternate-route</helm-release-name>	2	2	2	4	4	78.1	1
<helm-release-name>-appinfo</helm-release-name>	2	1	1	1	1	78.1	1
<helm-release-name>- perfinfo</helm-release-name>	2	1	1	1	1	78.1	1



4.7.1.2 STATE Data Quantum at NRF before Performance Run Begins

Table 4-16 STATE Data Quantum at NRF before Performance Run Begins

Parameters	Values	Details
Number of NF Profiles in DB	250	Following are the NfTypes: AMF: 80 AUSF: 9 BSF: 4 CBCF: 9 CHF: 3 DRA: 6 GMLC: 6 LMF: 6 NEF: 6 PCF: 10 SCP: 8 SMF: 80 SMSF: 6 UDM: 8 UDR: 21
Number of Subscriptions in DB	1000	Subscriptions are created with the below conditions: Subscription to a set of NF Instances identified by their NF Type. (NfTypeCond). NotificationCondition with monitored attributes set to "/priority" or "/load". reqNotifEvents set to NF_REGISTERED,NF_DEREGISTERED, NF_PROFILE_CHANGE.

4.7.1.3 Call-Mix

The following table describes the various type of service requests with the required traffic distribution and targeted TPS.

Table 4-17 Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
А	NF Register	0.00002	1
В	NF Update	0.00282	1
С	NF Heartbeat	Not considered	52
D	NF Subscribe + Update Subscription	0.01416	7
Е	NF Discover	98.45	41,500
F	NRF Forwarded Discovery (Incoming)	10% of Incoming discovery traffic	4,150
G	% of traffic forwarded to remote PLMN (case Visited NRF)	0%	Not included in this test.



Table 4-17 (Cont.) Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
Н	% of traffic received from remote PLMN (case Home NRF)	0%	Not included in this test.
I	SLF Query	49% of Discovery	22,400
J	NF Access Token for SLF	Extra	0.1
K	NF Profile Retrieval	0.00141	1
L	NF List Retrieval	0.00141	1
М	NF Status Notify	1.52328	750
N	NF Status UnSubscribe	0.00006	1
0	NF DeRegister	0.00002	1
Р	NF Access Token for Consumers	0.00141	1
Q	NRF Forwarding (Outgoing)	10% of discovery traffic	4,160

Table 4-18 Total Traffic

Traffic Type	Message Considered	Targeted TPS
Total Incoming Traffic	A+B+C+D+E+F+G+H+J+K+ L+N+O+P	45,726
Total Outgoing Traffic	I + M + Q	27,310

4.7.1.3.1 NF Count Per NF Types

The following table lists the NF count per NF type along with the NF profile size.

Table 4-19 NF Count Per NF Types

Target-NF Types	NF Count	Profile Size (with pretty printing) (in bytes)
AMF	58	8700-11300
AUSF	6	4640
BSF	3	1700
CHF	3	1800
GMLC	6	0630
LMF	6	2400
PCF	30	1500-2500
SMF	94	5700-7400
UDM	6	3200
UDR	36	1700-2000
SLF	3	2100
SMSF	3	11300
NEF	3	11300
CBCF	3	11300

Total number of NF Count Across all NRF Sites is 260 (No. of profiles in set 1 with 250 and set 2 with 10 = 260.)



4.7.1.3.2 Discovery TPS per NfType and Number of Profiles in Response

The following table indicates the discovery TPS per NfType and the number of profiles sent in the response.

Table 4-20 Discovery TPS per NfType and Number of Profiles in Response

Target-Nf Types	TPS (in %)	Absolute Discovery TPS	SLF Queries Posted	Number of Profiles in Response
AMF	4.25	218	0	6
AUSF	0.40	20.3	20.3	6
BSF	0.00	0	0	3
CBCF	0.00	0	0	3
CHF	0.075	3.82	0	3
GMLC	0.00	0	0	6
LMF	0.027	1.37	0	6
PCF	0.39	19.7	0	10
SMF	8.11	416	0	10
UDM	85.3	4383	4383	6
UDR	1.21	62.1	62.1	12
SLF	0	0	0	3
NEF	0.027	1.42	0	3
SMSF	0.025	1.28	0	3

4.7.1.4 Test Observations

This section following table provides the details of test duration and TPS used for the benchmarking test.

Table 4-21 Test Observations

Parameter	Values
Test Duration	60 hours
TPS Achieved	46.5K (* considered all Ingress and NfStatusNotify traffic)
Ingress incoming connections	192
Ingress outgoing connections	1.536K
Egress incoming connections	144
Egress outgoing connections	540

4.7.1.5 NRF Resource Utilization

The following table describes NRF microservices and their utilization.

Table 4-22 NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory (in Gi)
nfregistration	2	13.5%	23%



Table 4-22 (Cont.) NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory (in Gi)
nfdiscovery	60	64.65%	43.3%
nfsubscription	2	5.88%	23.4%
nrfauditor	2	0.45%	18.6 %
nrfconfiguration	1	1.75%	38.7%
nfaccesstoken	2	1%	29.2%
nrfartisan	1	0%	5.01%
nrfcachedata	2	13%	32.3%
alternate-route	2	0%	9%
perf-info	2	7.92%	12.5%
appinfo	2	5%	25%
ingressgateway	24	53.99%	61.2%
egressgateway	22	35.5%	39.1%

(i) Note

The features enabled for this benchmarking testing does not utilize alternate-route

4.7.1.6 cnDBTier Services Resource Utilization

The following table provides observed values of cnDBTier services.

Table 4-23 cnDBTier Services Resource Utilization

	1		
Service Name	Pod Count	Average CPU	Memory
SQL (ndbappmysqld)	2	0.524 (13.1%)	4.134 (67.285%)
DB (ndbmtd)	4	0.988 (4.94%)	16.277 (79.477%)
SQL (ndbmysqld)	2	0.02 (0.2%)	0.51 (1.5%)
MGMT (ndbmgmd)	2	0.015 (0.187%)	0.061 (0.496%)
Monitor Service (db-monitor-svc)	1	0.003 (0.75%)	0.356 (71.2 %)
Backup Manager Service (db-backup-manager-svc)	1	0.001 (0.01%)	0.23 (179.69%)
Replication Service	1	0.0 (0.0%)	0.41 (20.5%)

Table 4-24 cnDBTier Statistics

DBTier Statistics	Value
Disk Write operations per second	39.98
Disk Read operations per second	135.13
Transaction rates on data nodes	101.5



4.7.1.7 Latency Observations

Table 4-25 Latency Observations

Latency Parameter	Details		
	Min (ms)	Max (ms)	Avg (ms)
Average Turnaround time at Ingress Gateway, Discovery Processing, and SLF Egress Transaction	226	618	235
Average Turnaround time for Discovery Processing and SLF Egress Transaction	189	344	195
Average Turnaround time for SLF Egress Transaction (see Note)	164	201	165

(i) Note

Following simulators are used for performance measurement and their induced latency:

- NF simulator to NRF: 50 ms
- NRF to forwarding simulator and forwarding simulator to NRF: 150 ms
- NRF to SLF: 150 ms

4.7.2 Observations for 5K TPS

This section provides the details of observations noticed for 5K TPS.

4.7.2.1 NRF Services Resource Requirements

This section provides the resource requirement for NRF deployment.

Table 4-26 NRF Services Resource Requirements

			1	1	1	1	
Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/P od (in Gi)	Max Memory/P od (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>- nfregistration</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nfdiscovery</helm-release-name>	6	8	8	3	3	78.1	2
<helm-release-name>- nfsubscription</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfauditor</helm-release-name>	2	2	2	3	3	78.1	1
<helm-release-name>- nrfconfiguration</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nfaccesstoken</helm-release-name>	2	2	2	2	2	78.1	1



Table 4-26 (Cont.) NRF Services Resource Requirements

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/P od (in Gi)	Max Memory/P od (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
<helm-release-name>- nrfartisan</helm-release-name>	1	2	2	2	2	78.1	1
<helm-release-name>- nrfcachedata</helm-release-name>	2	4	4	3	3	78.1	1
<helm-release-name>- ingressgateway</helm-release-name>	3	4	4	4	4	78.1	1
<helm-release-name>- egressgateway</helm-release-name>	3	4	4	4	4	78.1	1
<helm-release-name>- alternate-route</helm-release-name>	2	2	2	4	4	78.1	1
<helm-release-name>- appinfo</helm-release-name>	2	1	1	1	1	78.1	1
<helm-release-name>- perfinfo</helm-release-name>	2	1	1	1	1	78.1	1

4.7.2.2 Call-Mix

The following table describes the various type of service requests with the required traffic distribution and targeted TPS.

Table 4-27 Call-Mix

_			
S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
Α	NF Register	0.00002	1
В	NF Update	0.00282	1
С	NF Heartbeat	Not considered	52
D	NF Subscribe + Update Subscription	0.01416	7
Е	NF Discover	98.8	5000
F	NRF Forwarded Discovery (Incoming)	10% of Incoming discovery traffic	0
G	% of traffic forwarded to remote PLMN (case Visited NRF)	0%	Not included in this test.
Н	% of traffic received from remote PLMN (case Home NRF)	0%	Not included in this test.
I	SLF Query	88.4% of Discovery	4420
J	NF Access Token for SLF	Extra	0.1
K	NF Profile Retrieval	0.00141	1
L	NF List Retrieval	0.00141	1
М	NF Status Notify	1.52328	500
N	NF Status UnSubscribe	0.00006	1
0	NF DeRegister	0.00002	1
Р	NF Access Token for Consumers	0.00141	1



Table 4-27 (Cont.) Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
Q	NRF Forwarding (Outgoing)	10% of discovery traffic	500

Table 4-28 Total Traffic

Traffic Type	Message Considered	Targeted TPS
Total Incoming Traffic	A+B+C+D+E+F+G+H+J+K+ L+N+O+P	5066
Total Outgoing Traffic	I + M + Q	5420

4.7.2.2.1 NF Count Per NF Types

The following table lists the NF count per NF type along with the NF profile size.

Table 4-29 NF Count Per NF Types

Target-NF Types	NF Count	Profile Size (with pretty printing) (in bytes)
AMF	58	8700-11300
AUSF	6	4640
BSF	3	1700
CHF	3	1800
GMLC	6	0630
LMF	6	2400
PCF	30	1500-2500
SMF	94	5700-7400
UDM	6	3200
UDR	36	1700-2000
SLF	3	2100
SMSF	3	11300
NEF	3	11300
CBCF	3	11300

Total number of NF Count Across all NRF Sites is 260 (No. of profiles in set 1 with 250 and set 2 with 10 = 260.)

4.7.2.2.2 Discovery TPS per NfType and Number of Profiles in Response

The following table indicates the discovery TPS per NfType and the number of profiles sent in the response.

Table 4-30 Discovery TPS per NfType and Number of Profiles in Response

Target-Nf Types	TPS (in %)	Absolute Discovery TPS	SLF Queries Posted	Number of Profiles in Response
AMF	4.25	218	0	6
AUSF	0.40	20.3	20.3	6



Table 4-30 (Cont.) Discovery TPS per NfType and Number of Profiles in Response

Target-Nf Types	TPS (in %)	Absolute Discovery TPS	SLF Queries Posted	Number of Profiles in Response
BSF	0.00	0	0	3
CBCF	0.00	0	0	3
CHF	0.075	3.82	0	3
GMLC	0.00	0	0	6
LMF	0.027	1.37	0	6
PCF	0.39	19.7	0	10
SMF	8.11	416	0	10
UDM	85.3	4383	4383	6
UDR	1.21	62.1	62.1	12
SLF	0	0	0	3
NEF	0.027	1.42	0	3
SMSF	0.025	1.28	0	3

4.7.2.3 Test Observations

This section following table provides the details of test duration and TPS used for the benchmarking test.

Table 4-31 Test Observations

Parameter	Values
Test Duration	72 hours
TPS Achieved	5195 (* considered all Ingress and NfStatusNotify traffic)
Ingress incoming connections	24
Ingress outgoing connections	240
Egress incoming connections	22
Egress outgoing connections	120

4.7.2.4 NRF Resource Utilization

The following table describes NRF microservices and their utilization.

Table 4-32 NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory
nfregistration	2	12.1%	37.1%
nfdiscovery	6	52.2%	50.8%
nfsubscription	2	4.47%	24.4%
nrfauditor	2	0.81%	24.4%
nrfconfiguration	1	0.96%	45.7%
nfaccesstoken	2	0.71%	33.8%
nrfartisan	1	0.10%	24.4%



Table 4-32 (Cont.) NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory
nrfcachedata	2	7.80%	31.2%
alternate-route	2	0.10%	8.29%
perf-info	2	11.8%	14.1%
appinfo	2	3.21%	25.6%
ingressgateway	3	49.4%	66.5%
egressgateway	3	48.6%	40.9%

(i) Note

If you enable Message Feed feature at Ingress Gateway and Egress Gateway, approximately 33% pod capacity is impacted. The features enabled for this benchmarking testing does not utilize alternate-route service.

4.7.2.5 cnDBTier Services Resource Utilization

The following table provides the observed values of cnDBTier services.

Table 4-33 cnDBTier Services Resource Utilization

Service Name	Pod Count	Average CDU	Momory
Service Name	Pou Count	Average CPU	Memory
SQL (ndbappmysqld)	2	0.48 (12.02%)	3.47 (57.83)
DB (ndbmtd)	4	0.56 (2.8%)	15.87 (79.35)
SQL (ndbmysqld)	2	0.047 (0.8%)	1.92 (19.2%)
MGMT (ndbmgmd)	2	0.01 (0.13%)	0.060 (0.48%)
Monitor Service (db-monitor-svc)	1	0.01 (2.5%)	0.354 (70.8%)
Backup Manager Service (db-backup-manager-svc)	1	0.001 (0.01%)	0.06 (46.875%)
Replication Service	1	0.0 (0.0%)	0.41 (20.5%)

Table 4-34 cnDBTier Statistics

DBTier Statistics	Value
Disk Write operations per second	45.4
Disk Read operations per second	166
Transaction rates on data nodes	102



4.7.2.6 Latency Observations

Table 4-35 Latency Observations

Latency Parameters	99th Percentil e (ms)	95th Percentil e (ms)	90th Percentil e (ms)	50th Percentil e (ms)
Average Turnaround time at Ingress Gateway, Discovery Processing, and SLF Egress Transaction	230	189	195	143
Average Turnaround time for Discovery Processing and SLF Egress Transaction	229	191	196	150
Average Turnaround time for SLF Egress Transaction (see Note)	222	196	191	150

(i) Note

Following simulators are used for performance measurement and their induced latency:

- NF simulator to NRF: 50 ms
- NRF to forwarding simulator and forwarding simulator to NRF: 150 ms
- NRF to SLF: 150 ms