Oracle® Communications

Cloud Native Core, Network Repository Function Benchmarking Guide

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Oracle Communications Cloud Native Core, Network Repository Function Benchmarking Guide, Release 25.1.200

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Preface

- Documentation Accessibility
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Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
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Acronyms

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

Table Acronyms

Term	Definition
ASM	Aspen Service Mesh
B	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 25.1.2xx.

Release 25.1.200- G37249-01, July 2025

Generic Updates

- Updated the cnDBTier version in the System Software section.
- Updated the NRF version test constraint, Average HTTP Request Packet Size, Average HTTP Response Packet Size, and Average size of NF Profiles in the Software Test Constraints section.

Benchmark Testing Updates

- Updated the NRF Features section.
- Updated the CNE Common Services Resource Utilization section.
- Updated the following sections in the Observations for 51.6K TPS chapter:
  - STATE Data Quantum at NRF before Performance Run Begins
  - Call-Mix
  - NF Count Per NF Types
  - Discovery TPS per NfType and Number of Profiles in Response
  - Test Observations
  - NRF Resource Utilization
  - cnDBTier Services Resource Utilization
  - Latency Observations
- Updated the following sections in the Observations for 51.6K+ 5K TPS chapter:
  - NRF Services Resource Requirements
  - STATE Data Quantum at NRF before Performance Run Begins
  - Call-Mix
  - NF Count Per NF Types
  - Discovery TPS per NfType and Number of Profiles in Response
  - Test Observations
  - NRF Resource Utilization
  - cnDBTier Services Resource Utilization
  - Latency Observations
- Added the following sections for the Observations for 5K TPS chapter:
  - NRF Services Resource Requirements
  - Call-Mix
  - Test Observations
  - NRF Resource Utilization

– cnDBTier Services Resource Utilization
– Latency Observations

1 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*

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

2.1.2 System Software

This section describes the system software details.

Table 2-2 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	25.1.200

2.1.3 Observability Services

This section describes the observability services used for NRF benchmarking.

Table 2-3 Observability Services

Service Name	Version
OpenSearch	2.3.0
OpenSearch Dashboard	2.3.0
FluentBit	1.9.4
Fluentd OpenSearch	1.16.2
Kyverno	1.9.0
Grafana	9.5.3
Prometheus	2.44.0
Jaeger	1.45.0

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:

> **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`	2
`<helm-release-name>-nfdiscovery`	2
`<helm-release-name>-nfsubscription`	2
`<helm-release-name>-nrfauditor`	2
`<helm-release-name>-nrfconfiguration`	1
`<helm-release-name>-nfaccesstoken`	2
`<helm-release-name>-nrfartisan`	1
`<helm-release-name>-nrfcachedata`	2
`<helm-release-name>-ingressgateway`	2
`<helm-release-name>-egressgateway`	2
`<helm-release-name>-alternate-route`	2
`<helm-release-name>-appinfo`	2
`<helm-release-name>-perfinfo`	2

Where, <helm-release-name> is prefixed in each microservice name. For example, if helm-release-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

> **Note**
>
> There is a change in the Memory/Pod resource requirement for Monitor Service (db-monitor-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*.

3
Test Topology

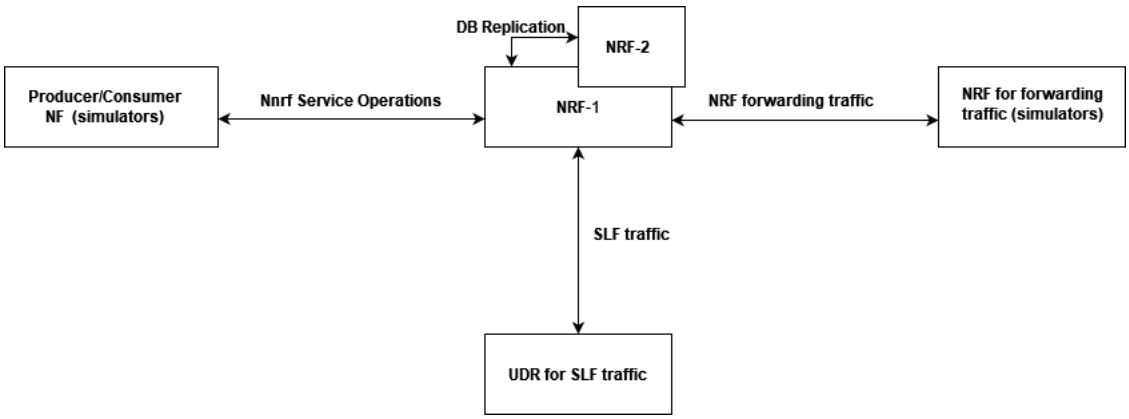
This section describes the topology used for testing Oracle Communications Cloud Native Core, Network Repository Function (NRF).

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



1. Producer NF sends NfRegister, NfHeartbeat, NfUpdate, and NfDeregister requests to NRF.
2. 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.

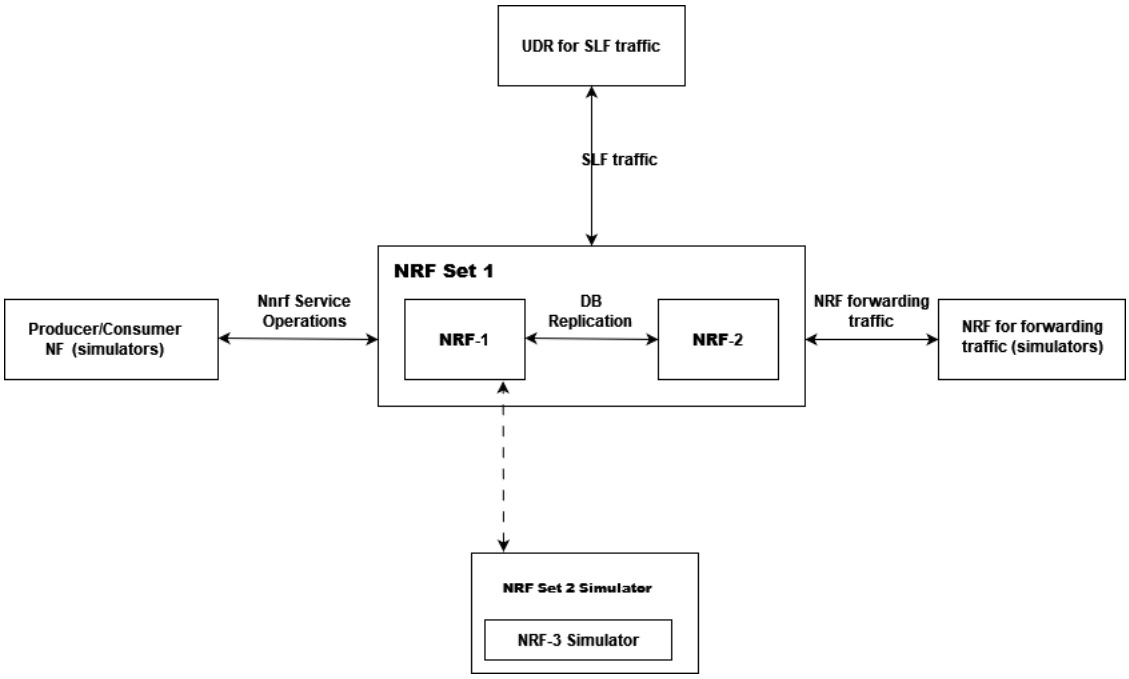
3.2 Multiset Test Topology (NRF Growth)

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.
2. 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.

4 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

The following table lists the features that are enabled during benchmarking.

Table 4-1 NRF Features

NRF Features	Feature Status	Notes
Subscriber Location Function	ENABLED	SLF is enabled for 3 NfTypes (AUSF, UDR, and UDM) in slfLookupConfig.
SLF Selection from Registered NF Profiles	ENABLED	Dynamic SLF feature is enabled.
Access Token Caching during SLF Query	ENABLED	Access Token Caching during SLF Query is enabled with 24 hour validity period based caching. For more information about the `accessTokenCacheEnabled` under `slfOptions`, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Overload Control	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Preferred Locality Feature Set	ENABLED	Extended Preferred locality is configured with 2 locationTypes, 8 locationMappings, 56 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.

Table 4-1 (Cont.) NRF Features

NRF Features	Feature Status	Notes
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*.
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 12 for the `profilesCountInDiscoveryResponse` parameter. For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*. **Note**: If the value is greater than 12, there will be a performance impact.
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*.
Discovery Validity	ENABLED	Discovery validity feature is enabled with a value as 1 minute (for all NF Types). For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Access Token Expiry Time	NA	The expiry duration for a NRF signed certificate. The limit is 24 hours. For more information about NRF Access Token Service Usage Details, see *Oracle Communications Cloud Native Core, Network Repository Function User Guide*.

Table 4-1 (Cont.) NRF Features

NRF Features	Feature Status	Notes
Load Change Threshold for Notifications from NRF	NA	This feature is configured using `nfNotifyLoadThreshold` parameter. Set the value to 10%. For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Monitoring the Availability of SCP Using SCP Health APIs	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
NRF to Retry Alternate Producer to Support Maximum Diversity	NA	The value of *maxSlfAttempts* parameter is set to 1 and the value of *useAlternateScp* parameter is set to true. For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Error Response Enhancement	NA	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Error Log Enhancements	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
NRF support for A_PFD DataSetId in registration and discovery (DataSetId Enhancements)	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
NFService Priority Update	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Subscriber Identity in messages (3GPP-SBI-Correlation-Info)	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide*.
Egress Gateway Pod Throttling	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function Installation, Upgrade and Fault Recovery Guide*.
Ingress Gateway Pod Protection Using Rate Limiting	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide.*
NF Profile Size Limit	ENABLED	For more information about the configuration, see *Oracle Communications Cloud Native Core, Network Repository Function REST Specification Guide.*

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	25.1.200
Ingress incoming connections	For more information on this, see • Test Observations for 51.6K TPS • Test Observations for 51.6K TPS and Test Observations for 5K TPS (with Growth 51.6K TPS + 5K TPS = 56.6K TPS)
Ingress outgoing connections	
Egress incoming connections	
Egress outgoing connections	
Average HTTP Request Packet Size	~630 to 11300 bytes (Based on NfRegister Request)
Average HTTP Response Packet Size	~2520-44000 bytes (Discovery Response with nfProfiles)
Average NF Heartbeats Timer per NF	30s
Average size of NF Profiles	~630 to 11300 bytes

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 query parameters:

- Target-nf-type, guami, and requester-nssais
- Target-nf-type, requester-nf-type, routing-indicator, and group-id-list
- Target-nf-type, requester-nf-type, supi, and service-names
- Target-nf-type, requester-nf-type, and service-names
- Target-nf-type, requester-nf-type, and group-id-list
- Target-nf-type and pgw
- Target-nf-type, requester-nf-type, supi, and service-names
- Target-nf-type, requester-nf-type, and service-names
- Target-nf-type, dnn, snssai, TAI, and pgw-ind
- Target-nf-type, SUPI, group-id-list, and service-names
- Target-nf-type, dnn, snssai, preferred-locality, and service-names
- Target-nf-type and guami
- Target-nf-type, requester-nf-type, and preferred-locality
- Target-nf-type, requester-nf-type, preferred-locality, and SUPI
- Target-nf-type, requester-nf-type, SUPI, group-id-list, requester-nf-type, and data-set
- Target-nf-type, requester-nf-type, routing-indicator, group-id-list, and service-names

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
occne-prometheus-server-1	2
occne-opensearch-cluster	10
occne-prometheus-node-exporter	16

4.6 Observations for 51.6K TPS

This section provides the details of observations noticed for 51.6K 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/Pod (in Gi)	Max Memory/Pod (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>-nfregistration	2	2	2	3	3	78.1	1
<helm-release-name>-nfdiscovery	58	8	8	3	3	78.1	2
<helm-release-name>-nfsubscription	2	2	2	3	3	78.1	1
<helm-release-name>-nrfauditor	2	2	2	3	3	78.1	1
<helm-release-name>-nrfconfiguration	1	2	2	2	2	78.1	1
<helm-release-name>-nfaccesstoken	2	2	2	2	2	78.1	1
<helm-release-name>-nrfartisan	1	2	2	2	2	78.1	1
<helm-release-name>-nrfcachedata	2	4	4	3	3	78.1	1
<helm-release-name>-ingressgateway	26	4	4	4	4	78.1	1
<helm-release-name>-egressgateway	24	4	4	4	4	78.1	1
<helm-release-name>-alternate-route	2	2	2	4	4	78.1	1
<helm-release-name>-appinfo	2	1	1	1	1	78.1	1

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

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/Pod (in Gi)	Max Memory/Pod (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
<helm-release-name>-perfinfo	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 Subscriptions in DB	1000	Subscriptions are created with the below conditions: • Subscription to a set of NF Instances identified by their NF Type - 506 • Subscription to a set of NF Instances identified by their NF Instance Id - 260 • Subscription to a set of NF Instances identified by their NF Set Id - 156 • Miscellaneous subscriptions - 78 • NotificationCondition with monitored attributes set to “/priority” or “/load”. • reqNotifEvents set to NF_REGISTERED,NF_DEREGISTERED, NF_PROFILE_CHANGE.

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
A	NF Register	0.00002	1
B	NF Update	0.00282	1
C	NF Heartbeat	Not considered	52
D	NF Subscribe + Update Subscription	0.01416	7
E	NF Discover	99.8	51600
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.

Table 4-6 (Cont.) Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
H	% of traffic received from remote PLMN (case Home NRF)	0	Not included in this test.
I	SLF Query	88.4% of Discovery	45600
J	NF Access Token for SLF	Extra	0.1
K	NF Profile Retrieval	0.00141	1
L	NF List Retrieval	0.00141	1
M	NF Status Notify	1.52328	750
N	NF Status UnSubscribe	0.00006	1
O	NF DeRegister	0.00002	1
P	NF Access Token for Consumers	0.00141	1
Q	NRF Forwarding (Outgoing)	10% of discovery traffic	5160

Table 4-7 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	51666
Total Outgoing Traffic	I + M + Q	51511

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
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	48 hours
TPS Achieved	54.091K (considered all Ingress and NfStatusNotify traffic)
Ingress incoming connections	327
Ingress outgoing connections	2.161K
Egress incoming connections	240
Egress outgoing connections	900

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
nfregistration	2	16.7%	36.1%

Table 4-11 (Cont.) NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory
nfdiscovery	58	59%	45.3%
nfsubscription	2	9.98%	23.9%
nrfauditor	2	1.13%	20.1%
nrfconfiguration	1	1.16%	52.1%
nfaccesstoken	2	0.94%	29.9%
nrfartisan	1	0.10%	32.6%
nrfcachedata	2	7.27%	21.9%
alternate-route	2	0.10%	8.29%
perf-info	2	10.8%	13.6%
appinfo	2	3.3%	25.6%
ingressgateway	26	58.8%	52.0%
egressgateway	24	55.2%	36.4%

> **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

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 Parameters	99th Percentile (ms)	95th Percentile (ms)	90th Percentile (ms)	50th Percentile (ms)
Average Turnaround time at Ingress Gateway, Discovery Processing, and SLF Egress Transaction	238	195	190	143
Average Turnaround time for Discovery Processing and SLF Egress Transaction	239	196	191	151
Average Turnaround time for SLF Egress Transaction (see Note)	230	196	191	150

> **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 51.6K+ 5K TPS

This section provides the details of observations noticed for 51.6K+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/Pod (in Gi)	Max Memory/Pod (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>-nfregistration	2	2	2	3	3	78.1	1
<helm-release-name>-nfdiscovery	58	8	8	3	3	78.1	2
<helm-release-name>-nfsubscription	2	2	2	3	3	78.1	1
<helm-release-name>-nrfauditor	2	2	2	3	3	78.1	1

Table 4-15 (Cont.) NRF Services Resource Requirements

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/Pod (in Gi)	Max Memory/Pod (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
<helm-release-name>-nrfconfiguration	1	2	2	2	2	78.1	1
<helm-release-name>-nfaccesstoken	2	2	2	2	2	78.1	1
<helm-release-name>-nrfartisan	1	2	2	2	2	78.1	1
<helm-release-name>-nrfcachedata	2	4	4	3	3	78.1	1
<helm-release-name>-ingressgateway	26	4	4	4	4	78.1	1
<helm-release-name>-egressgateway	24	4	4	4	4	78.1	1
<helm-release-name>-alternate-route	2	2	2	4	4	78.1	1
<helm-release-name>-appinfo	2	1	1	1	1	78.1	1
<helm-release-name>-perfinfo	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 Subscriptions in DB	1000 (900 + 100)	Subscriptions are created with the below conditions: • Subscription to a set of NF Instances identified by their NF Type - 253 • Subscription to a set of NF Instances identified by their NF Instance Id - 130 • Subscription to a set of NF Instances identified by their NF Set Id - 78 • Miscellaneous subscriptions - 39 • 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

This section describes the various type of service requests with the required traffic distribution and targeted TPS. For more details, see Call-Mix.

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 4-17 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 4-18 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 4-19 Test Observations

Parameter	Values
Test Duration	72 hours
TPS Achieved	54020 (* considered all Ingress and NfStatusNotify traffic)
Ingress incoming connections	208
Ingress outgoing connections	2.080K
Egress incoming connections	192
Egress outgoing connections	960

4.7.1.5 NRF Resource Utilization

The following table describes NRF microservices and their utilization.

Table 4-20 NRF Resource Utilization

NRF Microservices	Number of Pods	Average CPU	Average Memory
nfregistration	2	3.91%	32.3%
nfdiscovery	58	58.9%	50.9%
nfsubscription	2	4.46%	29.0%
nrfauditor	2	0.81%	22.0%
nrfconfiguration	1	1.59%	38.0%
nfaccesstoken	2	1.07%	35.7%
nrfartisan	1	0.12%	24.9%
nrfcachedata	2	14.6%	30.4%
alternate-route	2	0.10%	8.29%
perf-info	2	11.4%	14.0%
appinfo	2	3.52%	25.9%
ingressgateway	26	58.9%	69.0%
egressgateway	24	56.3%	42.0%

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

4.7.1.6 cnDBTier Services Resource Utilization

The following table provides observed values of cnDBTier services.

Table 4-21 cnDBTier Services Resource Utilization

Service Name	Pod Count	Average CPU	Memory
SQL (ndbappmysqld)	2	8.4%	38.6%
DB (ndbmtd)	4	2.5%	88.92%
SQL (ndbmysqld)	2	0.2%	1.5%
MGMT (ndbmgmd)	2	0.2%	0.54%
Monitor Service (db-monitor-svc)	1	0.2%	10.57%
Backup Manager Service (db-backup-manager-svc)	1	0.05%	9.0%

Table 4-22 cnDBTier Statistics

DBTier Statistics	Value
Disk Write operations per second	22.4
Disk Read operations per second	198
Transaction rates on data nodes	112

4.7.1.7 Latency Observations

Table 4-23 Latency Observations

Latency Parameters	99th Percentile (ms)	95th Percentile (ms)	90th Percentile (ms)	50th Percentile (ms)
Average Turnaround time at Ingress Gateway, Discovery Processing, and SLF Egress Transaction	283	190	196	143
Average Turnaround time for Discovery Processing and SLF Egress Transaction	243	191	196	151
Average Turnaround time for SLF Egress Transaction (see Note)	222	196	191	150

> **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 4-24 NRF Services Resource Requirements

Service Name	Pod Replica	Min CPU/Pod	Max CPU/Pod	Min Memory/Pod (in Gi)	Max Memory/Pod (in Gi)	Min (Mi) Ephemeral Storage	Max (Gi) Ephemeral Storage
Helm test	1	1	2	1	2	78.1	1
<helm-release-name>-nfregistration	2	2	2	3	3	78.1	1
<helm-release-name>-nfdiscovery	6	8	8	3	3	78.1	2
<helm-release-name>-nfsubscription	2	2	2	3	3	78.1	1
<helm-release-name>-nrfauditor	2	2	2	3	3	78.1	1
<helm-release-name>-nrfconfiguration	1	2	2	2	2	78.1	1
<helm-release-name>-nfaccesstoken	2	2	2	2	2	78.1	1
<helm-release-name>-nrfartisan	1	2	2	2	2	78.1	1
<helm-release-name>-nrfcachedata	2	4	4	3	3	78.1	1
<helm-release-name>-ingressgateway	3	4	4	4	4	78.1	1
<helm-release-name>-egressgateway	3	4	4	4	4	78.1	1
<helm-release-name>-alternate-route	2	2	2	4	4	78.1	1
<helm-release-name>-appinfo	2	1	1	1	1	78.1	1
<helm-release-name>-perfinfo	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 4-25 Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
A	**NF Register**	0.00002	1
B	**NF Update**	0.00282	1
C	**NF Heartbeat**	Not considered	52
D	**NF Subscribe + Update Subscription**	0.01416	7
E	**NF Discover**	98.8	5000

Table 4-25 (Cont.) Call-Mix

S.No	Type of Request	Traffic Distribution (in %)	Targeted TPS
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.
H	**% 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
M	**NF Status Notify**	1.52328	500
N	**NF Status UnSubscribe**	0.00006	1
O	**NF DeRegister**	0.00002	1
P	**NF Access Token for Consumers**	0.00141	1
Q	**NRF Forwarding (Outgoing)**	10% of discovery traffic	500

Table 4-26 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 4-27 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

Table 4-27 (Cont.) NF Count Per NF Types

Target-NF Types	NF Count	Profile Size (with pretty printing) (in bytes)
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 4-28 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

4.7.2.3 Test Observations

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

Table 4-29 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 4-30 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%
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%

> **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 4-31 cnDBTier Services Resource Utilization

Service Name	Pod Count	Average CPU	Memory
Backup Manager Service (db-backup-manager-svc)	1	0.9%	9.7%
DB (ndbmtd)	4	3.2%	88.9%
MGMT (ndbmgmd)	2	0.2%	0.27%
Monitor Service (db-monitor-svc)	1	0.2%	10.1 %
SQL (ndbappmysqld)	2	8.8%	23.03%
SQL (ndbmysqld)	2	0.2%	1.5%

Table 4-32 cnDBTier Statistics

DBTier Statistics	Value
Disk Write operations per second	72.5

Table 4-32 (Cont.) cnDBTier Statistics

DBTier Statistics	Value
Disk Read operations per second	182
Transaction rates on data nodes	85.6

4.7.2.6 Latency Observations

Table 4-33 Latency Observations

Latency Parameters	99th Percentile (ms)	95th Percentile (ms)	90th Percentile (ms)	50th Percentile (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

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