Tomi Niemi

Virtualizing Network Analytics in OpenStack Environment

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PREFACE

The situation with covid, working on multiple projects and taking care of the child and organizing schedules with my wife's evening and weekend-oriented work, have been my pet excuses.

After postponing this for countless times, the notification of my study right expiring finally got me to sit down and start writing. It was basically the exact replica of my bachelor thesis' struggle.

I'd like to thank my family for the support, my parents for helping with the kid, allowing me to write this thesis while it might have taken some time away from them. My line manager for the opportunity to take time off work and focus on my studies, and my colleagues for lending a hand when needed.

And for keeping me sane during the pandemic, I'd like to extend my gratitude to PiPe ry, PMC and the Athlone Daltons.

Helsinki, December 2, 2021
Tomi Niemi

Abstract

Author:	Tomi Niemi
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The goal of this project was to find a way to install the Network Analytics server on OpenStack Cloud platform, document the requirements and produce a Method of Procedure for the local markets, or anyone else interested and having the infrastructure, to follow the instructions in installing the server.

The selected hardware and software infrastructure were pre-defined as the Data Center environment already had OpenStack installed, and because the Network Analytics server has a strict set of software requirements that needed to be followed.

As the product of this study, a Method of Procedure was written to be used in upcoming Network Analytics Server installations, it can be updated for later releases of the product and the installed Server platform can be used for multiple purposes inside Ericsson for learning and training purposes.

The Method of Procedure was released as a global asset in the Ericsson Navigator 365 Asset Management Platform for re-use purposes.

Keywords: Cloud, OpenStack, NetAnServer, Network Analytics, ENIQ

Contents

List of Abbreviations

3GPP	3rd Generation Partnership Program
4G	Fourth Generation (mobile network)
5G	Fifth Generation (mobile network)
API	Application Programming Interface
BO	Business Objects
BP	Base Package
CA	Certificate Authority
CM	Configuration Management
CPU	Central Processing Unit
DDC	Diagnostic Data Collection
EBID	Ericsson Business Intelligence Deployment
ENIQ	Ericsson Network IQ
ENM	Ericsson Network Manager
ESM	Ericsson Software Model
ETL	Extract, Transform, and Load
ETLC	Extract, Transform, Load and Controller
FM	Fault Management
GUI	Graphical User Interface
HW	Hardware
ICT	Information and Communication Technology
KPI	Key Performance Indicator
MOP	Method of Procedure
NetAnServer	Network Analytics Server
NMEU	Network Management Expert Unit
NOC	Network Operations Center
OSS	Operations Support System
PDU	Product Design Unit
PM	Performance Management
PMIC	PM Initiation and Collection
RHEL	Red Hat Enterprise Linux
SQL	Structured Query Language

SW	Software
vCPU	Virtual Central Processing Unit
VM	Virtual Machine
VP	Value Package
VPN	Virtual Private Network

1 Introduction

Ericsson is one of the leading providers of Information and Communication Technology (ICT) to service providers. The Network Management Expert Unit (NMEU) is determined to share the knowledge and expertise, gathered over the years of working with different products and services, with the Service Delivery, Customer and Market Units.

The Telecommunication Operators managing their mobile networks are relying on the performance data collected from the network elements to see the bottle necks, detect, and identify problems, enhance, and optimize the performance of the network. Network Analytics helps the customer using Analyses to visualize the collected data to view in an efficient way using Key Performance Indicators (KPI) and allowing them to react faster and be more proactive to issues in the network, improving customer satisfaction and saving costs.

The Network Analytics server (NetAnServer) has been previously implemented on physical hardware as a Standalone deployment or co-deployed with an Ericsson Business Intelligence Deployment (EBID) server, requiring a lot of capital and resources that the local units might not have. The goal of the project was to virtualize the NetAnServer on Cloud environment and create a possibility for the Units to setup, train and ramp up on their competence on the server themselves, without investing on physical assets.

The infrastructure used in the project is owned by the NMEU and the Cloud is implemented on OpenStack Platform. OpenStack is used mainly because there are no license fees for the software, but also because various other products running in the Lab environment have a dependency on it.

With the constraints of the existing infrastructure and the software requirements, the primary goal of the thesis was to provide the local units an easy-to-follow procedure that could be shared across Ericsson. It did not take in to account any other vendor of the underlying cloud environment and only focused on the NetAnServer version that is compliant with the existing Ericsson Network IQ (ENIQ) server version, while it might still be used in other scenarios as well.

The secondary goal was for the author to explore the OpenStack technology and understand the different components and services that form the cloud.

The project implemented in this study started with gathering the current requirements for the solution and seeing that the server can be installed in the existing cloud. The OpenStack platform was reviewed using the available literature and used for getting familiar with the cloud platform and studying how to execute the project. The Network Analytics server installation and configuration was executed during the thesis work, each step was documented in a document and finally the server acceptance tested to validate the procedure.

The thesis will first guide the reader through the background of the project and the components included in the ENIQ and NetAnServer. Then it continues to define requirements for the implementation and the environment used. Final chapters include a walkthrough of the installation procedure and testing, concluding in results and conclusions. The actual product of the thesis, the Method of Procedure (MOP), was produced with each step documented and using screenshots to minimize the possibility for human errors.

2 Background

The Ericsson Analytics and Assurance products and services provide solutions to the operators needs by improving their customer experience, identifying bottlenecks in their networks, and suggesting improvements in the performance to maintain a high service quality and to proactively deal with issues and prevent them from escalating.

In this domain the ENIQ and the Network Analytics play a vital role.

2.1 ENIQ Statistics

ENIQ Statistics (ENIQ-S) is a full network performance management solution, providing both monitoring and long-term analysis capabilities. It collects and presents performance management (PM) and configuration management (CM) data from multiple Operation Support System (OSS) installations and multiple vendors. ENIQ supports the PM data from all technologies; 2G, 3G, 4G and 5G providing end-to-end visibility to Network Operations Center (NOC) personnel.

The network element data is collected by a Network Management system, such as the Ericsson Network Manager (ENM), and the ENIQ Technology Packages, or TechPacks (TP), execute the Extract, Transform, and Load (ETL) procedures on the raw data. After ETL processing, the data is available on the Data Warehouse (DWH) database and the data is then aggregated, and Busy Hour ranking is performed. The AdminUI provides a web interface for various administrative tasks such as System Monitoring, ENM Interworking, Feature Version Manager, Data Flow Monitoring and Data Verification and Configuration. [1]

Figure 1 illustrates the integration of ENIQ to multivendor and multi-technology networks and the functional architecture.

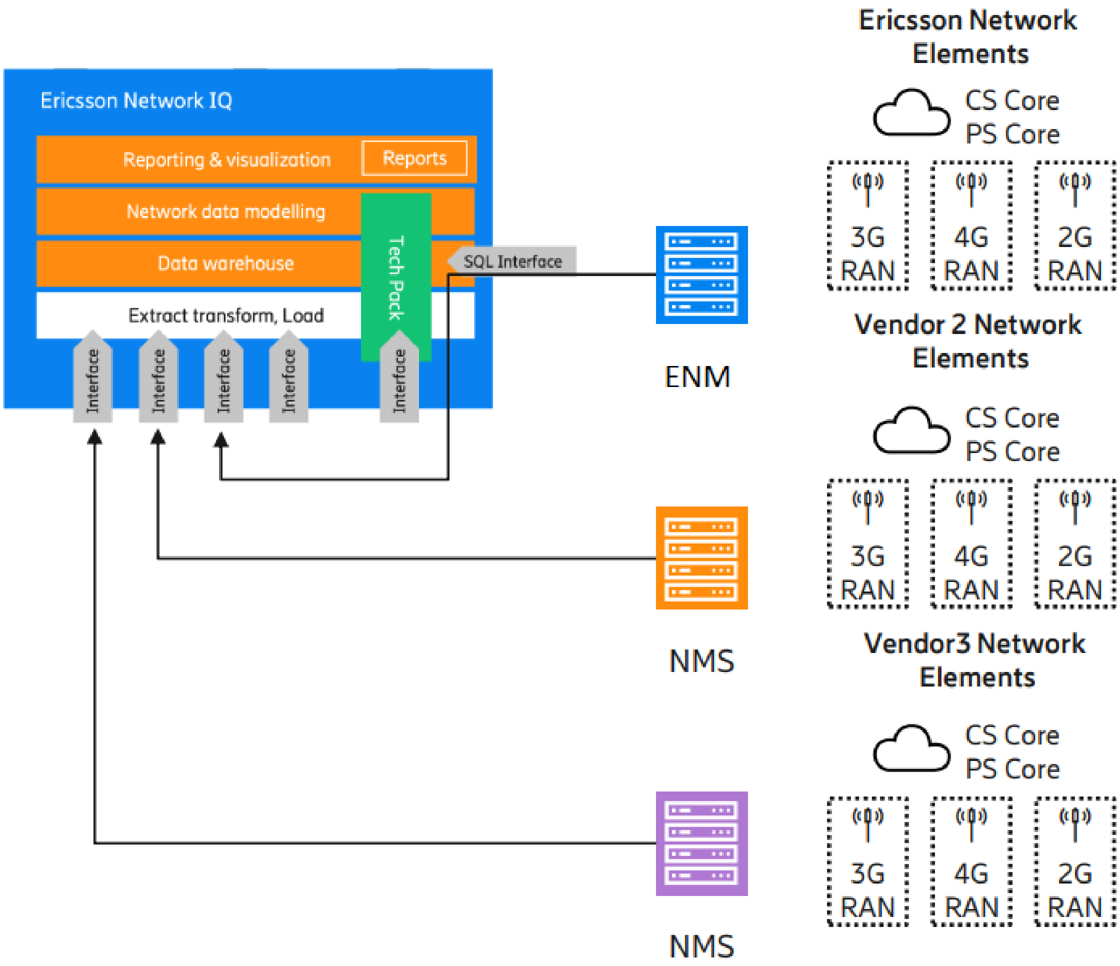

Figure 1. ENIQ Integration and Data processing layout. [2]

ENIQ Statistics (hereinafter ENIQ) utilizes Ericsson Software Model (ESM), where the functionalities are divided in the Base Packages (BP) and Value Packages (VP). The packages contain the following high level functionality:

- *Network Assurance Data Store BP*
  Includes the SW for PM data processing and storage as well as the Technology Packages (TP) which collects the PM counters.

- *Historical Network Analytics VP*
  includes an integrated network analytics platform (Network Analytics Server) and pre-defined analyses

There are two Value packages to visualize/analyze the PM counters collected in the Base Package. One is built on Business Objects (BO) and the other Value Package contains Network Analytics Server as a base. [3] This thesis will focus on the latter

The ENIQ server runs on Red Hat Enterprise Linux (RHEL) from version 19.4 onwards and for the thesis project, the installed version was 20.2.8 EU5:

```
ceniq1[eniq_stats] {root} #: cat /eniq/admin/version/eniq_status
ENIQ_STATUS ENIQ_Statistics_Shipment_20.2.8.EU5_Linux AOM901204 R1H05
```

While there are multiple installation types for the ENIQ server, in the thesis the existing compact rack installation was used.

2.2 Network Analytics

The Network Analytics Server is a Windows Server deployment and is an optional product for ENIQ Statistics. It provides functionality to both off the shelf reports provided by Ericsson and Ad-hoc reports through a web interface and supports advanced analytics use cases with full access to the data stored within the ENIQ Statistics system. [1;4]

It can combine data from multiple sources into a single unified view. The bare metal deployment architecture with ENIQ integrated to OSS systems is presented in Figure 2.

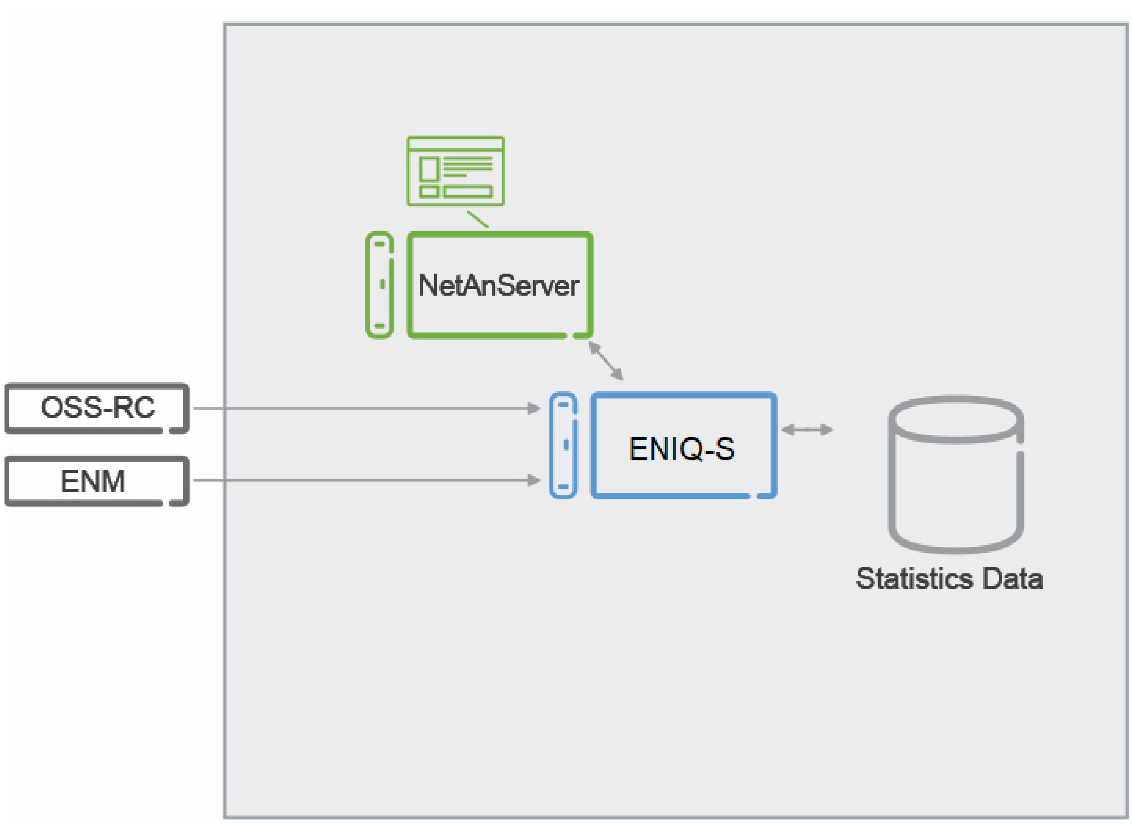

Figure 2. NetAnServer deployment in bare metal.

The Network Analytics Server Platform refers to the overall infrastructure and deployment of the individual tools and components. [5]

The logical view of the server components is presented in Figure 3.

- Network Analytics Server
  The controlling node for the Network Analytic Server feature

- Network Analytics Analyst
  A desktop tool for creating Analyses and Information Packages

- Node Manager
  Supports the following services:

- Web Player - provides access to published analyses reports through a web browser.

- Automation Services - is a tool for running automated server jobs.

- Network Analytics Server Database
  Stores information from the Network Analytics Server related to Users, Libraries, Analysis Reports and Data Models

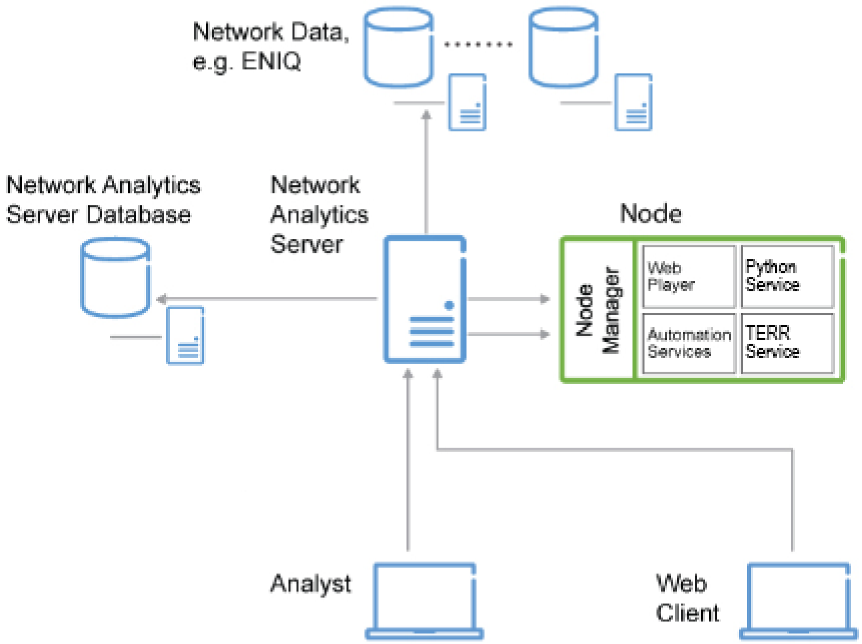

Figure 3. Logical Network Analytics Server Components. [5]

The Network Analytics uses Feature Packages for the analysis of the data gathered from the network. The features are related to a specific area or problem domain and are bound to a predefined set of dimensions and measures. The Feature Packages consist of one or more related Analyses and Information Packages. The Information Packages define the contents of the feature and it consists of multiple columns from various data tables in the ENIQ database. The Analysis uses the Information Package to connect to the external data source, ENIQ, and it consists of one or more visualizations like charts, tables, and calculated values, grouped into one or more pages to, for example, give an accurate view of the performance of the network or to give the user energy consumption of the nodes for the past 7 days.

The Ericsson Product design unit (PDU) has provided instructions on the different deployment types of the NetAnServer for the bare metal servers, it can be installed on a separate Blade or Rack server [6], or it can be co-deployed with a EBID Blade or Rack server [7] to save on hardware costs. However, there are no clear instructions for the virtual machine (VM) deployment and this thesis will focus on changing that.

2.3 OpenStack Cloud Environment

The Ericsson Finland Lab environment has been used by the global services delivery organization, now known as NMEU, for more than 15 years for various purposes, ranging from new product introductions, spare-wheel upgrades and installations, replication of fault scenarios and asset development.

In the years, some of the hardware has been allocated to the organization and given full custody of. This hardware now also contains the OpenStack environment used in this thesis.

2.3.1 What is OpenStack?

“OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter, all managed and provisioned through Application Programming Interfaces (API) with common authentication mechanisms”. [8]

By 2021 most of the people working in the ITC industry must have heard of OpenStack. Since its beginning in 2010, it has grown to be probably the most widely deployed open source Cloud software in the world. The OpenStack foundation states its goal is “to serve developers, users, and the entire ecosystem by providing a set of shared resources to grow the footprint of public and private OpenStack clouds, enable technology vendors targeting the platform and assist developers in producing the best cloud software in the industry”. [9]

OpenStack’s principles are to have open developments model so that all the code for OpenStack is freely available under the Apache 2.0 license. The design process is open as every 6 months a design summit, open for public, is arranged. In the summit the requirements are gathered, and specifications written for the next upcoming release. Open Community that controls the design process and decisions are made based lazy consensus [10] model. The community consist of developers, corporations, service providers, researchers, and users globally. All the processes in the community are documented, open and transparent. [9]

In Figure 4 the three pillars, OpenStack Compute, Storage and Networking, provide the foundation for the cloud and with several shared services, ease the implementation and operation of the cloud by integrating the OpenStack components, and external systems, together to provide the user a unified experience using APIs or Dashboard for management.

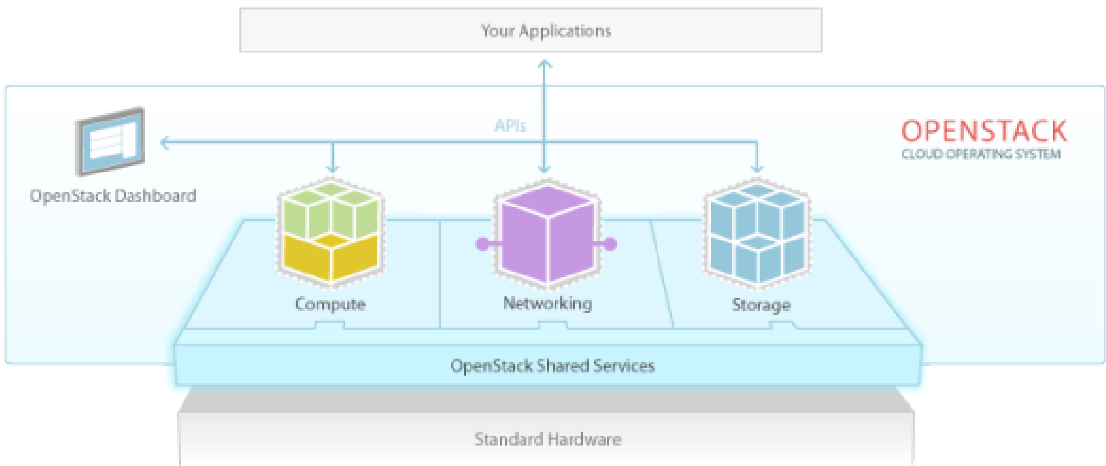

Figure 4. OpenStack Cloud Infrastructure. Snipped from the OpenStack Community Welcome Guide. [9]

2.3.2 What is OpenStack Built on?

OpenStack consists of various components with a modular architecture and different code names. There are different tools that can be used to handle the components:

- Horizon Dashboard is the web UI
- OpenStack client is the official CLI for OpenStack Project and includes commands for most of the projects in OpenStack
- The REST API is also available for more complicated logic or automation.

This subchapter goes through the services that enable the user to plug and play components depending on their needs. This thesis is only targeting the services that are installed in the Lab environment.

OpenStack Compute

It provides the way to provision and manage extensive networks of virtual machines by running a set of daemons on the existing Linux servers. OpenStack Compute’s codename is Nova. [11]

OpenStack Storage

There are 2 different storage services for use with servers and applications in the Lab environment, object storage (codename Swift) and for block storage (codename Cinder).

Swift is used for storing large amounts of static data which can be updated and retrieved and is ideal for unstructured data. [11]

Cinder is designed to present storage resources to end users that can be consumed by Nova without any knowledge of where the storage is deployed or on what type of device. [11]

OpenStack Networking

It enables the network connectivity for OpenStack services, such as OpenStack Compute, and an API for users to define networks and the attachments into them. It's described as a pluggable, scalable, API-driven network and IP management. Codename Neutron. [11]

Shared Services

As mentioned, OpenStack has some shared services that integrate the OpenStack components, making it easier to implement and operate the cloud.

Identity

It provides the authentication and authorization service and controls which of the OpenStack services consumers are allowed to access via multiple forms of authentication like usernames, tokens etc. Codename Keystone [11]

Image

Works as an image registry and used for storing and retrieving the virtual machine images, a single file which contains a virtual disk that has a bootable operating system installed on it, and its metadata. It supports multiple different image formats and can be configured to use different backends for storing the images. Codename Glance. [11]

Orchestration

With the use of Heat Orchestration Templates (HOT), users can describe and automate the creation of resources and applications with just a push of a button. Codename Heat. [11]

Telemetry

Provides a monitoring and metering service in OpenStack by collecting data from physical and virtual resources, processing, storing, and retrieving the data using different agents. Codename Ceilometer. [11]

In Figure 5 the logical architecture with the most common services is seen.

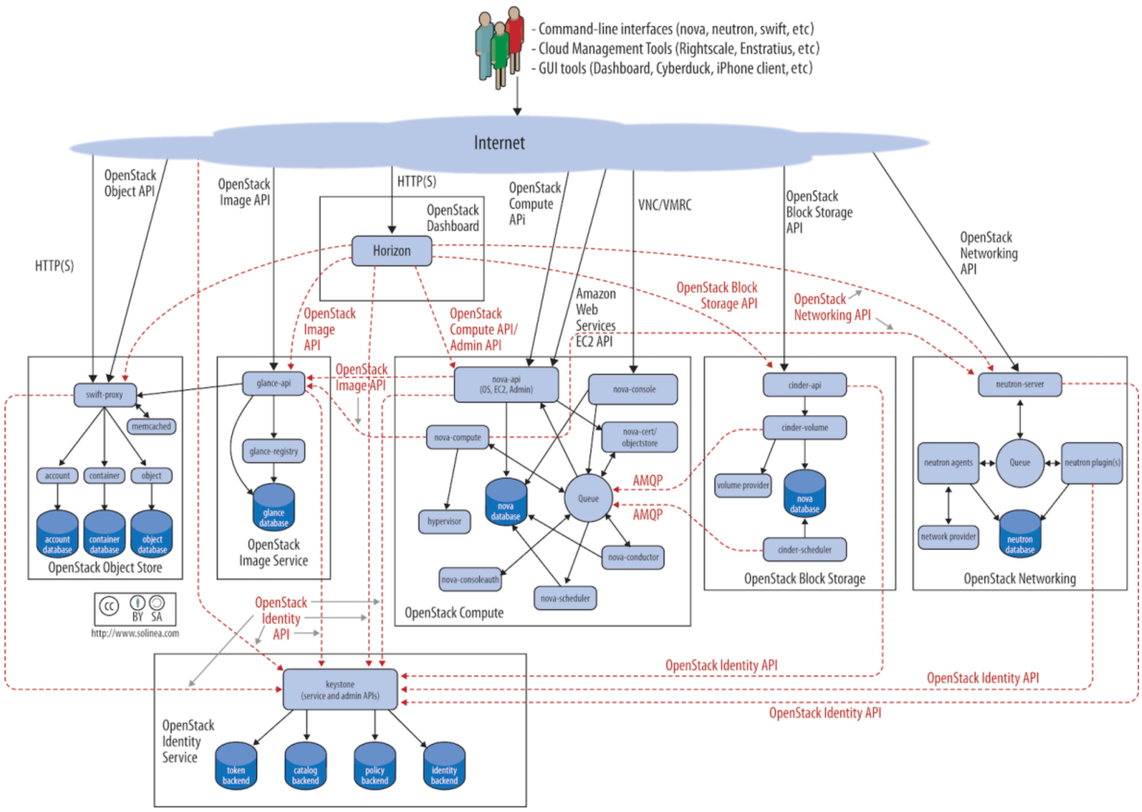

Figure 5. OpenStack Logical Architecture. [12]

From the Figure 5 it can be seen how each of the OpenStack services have at least one API interface listening to the requests from users and other services and how authentication is handled by the common Identity Service via the Identity API calls. For most of the services, the API requests are pre-processed and passed on to the underlying processes that do the actual work, except the Identity service where the work is done by the keystone service and admin API. Internal communication between the processes in a service, Advanced Message Queuing Protocol (AMQP) message broker is used. On the top of the figure, it can be seen how the end users manage the OpenStack cloud using different tools.

3 Current Requirements

This chapter describes the HW and networking requirements that the bare metal deployment has.

As mentioned previously the NetAnServer can be installed as a Standalone Deployment or co-deployed with EBID, both rack and blade server. These servers have requirements from the PDU regarding the hardware components, SW, cabling, firewall configuration and the licensing.

In addition to the physical requirements, there are also requirements on experience or knowledge on the HP Blade and rack hardware, HP Blade technologies, e.g., Virtual Connect, switch configuration and physical cabling and firmware installation.

For the sake of simplicity, the thesis will only focus on the Standalone deployment of NetAnServer on rack mounted server requirements.

3.1 Hardware Requirements

As the ENIQ server installed in the Lab environment is running on Compact Rack Deployment for test purposes, the thesis will use the requirements presented for that deployment type for the NetAnServer. The Table 1 shows the NetAnServer hardware requirements for a HPE DL360 Gen10 rack server from the Ericsson ordering tool. [12]

Table 1. NetAnServer HW Specification

Description	Quantity
HPE OEM DL360 Gen10 8-SFF CTO Server	1
HPE Fctry Express Svr Sys Custom SVC	1
OEM LL DL360 Gen10 6130 Xeon-G FIO Kit	1

OEM LL DL360 Gen10 6130 Xeon-G Kit	1
HPE 32GB 2Rx4 PC4-2666V-R Smart Kit	4
HPE 1.2TB SAS 10K SFF SC DS HDD	4
HPE DL360 Gen10 LP Riser Kit	1
HPE Ethernet 10Gb 2P 562SFP+ Adptr	1
HPE 96W Smart Storage Battery 145mm Cbl	1
HPE Smart Array P408i-a SR Gen10 Ctrlr	1
HPE Ethernet 10Gb 2P 562FLR-SFP+ Adptr	1
HPE BLc 10G SFP+ SR Transceiver	4
HPE DL360 Gen10 High Perf Fan Kit	1
HPE 800W FS Plat Ht Plg LH Pwr Sply Kit	2
HPE OV for DL 3y 24x7 FIO Phys 1 Svr Lic	1
HPE Legacy FIO Mode Setting	1
HPE 1U Gen10 SFF BB Rail Kit	1
HPE 1U CMA for Easy Install Rail Kit	1

As seen from the above table, the HW requirements for a single server are quite substantial and the deployment would also need at least the ENIQ and ENM servers to have functioning system.

On top of the HW requirements, there would be a need for the data center floor space, a rack to install the server on as well as power and server installation service. The yearly costs for the rental of that deployment would grow to be substantial.

3.2 Network Requirements

The requirements for the networking are defined in terms of the IP addresses needed, Virtual Local Area Network (VLAN) configuration in the switch, speed of the interfaces and the cabling for the server. Figure 6 presents an example of the cabling and the VLANs needed for the NetAnServer on Gen10 rack server.

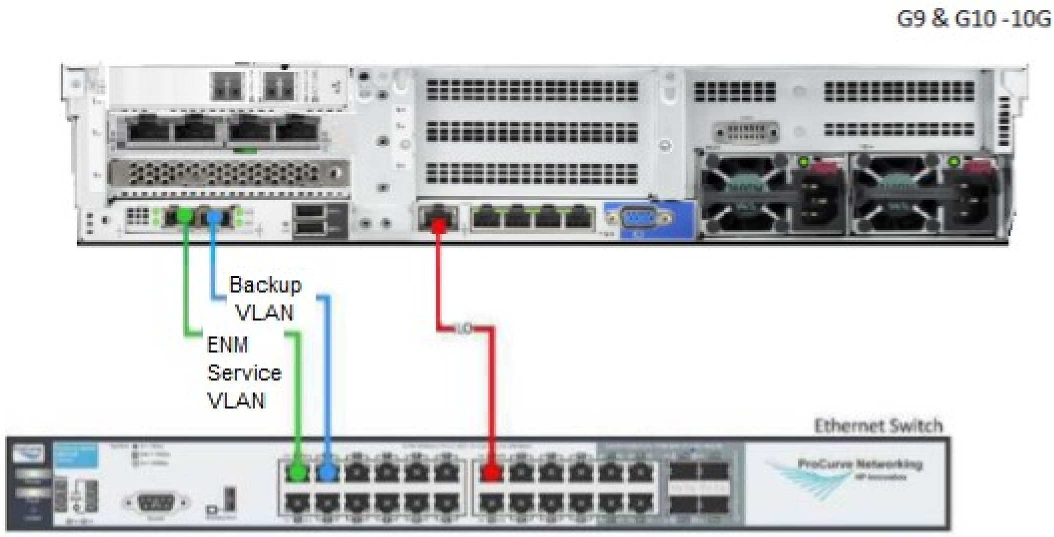

Figure 6. Ethernet cabling on NetAnServer.

The NetAnServer requires network addresses for each 10Gb Network interface card (NIC) connected to the network VLANs. One is needed in the management network for ILO access, used for the management and initial configuration of the server, one for the backup IP for the backups to the Ericsson Operation and Maintenance Backup Solution (OMBS) and one for the ENM Service for user access and the communication towards the ENIQ and ENM servers. [14]

For firewall configuration, at least the below ports should be opened:

- Port 3389 must be opened to allow Remote Desktop Protocol (RDP) access to the Network Analytics Server.
- Port 443 for Clients to access Network Analytics secure port.
- Ports 2640 and 2642 from NetAnServer to ENIQ to access the SQL database.

4 Installation

This chapter goes through the environment used and the installation of the NetAnServer.

4.1 Overview of Environment

The Lab environment in the Ericsson Finland data center was chosen to be the environment to run the project on, as it has been configured to contain the OpenStack Cloud, OMBS, ENM and the ENIQ. In Figure 7 below, the current layout of the rack is presented.

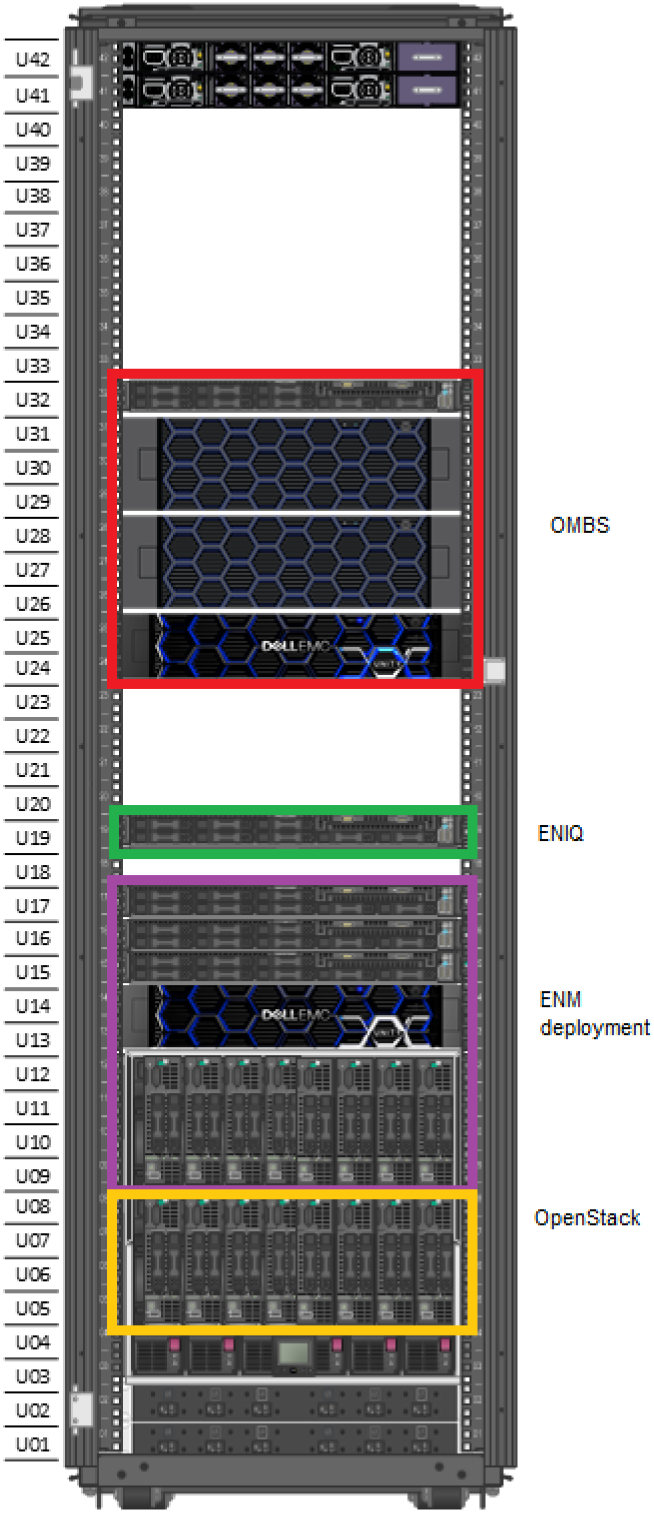

Figure 7. Lab environment rack layout.

The OMBS is the Ericsson backup solution and as such is not used in this project.

ENM deployment is the Ericsson network management solution that provides PM and CM, SW, HW, and Fault Management (FM), as well as security, self-monitoring, and system administration. It is used in the solution to collect the PM and CM topology data from the network elements for ENIQ to process.

The switches are owned by the Ericsson IT and Test Environment (ITTE) and ITTE provides the necessary configurations for connectivity between the different services and to the Ericsson Corporate network (ECN) for remote connectivity.

4.2 Underlying OpenStack Cloud

The hardware reserved for the OpenStack contains 6 HPE ProLiant BL460c Gen8 servers, named venm1 to venm5, each with 256GB of memory and two 16 core Intel Xeon E5-2660 v3 Central Processing Unit (CPU) and 2 HPE ProLiant BL460c Gen10 servers, named venm6 to venm8, each with 256GB of memory and two 16 core Intel Xeon Gold 6130 CPU and equipped with 10Gb NICs and 16Gb FC HBA cards. These servers have been installed with CentOs Linux 7 operating system and the OpenStack release installed is OpenStack Train, the 20th version of the cloud infrastructure software. The Figure 8 presents the available physical resources on the OpenStack. In the Lab environment the CPU overcommit is configured to 3:1, that is why the consumed vCPU resources exceed the physical resources. Overcommitting allows more instances to run on the deployment but reduces the performance of the instances.

ID	Hypervisor Hostname	Hypervisor Type	Host IP	State	vCPUs Used	vCPUs	Memory MB Used	Memory MB
1	venm7	QEMU	131.160.100.17	up	90	64	203264	257453
2	venm8	QEMU	131.160.100.18	up	48	64	111104	257453
3	venm6	QEMU	131.160.100.16	up	90	64	208384	257629
5	venm5	QEMU	131.160.100.15	up	82	40	257536	257835
6	venm4	QEMU	131.160.100.14	up	93	40	251392	257835
7	venm3	QEMU	131.160.100.13	up	91	40	198144	257835
8	venm2	QEMU	131.160.100.12	up	58	40	139776	257835
9	venm1	QEMU	131.160.100.11	up	73	40	161280	257835

Figure 8. OpenStack Server Resources

Of the 8 hosts, venm8 is acting as the controller, storage, and compute node and the remaining 7 serve as compute nodes. For Cinder block storage, 15 disks of

600GB have been allocated from the EMC VNX5200. The VNX is also co-hosting the ENM deployment. Figure 9 below shows the compute service list of the OpenStack, where the distribution of the nodes is seen.

```
[ubuntu@openstack-client ~(keystone_admin)]$ openstack compute service list
+----+----------------+-------+----------+---------+-------+----------------------------+
| ID | Binary         | Host  | Zone     | Status  | State | Updated At                 |
+----+----------------+-------+----------+---------+-------+----------------------------+
|  2 | nova-conductor | venm8 | internal | enabled | up    | 2021-11-09T13:50:49.000000 |
|  4 | nova-scheduler | venm8 | internal | enabled | up    | 2021-11-09T13:50:49.000000 |
| 12 | nova-compute   | venm7 | nova     | enabled | up    | 2021-11-09T13:50:41.000000 |
| 13 | nova-compute   | venm8 | nova     | enabled | up    | 2021-11-09T13:50:40.000000 |
| 14 | nova-compute   | venm6 | nova     | enabled | up    | 2021-11-09T13:50:42.000000 |
| 16 | nova-compute   | venm5 | nova     | enabled | up    | 2021-11-09T13:50:49.000000 |
| 17 | nova-compute   | venm4 | nova     | enabled | up    | 2021-11-09T13:50:43.000000 |
| 18 | nova-compute   | venm3 | nova     | enabled | up    | 2021-11-09T13:50:39.000000 |
| 19 | nova-compute   | venm2 | nova     | enabled | up    | 2021-11-09T13:50:46.000000 |
| 20 | nova-compute   | venm1 | nova     | enabled | up    | 2021-11-09T13:50:44.000000 |
+----+----------------+-------+----------+---------+-------+----------------------------+
```

Figure 9. OpenStack compute service list

Figure 10 shows the OpenStack services circled with black boxes running in the Lab OpenStack Cloud.

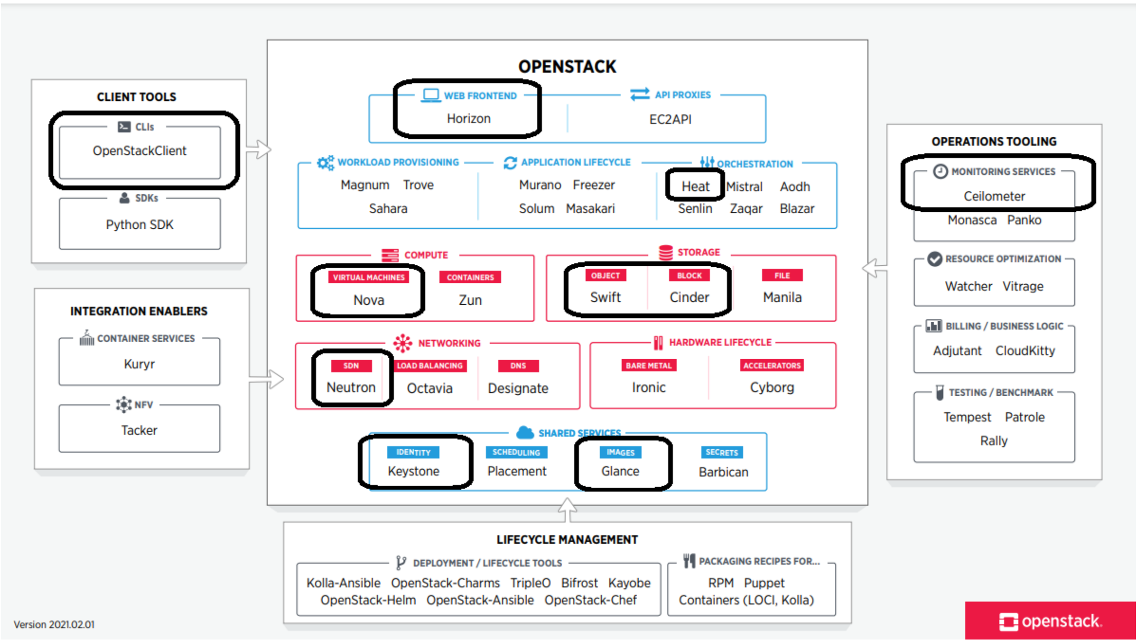

Figure 10. OpenStack Services in the Lab Environment. Modified copy of the OpenStack map. [15]

The OpenStackClient is running on the OpenStack as an instance or VM on top of Ubuntu OS. The VM has been configured with enough resources to store the SW needed for the application and to run the openstackcli software for controlling the cloud. The OS image, ubuntu-20.04.1-desktop-amd64, has been registered in Glance and the flavor, flavor-ubuntu-20.4, defines the virtual CPU (vCPU), memory and storage allocated for the VM. Figure 11 shows the information about the OpenStackClient, with the provider IP address partly hidden.

```
[ubuntu@openstack-client ~(keystone_admin)]$ openstack server show openstack-client
+-------------------------------------+--------------------------------------------------------------------------+
| Field                               | Value                                                                    |
+-------------------------------------+--------------------------------------------------------------------------+
| OS-DCF:diskConfig                   | MANUAL                                                                   |
| OS-EXT-AZ:availability_zone         | nova                                                                     |
| OS-EXT-SRV-ATTR:host                | venm5                                                                    |
| OS-EXT-SRV-ATTR:hypervisor_hostname | venm5                                                                    |
| OS-EXT-SRV-ATTR:instance_name       | instance-00000915                                                        |
| OS-EXT-STS:power_state              | Running                                                                  |
| OS-EXT-STS:task_state               | None                                                                     |
| OS-EXT-STS:vm_state                 | active                                                                   |
| OS-SRV-USG:launched_at              | 2020-11-30T12:30:55.000000                                               |
| OS-SRV-USG:terminated_at            | None                                                                     |
| accessIPv4                          |                                                                          |
| accessIPv6                          |                                                                          |
| addresses                           | provider=[redacted].33                                                   |
| config_drive                        |                                                                          |
| created                             | 2020-11-30T12:29:01Z                                                     |
| flavor                              | flavor-ubuntu-20.4 (5864e260-e52e-400b-8358-b190a652c1f0)                |
| hostId                              | 2eeadc5866f80160bc92b3555d4b23aef5e8542d57a668dfab24f210                 |
| id                                  | de2faa89-2d86-4df2-a2b2-b7b3866ff79e                                     |
| image                               | ubuntu-20.04.1-desktop-amd64 (e6d34a51-527c-4e43-8bec-2e8ee3f7b1ad)      |
| key_name                            | None                                                                     |
| name                                | openstack-client                                                         |
| progress                            | 0                                                                        |
| project_id                          | 49dd652c9a234c6ca531cd1424c07f37                                         |
| properties                          |                                                                          |
| security_groups                     | name='admin_security_group'                                              |
| status                              | ACTIVE                                                                   |
| updated                             | 2020-12-04T07:09:36Z                                                     |
| user_id                             | 47d9d8cd9b164285beaa164176b3c253                                         |
| volumes_attached                    |                                                                          |
+-------------------------------------+--------------------------------------------------------------------------+
[ubuntu@openstack-client ~(keystone_admin)]$
```

Figure 11. OpenStackClient details.

The Lab OpenStack Glance image service, running on the venm8, uses the Swift object storage as the storage back end. The Swift object storage is configured as loopback devices on the venm8. The venm8 also runs Cinder block storage service and the Dell VNX storage array is configured as the block storage backend.

The OpenStack external network has been configured on the provider network and the ENIQ has been configured on the services network, the traffic is routed between the networks. There are no firewall configurations preventing the connectivity. The OpenStack servers are directly connected to the external networks and each host has 2 interfaces bonded using Link Aggregation Control Protocol (LACP) to the provider network and 2 interfaces to the services VLAN. The internal network is configured with Open vSwitch (OVS) on the controller node, venm8.

The venm8 is also running the Keystone identity service, Heat, Ceilometer, and the Dashboard. The compute service, Nova, is running on all the OpenStack nodes.

4.3 NetAnServer Installation

Installing of the Network Analytics Server consists of multiple steps and the installation flow is illustrated in Figure 12. Installation Flow of Network Analytics Server Figure 12

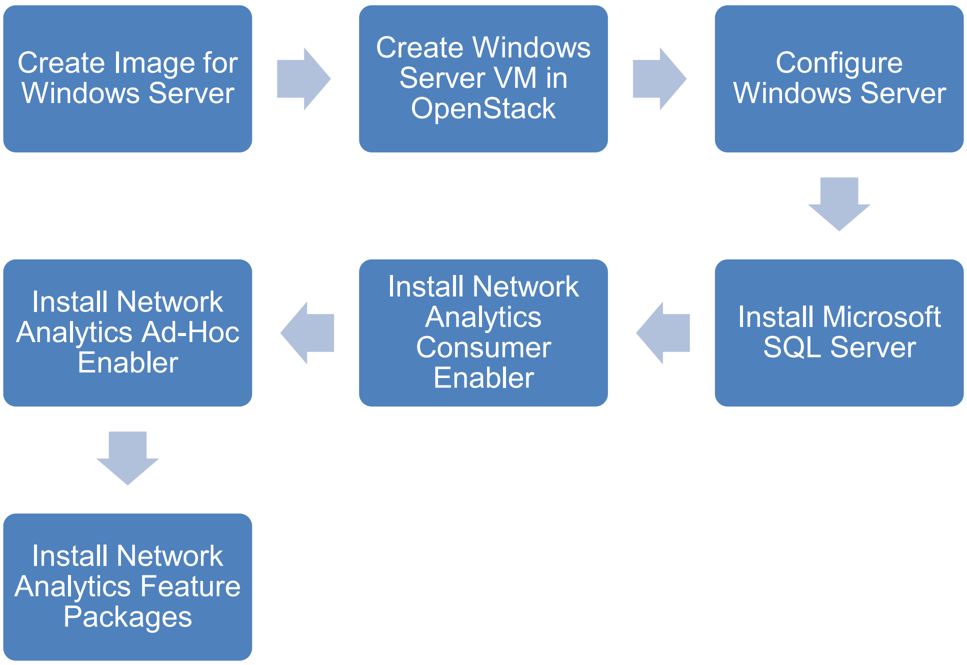

Figure 12. Installation Flow of Network Analytics Server

The installation instruction for Network Analytics server for bare metal has the following requirements for SW installation [6]:

- Windows Server 2016 Standard OS
- Active scripting is enabled
- The Network Analytics Server installation media
- Network Analytics Server license available on the ENIQ license manager
- Remote Desktop capabilities have been enabled
- Microsoft SQL Server 2016
- Signed certificate from the ENM

Parameters required for the installation are listed in the Table 2 below.

Table 2. Required inputs for installation purposes. [6]

Data Value	
MS SQL Server Administrator Password: This is the ‘sa’ password for the installed MS SQL server instance that is installed as a prerequisite to the install of Network Analytics Server.	Mandatory
Network Analytics Server Platform Password: This is a new password for the Network Analytics Server Platform	Mandatory
Network Analytics Server Administrator User Name: This is the username required for the Network Analytics Server Administrator	Mandatory
Network Analytics Server Administrator Password: This is a new password for the Network Analytics Server Administrator	Mandatory

Data Value	
<host-and-domain> Use the Network Analytics Server URL.FQDN for this variable.	Mandatory
ENIQ IP Address	IP address required
Certificate password: This is a new password used for generating certificate	Mandatory

4.3.1 Creating VM image

To create a new image for the Windows Server on an OpenStack cloud, the following steps should be taken. [16]

- Download the installation CD or DVD ISO file for the Windows Server 2016 and the VirtIO drivers.
- Create the empty image.
- Boot up the VM with the Windows ISO using the image created, using a virtualization tool like KVM. Connect to the console of the hypervisor, the console will allow access to the guest OS and enable the use of keyboard and mouse.
- Start the installation from the Graphical User Interface (GUI).
- Load the VirtIO drivers for disk and network.
- Install the cloudbase-init which provides the guest initialization features.
- Upload image to Glance.

The creation of the Windows disk image on Ubuntu VM requires some preparation. The packages needed for the KVM installation depend on the decided installation method, either using the GUI (virt-manager) or executing the installation from the command line options (virt-install). [17] In this thesis, the end product, Method of Procedure will focus on the CLI option.

For the disk image to accommodate the Windows Server software, the size needed was set to 15G. Cloudbase-init is deployed as a service on Windows, it takes care of the guest initialization actions like disk volume expansion, user creation, password generation, user data scripts, Heat templates, PowerShell remoting setup. [18] The steps for the Windows installation and driver loading are explained in detail and using screenshots in the MOP to minimize the human error factor.

Once the KVM installation was done and the machine was shutdown, the image was imported into Glance [22] and ready for the OpenStack VM installation steps in the next phase.

4.3.2 Creating the VM on OpenStack

Once the image is uploaded to Glance, the server hardware definitions were needed. In OpenStack the definitions are done with flavors. Flavor sets the compute, memory, and storage capacity restrictions on the VMs. The requirements for the required software, Microsoft Windows Server 2016 Desktop version, Microsoft SQL Server 2016 with latest Service Pack and TIBCO Software that the Network Analytics software is based on, were examined to come to a baseline of minimum 8 vCPU, 32 GB of RAM and 70 GB disk space. [19;20;21]

The PDU recommendation for the flavor to be created was mentioned in the Deployment Description document and it was decided to set as instructed for the initial installation. [5] The flavor for the VM was configured with 8 vCPUs, 72 GB of RAM and a 100 GB disk size. The resource consumption of the VM could be later examined using standard monitoring tools and then redefine the flavor for the VM. [23]

To be able to connect to the VM, it needed an IP address. Due to the nature of the Lab environment and its usage, Dynamic Host Configuration Protocol (DHCP) was disabled in the provider network, so a port creation with a fixed IP address was needed for the VM. [24]

Next step was, using the flavor, Glance image and the port defined in the previous step, to create the VM where the Network Analytics Server would run. [25]

After the Windows server was running, the configuration of the server was done by connecting to the console URL. The configuration included setting the Administrator password, IP address, hostname, enabling Remote Desktop, extending the C: drive volume to full 100 GB and running the Windows Update packages offline. [26]

4.3.3 Installing Network Analytics Server Software

Once the Windows Server was configured, the Remote Desktop Session could be used for the preparations needed for the NetAnServer software. The Active Scripting was enabled using the Local Group Policy Editor, the Certificate Authority (CA) signed certificate was created on the Lab physical ENM, the certificate and the NetAnServer software were copied to the server and the NFS Module installed as per the Network Analytics Server Installation Instructions. [6]

Before the NetAnServer software could be installed, the Microsoft SQL Server and the latest Service Pack for it needed to be installed. As this was not documented in the installation instructions provided by the PDU, it was done using standard Microsoft Installation Guide and the features selected were trial based. If more features would be needed, those could be installed later using the same media. [27]

The Network analytics software installation required three separate installation flows; first one was the Network Analytics Consumer Enabler package. The ISO media was mounted, decrypted by checking and using the ENIQ license key and then extracted to the local file system on the server. This step was crucial, because if there was no connectivity between the NetAnServer and the ENIQ, or if the license was not installed, the installation could not be started. Once the media was extracted to the local directory, the semi-automated PowerShell installation script could be executed. In this step, the installer was requested to provide the required passwords for administrator users in the Microsoft SQL Server, platform server and the Network Analytics server as well as the certificate password. After the passwords were entered and confirmed, the installation script proceeded to create the required Network Analytics databases in the MS SQL Server, create, and configure the server component and a windows service for the Network Analytics Server installation. Then installed, configured, and started the Node Manager and deployed Web Player and Automation Service services. Finally, the Network Analytics Server library structure was created, Network Analytics Analyst installed, the Network File System (NFS) share configured for the ENIQ Diagnostic Data Collection (DDC) to collect some system and application statistics and the Ericsson Custom branding update was applied after installation of the server was completed and the Analyst installation validation done. After the automated installation was done, some post installation steps were executed to harden the security on the server and to enable logging and monitoring of the Web Player. This ended the first part of the installation flows. [6]

The second package that was installed on the server was the Network Analytics Server Ad-Hoc Enabler Package. The license check was executed towards the ENIQ, installation would not proceed if the Ad-Hoc Enabler license was missing. The package installation included creating Business Author and Business Analyst groups and setting the licenses and installing the Network Analytics Statistical Services. Users created in the Business Author group can create and edit the Analyses in the Analyst tool or the Web Player and users created in the Business Analyst group contains all privileges provided by the Business Author group and can create and edit the Information Packages using the Network Analytics Server Analyst tool. Post installation steps were executed to configure Network Analytics Server to use the Network Analytics Statistical Services and to create a test user for both groups created by the installer and setup the ENIQ as data source for the Network Analytics. [28]

The last installation flow was to install the Network Analytics Features packages. These packages were delivered in zip files and were installed one by one using PowerShell scripts that extracted the files, verified the license from the ENIQ license manager and defined the data sources. During installation, a library path was created with the Information Package and Analysis files to be used in the Network Analytics Analyst or Web Player. The post installation steps included adding a rule for scheduled updates for analyses from ENIQ, clean-up of the Feature Package files and installing the offline maps from Tibco website and finally verifying the Analyses were opening and the maps were visible from the Analyst and Web Player. [29;30]

The MOP grew during the installation to a 124 page document, with details and undocumented additions that were needed in some parts to have the installation proceed and due to its sheer size, it was decided not to include it in the final thesis as appendix.

5 Validation of Installed Server

Once the MOP had been written for the installation of the Network Analytics Server, the validation of the installed system was required to see that the MOP would fill its purpose. For a successful test of the Analysis, data was required from the Network Elements integrated in the Lab ENM and it needed to be processed by the ENIQ so the Network Analytics could read the required data from the database. There was no real user acceptance testing conducted as there was no prepared general acceptance testing document available.

5.1 ENM integration with ENIQ

The Lab environment ENM had been reinstalled some time back for learning purposes and the integration between the ENM and ENIQ had been lost and not recovered after the reinstallation. The data loading from ENM to ENIQ had stopped and thus no data was available for the Network Analytics Analysis to run. The first step was to run the ENIQ activation on ENM to export the mountpoints and allow the ENIQ to mount the data from the ENM. Once the NFS mounts were accessible, steps were executed to store ENM user credentials and import ENM certificates to the ENIQ server. This enabled the File Lookup Service (FLS) to query the ENM server Northbound Interface (NBI) for the PM files and to generate FM Alarms to the ENM Alarm Monitor. The last step was to restart the ENIQ services to update the cache with the executed changes. [31]

Once these steps were executed, the PM data from the ENM integrated nodes, that had PM Initiation and Collection (PMIC) Profiles created in ENM and data collected, was seen in the ENIQ NFS mounted directories. Once the data was visible in the filesystem, the relevant installed TechPacks processed the raw data using the ETL procedures and loaded it in the DWH database for the Network Analytics to read from the data tables. It was decided to let data loading run for some time to allow ENIQ to process the sudden overwhelm of data and to get enough data for the Analysis to work properly.

5.2 Network Analytics Analyst and Web Player Verification

Once the data loading had been running for over 12 hours, the loading and the aggregation of the data could be seen in the ENIQ AdminUI's Extract, Transform, Load and Controller (ETLC) Monitoring, shown in Figure 13.

Executed ETL Sets

Tech Pack Name	Set Name	Set Type	Version	Start Time	End Time	Status	Priority	Running Slot	Scheduling Information	Service Node
DC_E_ERBSG2	Loader_DC_E_ERBSG2_EUTRANCELLFDD	Loader	((120))	2021-11-24 10:16:05.000	2021-11-24 10:21:13.000	FINISHED		132		dwhdb
DC_E_CPP	Loader_DC_E_CPP_IKEPEER	Loader	((280))	2021-11-24 10:20:49.000	2021-11-24 10:21:12.000	FINISHED		127		dwhdb
DC_E_CPP	Loader_DC_E_CPP_IPHOSTLINK	Loader	((280))	2021-11-24 10:20:53.000	2021-11-24 10:21:12.000	FINISHED		126		dwhdb
DC_E_CPP	Loader_DC_E_CPP_DEFAULTROUTER	Loader	((280))	2021-11-24 10:20:49.000	2021-11-24 10:21:02.000	FINISHED		129		dwhdb
DC_E_RAN	Loader_DC_E_RAN_RA	Loader	((285))	2021-11-24 10:20:50.000	2021-11-24 10:21:02.000	FINISHED		131		dwhdb
AlarmInterfaces	Adapter_AlarmInterface_10min	Alarm	((13))	2021-11-24 10:21:00.000	2021-11-24 10:21:02.000	FINISHED		95		dwhdb
INTF_DC_E_IMS-eniq_oss_2	Adapter_INTF_DC_E_IMS_mdc	Adapter	((204))	2021-11-24 10:20:57.000	2021-11-24 10:20:57.000	FINISHED		95		dwhdb
DC_E_CPP	Loader_DC_E_CPP_VT15TTP	Loader	((280))	2021-11-24 10:20:41.000	2021-11-24 10:20:56.000	FINISHED		130		dwhdb
INTF_CV_MTAS_MTAS-eniq_oss_2	Adapter_INTF_CV_MTAS_MTAS_information_store_parser	Adapter	((4))	2021-11-24 10:20:54.000	2021-11-24 10:20:55.000	FINISHED		95		dwhdb
DC_E_ERBS	Loader_DC_E_ERBS_RIPORT_V	Loader	((262))	2021-11-24 10:20:39.000	2021-11-24 10:20:53.000	FINISHED		126		dwhdb
INTF_DC_E_CCPC-eniq_oss_2	Adapter_INTF_DC_E_CCPC_3gpp32435	Adapter	((1))	2021-11-24 10:20:51.000	2021-11-24 10:20:52.000	FINISHED		95		dwhdb
DC_E_ERBSG2	Loader_DC_E_ERBSG2_EUTRANCELLTDD_V	Loader	((120))	2021-11-24 10:18:39.000	2021-11-24 10:20:50.000	FINISHED		131		dwhdb
DC_E_ERBS	Loader_DC_E_ERBS_EUTRANCELLFDD_FLEX	Loader	((262))	2021-11-24 10:19:55.000	2021-11-24 10:20:49.000	FINISHED		129		dwhdb
DC_E_CPP	Loader_DC_E_CPP_PEERIPSECTUNNEL	Loader	((280))	2021-11-24 10:20:35.000	2021-11-24 10:20:49.000	FINISHED		124		dwhdb
DC_E_TCU	Loader_DC_E_TCU_BFDSESSIONIPV6	Loader	((92))	2021-11-24 10:20:37.000	2021-11-24 10:20:49.000	FINISHED		127		dwhdb
INTF_DC_E_CCES-eniq_oss_2	Adapter_INTF_DC_E_CCES_3gpp32435	Adapter	((2))	2021-11-24 10:20:44.000	2021-11-24 10:20:46.000	FINISHED		95		dwhdb
INTF_DC_E_SC-eniq_oss_2	Adapter_INTF_DC_E_SC_3gpp32435	Adapter	((2))	2021-11-24 10:20:42.000	2021-11-24 10:20:42.000	FINISHED		95		dwhdb
DC_E_RAN	Loader_DC_E_RAN_RNCMODULE	Loader	((285))	2021-11-24 10:20:34.000	2021-11-24 10:20:41.000	FINISHED		130		dwhdb
INTF_CV_SBG_IMSGW-eniq_oss_2	Adapter_INTF_CV_SBG_IMSGW_information_store_parser	Adapter	((4))	2021-11-24 10:20:39.000	2021-11-24 10:20:40.000	FINISHED		95		dwhdb
DC_E_RAN	Loader_DC_E_RAN_POSSERVCLASS	Loader	((285))	2021-11-24 10:20:30.000	2021-11-24 10:20:39.000	FINISHED		126		dwhdb

Figure 13. Executed ETL Sets from ENIQ AdminUI.

The next step was to make sure the analyses were able to fetch the data from the data source and present the data in a user-friendly format. The chosen Analysis was the Ericsson NR KPI Dashboard, as the ENM was integrated with the node types it could be verified that all the required TechPacks were installed on the ENIQ. The requirements were found in the Feature Package User Guide - Data Description documents from the Customer Product Information (CPI) library for each of the Feature Packages. [32]

Opening the Network Analytics Analyst using the Tibco Spotfire shortcut created on the Desktop, the Login credentials screen was presented. Screen with the Business Author test user username and password filled in shown in Figure 14.

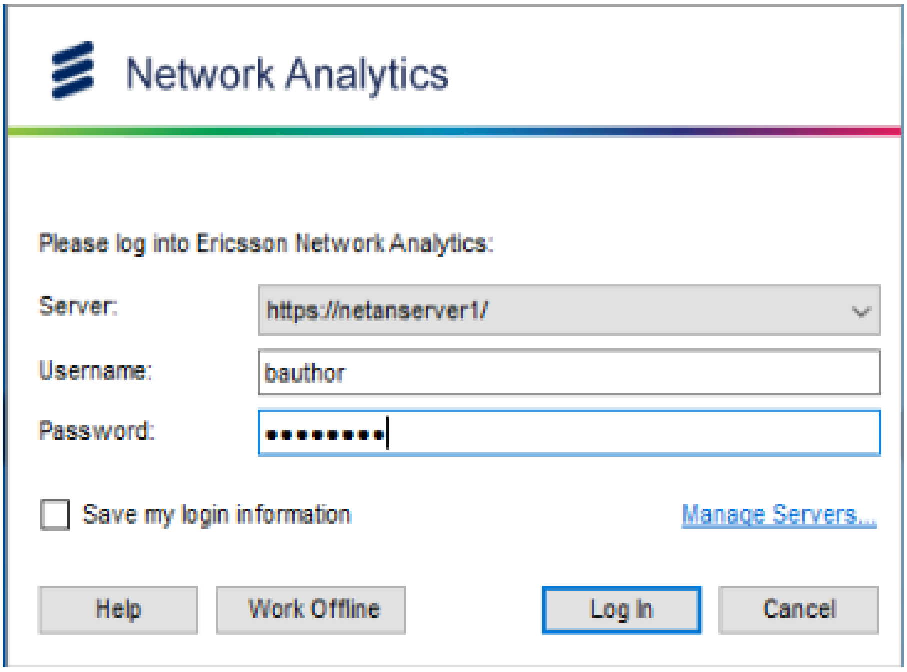

Figure 14. Login screen for the Network Analytics Analyst.

When logged in as user with the Business Author role, the options are limited to Opening File or from Library in the “Add Data” section, as seen in Figure 15.

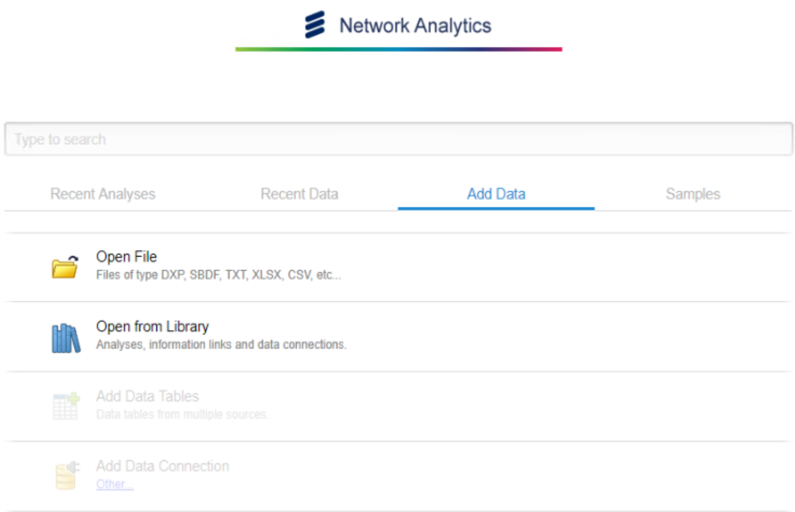

Figure 15. Business Author role options

In the Web Player, both users had the same rights to create and edit the Analyses, as expected.

Once logged in the dashboard for the Network Analytics Analyst was shown with all the options available in the "Add Data" section as seen in Figure 16, including the options to add data tables and add data connections, as the Business Analyst group members should.

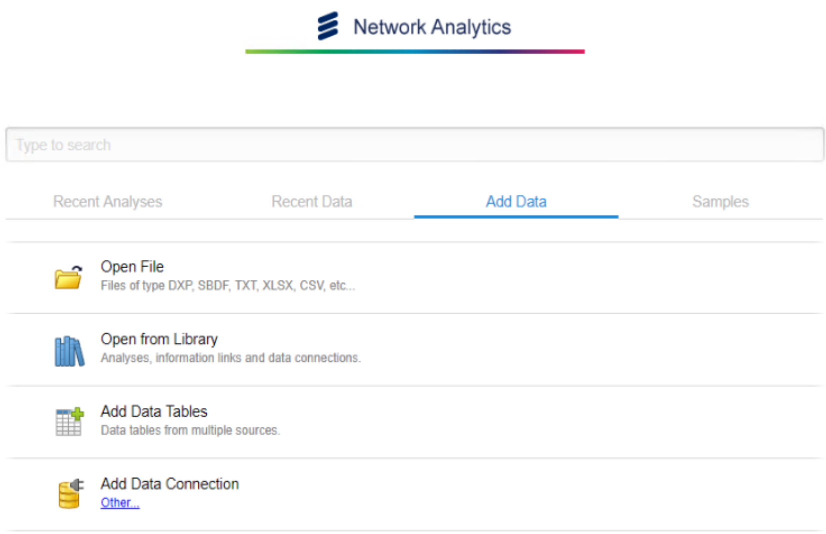

Figure 16. Business Analyst group options.

As the Business Analyst user, clicking the "Open from Library" option, and following the library tree, the Ericsson Energy Report Analysis was selected as it was presented with real nodes and not just simulated nodes. Once opened, it was seen how the external data source ENIQ was contacted and the predefined data in the analysis fetched from the DWH database and once the procedure had finished, the main window for the analysis was opened. From there the Ranked Nodes option was chosen to see the top nodes for energy consumption and information on data volumes as pictured in Figure 17 for the chosen Radio nodes.

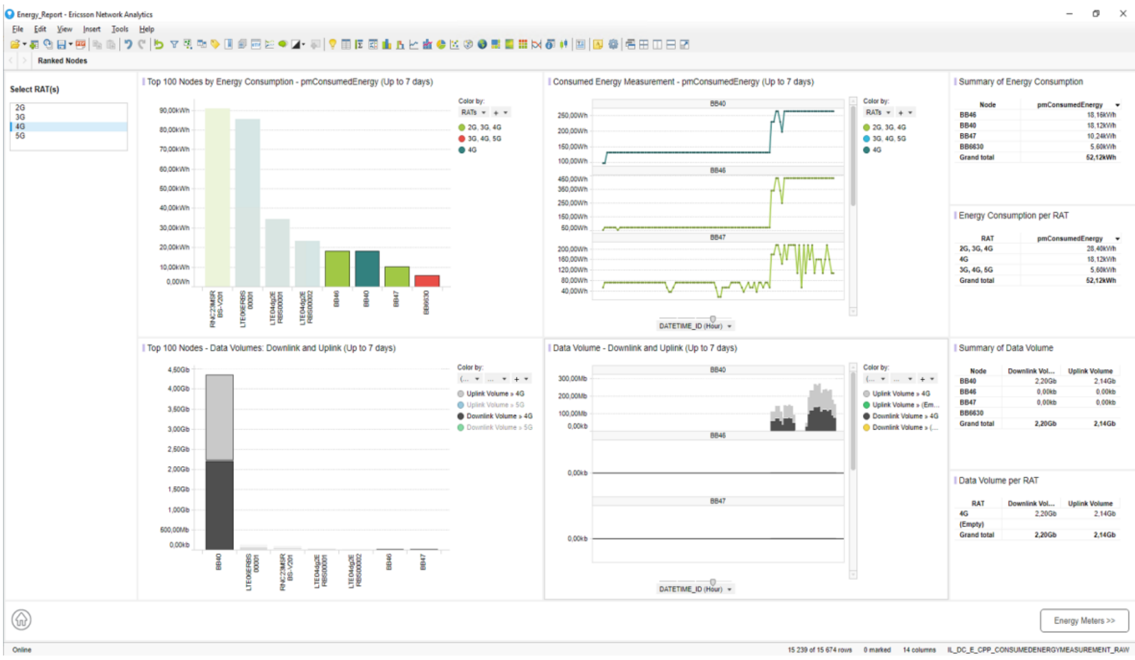

Figure 17. Energy Report Analysis for Ranked Nodes.

5.3 External Connections to Network Analytics Server

Once the Network Analytics Analyst tool was verified, the external connectivity from outside the Windows server needed to be verified. For this the Web Player was used. The Network Analytics Web Player is a web browser-based application, accessible with the URL https://<server hostname>/ and requires a valid username and password. The testing of this feature was done connected to the Ericsson Virtual Private Network (VPN) while working from home. The Windows firewall on the NetAnServer needed a rule to allow the access to port 443 and for additional security, only the Ericsson provided host IP of the laptop was allowed. The connection was established through the VPN and login was successful as the Business Analyst user. The Dashboard for the Web Player can be seen in Figure 18. It was also tested that when changing the allowed host IP to a dummy one, the connection failed. This could be used in setting access restrictions in future usage of the server.

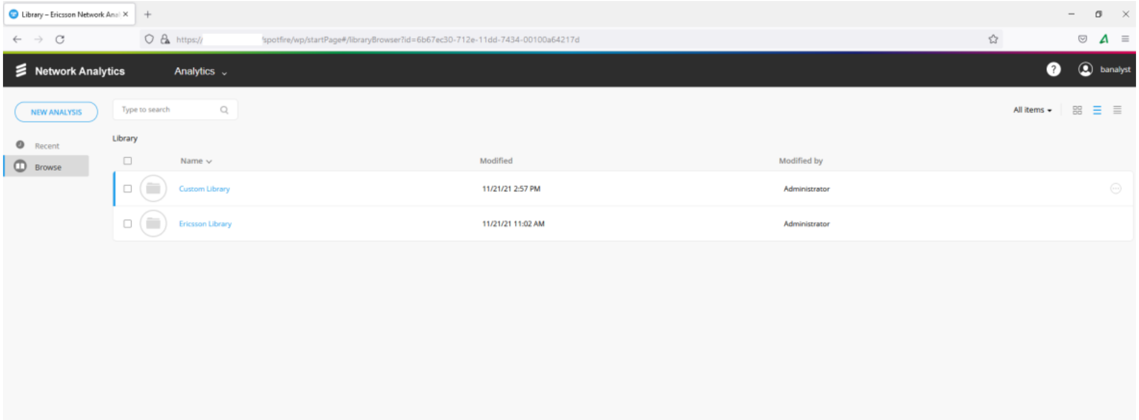

Figure 18. Network Analytics Web Player accessed from VPN.

5.4 Performance monitoring

The Network Analytics Server was configured for real-time monitoring during the installation and the report was available for Administrator user using the Network Analytics Analyst under Monitoring. The monitoring Overview page included checks for Memory Usage and CPU Load From Performance counters and gave a quick overview of the resource usage. As seen in Figure 19, the preliminary results before any heavy usage of the server seemed to be rather low compared to the configured resources. This monitoring would be followed up on once the user access and load was heavier to see if there were any bottlenecks.

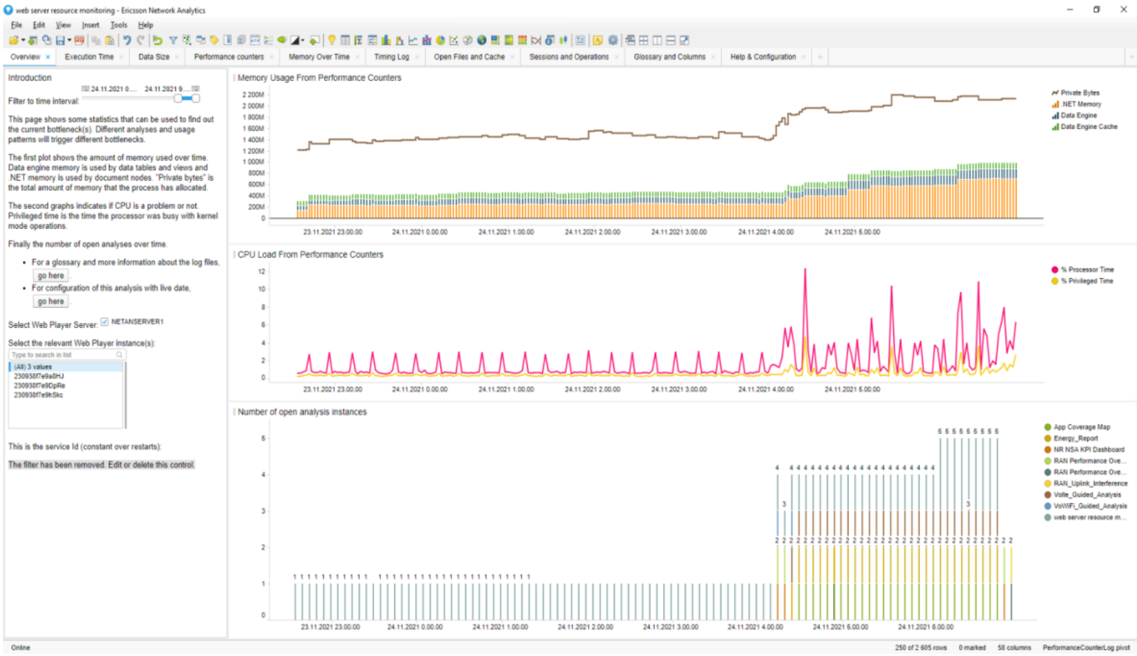

Figure 19. Web Server Resource Monitoring.

Apart from the Network Analytics monitoring, the Windows Performance Monitoring was configured use Data Collector set every hour to collect and check the underlying systems resources. [33] The hourly monitoring results were compared from two days and there were no issues seen in the resource usage apart from random spikes in disk and network activity. In Figure 20 two 1 hour measurements from different days are shown.

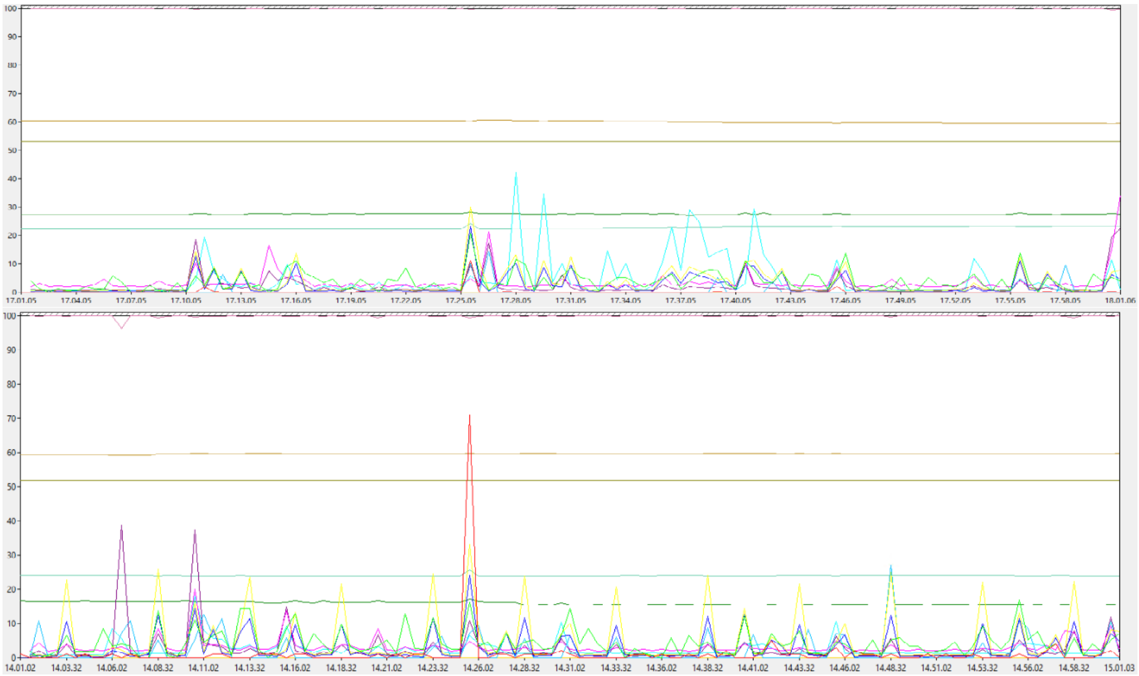

Figure 20. Comparison of two busy hour performance monitoring reports

5.5 External Testing

Once the system had been configured to be used by other users, Service Delivery Unit engineer with Network Analytics and ENIQ background took over the server to prepare for internal demo. An informal screen sharing session was conducted where the main capabilities of the product were discussed and exhibited to the author of the thesis. The engineer verified the server was working as expected, there were no issues with the application or running the connections remotely from another country. While the different Analyses were demoed, some were missing node information, but this was due the node types missing from the ENM or PM data not loaded and not because of the Network Analytics server.

6 Discussions and Conclusions

With regards to learning about OpenStack and getting familiar with the different components and services that make up the cloud as the secondary goal, it can be said to fulfilled. While OpenStack related actions were not a major part of the procedure, it was a good starting point for digging deeper into the cloud infrastructure. Reading the literature and having hands on experience in the Lab environment, gave a better understanding of the OpenStack environment and some confidence operating on it. The installation had not been done before by the author, so it required some trial and error when defining the disk images and installing the server on the OpenStack cloud. While the documentation was readily available, most of the knowledge was transferred by colleagues with more experience in running cloud operations and the documentation complemented the knowledge shared. OpenStack has been the dominant cloud platform for many years, but it feels like now the trend is heading towards Kubernetes and will most likely be taken as the next step towards virtualization of the Lab environment.

As the environment had not been maintained properly and with the introduction of new node types in ENM, the ENIQ server configuration needed more attention than was initially expected. Using the Network Analytics Server without prior experience was challenging, the different requirements from each Analysis had to checked and based on that actions were taken to have the data available. As there was a lack of competence in the ENIQ domain, the author had to rely on colleagues to help on the TechPack installations and configuration.

Network Analytics Server installation was done following the PDU provided instructions and during the execution of the installation procedure, it became apparent how flawed the installation instructions were in whole. There were multiple steps where the installer could make a mistake, miss a step, or just misunderstand what needs to be done. Multiple documents needed to be followed and in some cases the information was obsolete and had been updated in a later version of the product, leaving the original document flawed but still referenced in the release notes. The MOP was initially targeted for installing the Network Analytics in the OpenStack environment, but after running through the procedure it could be divided in to two, one for the installing the server on OpenStack and the other for Network Analytics Server installation and configuration.

While running the validation of the Network Analytics server, it worked to an expected degree and validated the MOP. The author ran just basic functionality testing and confirmed the applications were working and the users were able to login according to their roles and an external validation using an engineer in Service Delivery Unit over screen sharing session, proved that the server could be used for demo purposes.

The Performance monitoring did not reveal anything that caused the system to misbehave, nor did it show any bottlenecks in the allocated resources. The given vCPU and memory allocations will need to be revised after the system has been tested for some time and possibly finetuned for freeing up resources for other projects.

The Network Analytics Server itself, running in OpenStack cloud and once installed and configured, can be used for multiple purposes. The first requests to use the server for an internal demo came before the installation had finished. The platform could be used for similar purposes by the Learning Services, giving customer demos in presales phase or used for training the engineers on upgrade procedures. The base VM image for Windows Server can be used by the Service Delivery Units for training purposes to run the Network Analytics Server installation using the MOP.

In conclusion, as someone who is not that familiar with the product, running the procedure gave an insight to the struggles that the installer might have before they have had repetition on the installation procedure. The MOP will answer some, if not all, of the questions that the installation engineer might have on the procedure and it will be peer tested and updated when needed, as the MOP was shared in the Ericsson internal Navigator 365 Asset Management Platform for re-use purposes. Plans were made to update it for the latest version of the Network Analytics once the Lab environment ENIQ server has been uplifted. Consideration for automating the creation and configuration the Windows Server and possibly containerizing the images were discussed in internal reviews of the MOP.

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