Illumio Core®

Compatible PCE Versions: 21.5.x – 24.1.x

NEN

Version: 2.6.10

NEN Installation and Usage Guide

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22000-100- 2.6.10

Legal Notices

Product Versions

NEN Version: 2.6.10

Compatible PCE Versions: 21.5.x – 24.1.x

Standard versus LTS Releases

For information on Illumio software support for Standard and LTS releases, see Versions and Releases on the Illumio Support portal.

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Contents

Chapter 1

Introducing the Illumio Network Enforcement Node

This chapter contains the following topics:

This section provides an overview of how the NEN integrates with network devices and presents the new features across several releases.

IMPORTANT:
This Documentation Portal for Illumio Core 21.5.x – 24.1.x contains the documentation for NEN 2.6.x; however, Illumio Core 21.5.x – 24.1.x also supports NEN 2.5.2, NEN 2.4.10, and NEN 2.3.10.

- To review the documentation for NEN 2.5.2 (even if you are running Illumio Core21.5.x – 24.1.x), go to the 22.25 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.4.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 22.2 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.3.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 21.5 Documentation Portal: HTML | PDF

Overview of the NEN

This section describes the situations where installing an agent (the Illumio VEN) on a device is not possible and how to workaround it by using the NEN.

When Installing a VEN Isn't Possible

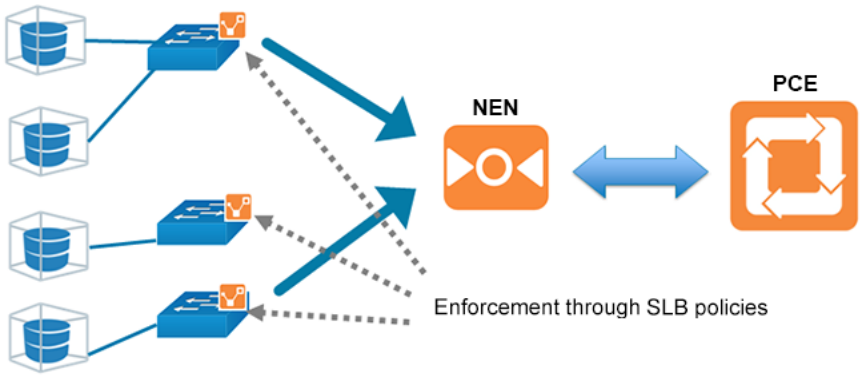
Visibility of communication across applications is critical for segmentation. The optimal method of getting visibility is to use a lightweight agent or a VEN, to report all inbound and outbound communications for each workload.

However, in certain cases a VEN cannot be installed on special purpose systems that provide services to application workloads; for example, IBM Mainframes, NetAPP Filers, legacy Windows machines, or appliances. In other cases, the VEN could be installed on a workload but customers choose not to; for example, installing a VEN might void the vendor's support agreement or the workload is sensitive to latency because it is a high transaction server.

How the NEN Integrates with Network Devices

In cases where a VEN cannot be installed, the NEN extends visualization capabilities to agentless workloads via the network. The NEN is installed as part of an Illumio Core deployment and paired with a PCE. Every IP address associated with the network endpoints managed by the NEN has one workload or virtual server associated with it. The NEN can manage multiple endpoints and enforce policy for those endpoints.

This guide describes how to integrate the NEN with supported load balancers (SLBs).



Using the NEN, Illumio Core enforces policy on the nearest point to the workload, either:

- A virtual Server on a load balancer in front of the workload
- A switch port on a router in front of the workload

The NEN receives generic policy from PCE and generates policy appropriate to the managed network devices:

- **SLBs:** Firewall policy; for example, the F5 load balancer has two variants of applying policy: AFM and LTM
- **Switches**: ACLs

Until a NEN is paired to the PCE, the switch and load balancer features are deactivated. Using the PCE web console, Illumio users associate unmanaged workloads to the network device endpoints. The NEN syncs its configuration with the PCE every 1 minute. For switch devices, the NEN can be configured to receive traffic flow information from the managed network devices and provide Illumination data to the PCE.

Currently, the NEN does not configure network devices automatically. Network device management has to be done by the user. This process includes applying generated policy by using the Illumio REST API. For information about applying policy to switches, see Apply Policy for Switches and NEN Switch Configuration Using REST API. For information about applying policy for SLBs, see Write SLB Policy.

What's New in the Releases

This section describes new features introduced in the following NEN releases.

NEN 2.6.10 New Features

Support for Verifying NEN RPM Signature

Beginning with NEN release 2.6.10, you can verify the signature of the NEN RPM package before installation. This allows you to ensure that the package

hasn't been modified since it was signed. For details, see Verify the NEN RPM digital signature.

Support for NEN Proxy Communication

Beginning with NEN release 2.6.10, there is now `runtime_env` support for defining an HTTP/HTTPS proxy for communication between the NEN and the PCE or between the NEN and managed devices (such as Server Load Balancers (SLBs)). You can also specify a list of IP address that are not allowed to communicate via a proxy server. For details, see Configure Proxy Support for NENs.

Ruby updated to version 3.1.2

Ruby was upgraded from version 2.7.1 to 3.1.2.

NEN 2.6.1 New Features

Support for all Citrix ADC (Netscaler) Load Balancer-supported protocols

With this release, the NEN now supports all the protocols that Citrix (NetScaler) 13.1 lists in the **Load Balancing > Virtual Servers > Add > Protocol** menu.

NEN 2.6.0 New Features

Support for Citrix ADC (Netscaler) Load Balancer

With this release, the NEN now supports Citrix ADC (Netscaler) Load Balancers and their associated virtual servers that have only a single IPv4 address.

To add a Citrix Software Load Balancer, see the section *Configure Load Balancers* in the topic Load Balancers and Virtual Servers for the NEN

Support for allowing customers to specify whether disabled VIPs are reported to the PCE

Prior to the release of NEN 2.6.0, if VIP filtering was disabled, all VIPS – including disabled VIPs – were reported to the PCE. You can now disable this reporting using the following new option in the `illumio-nen-ctl slb-enable` command:

```
--disabled-virtual-server-reporting enabled|disabled
```

To ensure backwards compatibility, the default value is `enabled`.

PCE-provided rule IP addresses and ports now combined into CIDR blocks

NENs now combine rule IP addresses and ports provided by the PCE into CIDR blocks and port ranges. This reduces the number of ACLs that NENs need to generate for switches.

Benefits include:

- Fewer ACLs that the NEN generates for switches.
- Fewer ACLs generated for the IBM iSeries integration with Precisely (current limit: 10k ACLs) allows for optimization of IP addresses into ranges larger than can be covered by a single CIDR block.
- Lower demand on switch TCAM where ACLs are stored.

Support for Rocky Linux 8.7

This release includes support for running standalone NENs on Rocky Linux 8.7.

Support for configuring a PCE policy request timeout

Beginning with NEN 2.5.2.A1, you can configure a PCE policy request timeout. This may be needed If your NEN SLB implementation will involve large policy calculations. The timeout ensures that the NEN doesn't wait too long for the PCE to respond to policy requests in scenarios involving large policy calculations.

To configure the timeout, use the following runtime environment variable:

```
pce_policy_request_timeout_minutes
```

- Default value: 10 minutes
- Minimum value: 3 minutes

NEN 2.5.2 New Feature

Support for AVI NSX Advanced Load Balancer version 21.1.4 2p9

With this release, the NEN now supports AVI NSX Advanced Load Balancer version **21.1.4 2p9**.

NEN 2.5.0 New Feature

IMPORTANT:
NEN 2.5.0 is compatible with PCE releases prior to Core 22.3.0-PCE; however, to use the new features available with NEN 2.5.0, you must be using a version of Core 22.3.0-PCE (Illumio Cloud customers only) or later. NEN 2.5.0 is not available for Illumio On-Premises Core customers who are running the PCE in their own data centers.

Enforcement Boundary Support

NEN 2.5.0 now supports the Selective Enforcement policy mode of Enforcement Boundaries by generating deny rule ACLs for the Enforcement Boundary IP addresses. Enforcement Boundaries are a security policy model available in the Core PCE for broadly managing communication across a set of workloads, ports, and/or IP addresses. They allow you to define the end state and then the PCE implements an Enforcement Boundary to create the appropriate native firewall rules. For more information about Enforcement Boundaries, see Enforcement Boundaries in the Illumio Security Policy Guide.

NEN 2.4.10 New Features

Support for discovering pool groups on AVI SLBs

Beginning with this release, NENs can discover – on AVI Server Load Balancers (SLBs) – virtual servers configured with pool groups instead of server pools. Prior to this release, NENs could discover only virtual servers with server pools and ignored pool groups.

Configurable polling interval for discovering new virtual servers

Beginning in release NEN 2.4.10, you can configure how frequently the NEN polls Server Load Balancers (SLBs) to discover new virtual servers (VS). You do this by adding a field to the runtime_env.yml file. In previous releases the timeout value was fixed at 5 minutes, which was too long for some use cases. SLB discovery events are customer-configurable as follows:

- **Default** = 5 minutes. You don't have to modify the runtime environment file if you want to keep the default setting.
- **Minimum** = 2 minutes
- **Maximum** = none

The NEN reads the timeout value at startup and polls SLBs accordingly. If you add this field and/or update the timeout value in the field, you must restart the NEN for the change to take effect.

Procedure

You can modify the runtime environment file on an already-running NEN or when installing a NEN. For details, see Install a New Standalone NEN.

1. Locate the NEN runtime environment file in the following directory:

```
/etc/illumio-nen/runtime_env.yml
```

2. If it's not already present, add the line slb_discovery_timeout_minutes to the file.
3. Add a space, a colon (:), and value of 2 or higher at the end of the line. For example, to configure the SLB discovery timeout to **3 minutes**, you'd enter:

```
slb_discovery_timeout_minutes: 3
```

4. Restart the NEN for the new setting to take effect.

If you've updated the timeout value on an already-running NEN, you're done at this point. If you've configured the timeout value as part of a new NEN installation, continue to NEXT STEPSbelow.

NEXT STEPS

1. Activate the NEN with a pairing key from the PCE. See Obtain Pairing Key and Activate the NEN.
2. To enable the NEN to integrate with a load balancer, see Enable load balancer support.
3. (Optional) To configure the NEN as an HA pair, perform the steps in Configure HA Support for the NEN.

NEN 2.4.0 New Features

Support for moving SLBs to a different NEN host (single and super cluster)

NOTE:
Requires Core PCE version 22.2.0 or later.

You can move a Server Load Balancer to a different NEN host from the PCE Web Console. This capability preserves – on the moved SLB – all policies already assigned to the managed virtual server.

1. From the PCE Web Console, go to **Infrastructure > Server Load Balancers**.
2. In the **Name** column, click the link for the SLB you want to move.
3. On the **Summary** tab for the selected SLB, click **Edit**.
4. In **NEN hostname**, click the drop down list to select the destination NEN host where you want to move the SLB.
5. Click **Save**. The PCE recognizes that the SLB has been moved to the chosen NEN host.

Support for moving a NEN from one PCE to another PCE

You can move a NEN from one PCE to another PCE in the same supercluster. When a NEN is moved in this way, associated Server Load Balancers maintain policy for managed virtual servers. After the PCE database is restored, the moved NEN remains connected to the new PCE. The command for moving a NEN is:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl pce-host-update <pce-host-addr>:<port>
```

Support for using LTPs instead of iRules on the F5 BIG-LTM

You can use Local Traffic Policies (LTP) on the F5 BIG-IP-LTM. This support is provided in addition to existing support for using iRules.

IMPORTANT:
If you use this functionality, only use LTP rules. Don't use both LTP and iRules together.

1. From the PCE Web Console, go to **Infrastructure > Server Load Balancers**.
2. Select a NEN host. The **Device Type** field appears.
3. In Device Type, select **F5 Big-IP LTM (LTP)**.

Support for maintaining PCE-managed virtual servers when associated SLB virtual servers are disabled

NOTE:
This applies to IPv4 only. IPv6 is not currently supported.

Beginning with this release, the PCE continues to maintain and display PCE-managed virtual servers even when their associated Server Load Balancer (SLB) virtual servers are disabled. This ensures that the PCE doesn't drop or invalidate policy rules for a managed virtual server if the associated SLB virtual server is temporarily disabled. It also ensures virtual servers that were temporarily disabled receive policy updates when they come back online. Previously, when an SLB virtual server was disabled, the associated PCE-managed virtual server showed up as "deletion pending" even after the SLB virtual server was re-enabled.

Support for Red Hat Enterprise Linux (RHEL) 8

This release includes support for running standalone NENs on RHEL 8.

Support for IBM iSeries

Beginning with this release, it's now possible to generate IBM iSeries firewall policies for the Precisely integration using the PCE's capability to generate switch ACLs. For details, see Generate and Download ACLs.

Support for Enabling/Disabling Debug Mode Logging

You can now turn debug mode logging on or off. When enabled, debug mode logging provides detail for the network_enforcement_service. The following command allows you to show the current debug mode node status or turn debug logging mode on or off dynamically:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl debug-mode status/on/off
[--all-nodes]
```

Faster Checks for Policy Tampering for Managed F5 Virtual Servers

Beginning with this release, the NEN sends fewer API calls to the F5 Advanced Firewall Manager SLB to check for policy tampering on Virtual Servers, resulting in faster checking for policy tampering.

Faster Policy Programming for Managed F5 Virtual Servers

Beginning with this release, the NEN sends fewer API calls to the F5 AFM SLB to program policy for managed F5 Virtual Servers, resulting in faster policy programming.

NEN 2.3.10 New Features

NEN discovery of Virtual Servers with Protocol/Ports ANY/ANY

NENs can now discover Virtual Servers (VS) with protocol type ANY and ports ANY. This functionality was added to support configuring Layer 3 Forwarding VIP where the VIP acts as a gateway for servers. In order for outbound traffic from servers to work, these VIPs must be configured to handle protocol type ANY. Prior to this update, VS discovery was limited to SNAT-enabled VSs, VSs that are members of a server pool, or VSs operating on protocol TCP/UDP. To enable discovery of Virtual Servers (VS) with protocol type ANY and ports ANY, disable virtual server filtering with this command:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl slb-enable --virtual-server-filtering disabled
```

Support for IBM iSeries Integration (AS/400)

In this release, the NEN supports PCE integration with IBM iSeries (AS/400) computers running Precisely Assure Security. Although the IBM iSeries is not a switch, you will use the PCE switch integration user interface to perform the integration. For more information, see IBM i Series Integration (AS/400).

Support for Enabling/Disabling Debug Mode Logging

You can now turn debug mode logging on or off. When enabled, debug mode logging provides detail for the network_enforcement_service. The following command allows you to show the current debug mode node status or turn debug logging mode on or off dynamically:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl debug-mode status/on/off
[--all-nodes]
```

Full support for NEN on Supercluster

NEN 2.3.10 supports environments with large numbers of widely distributed SLBs and Virtual Servers. Whereas NEN 2.1.0 supported installing the NEN only on the 2 database nodes of the Supercluster leader (but not on a standalone system or on non-Supercluster leader nodes), NEN 2.3.10 allows deployment of multiple NENs per Supercluster region. Policy is written centrally, similar to VEN deployments.

Scale

- 200 SLBs across all regions
- 32k VIPs, 32k Virtual Servers across all regions
- 6k VIPs, 6k Virtual Servers per NEN cluster, for 2 HA pairs per Super-cluster region

Restrictions

- Support only for the standalone NEN (not installed on PCE data nodes).
- No support for moving NENs from one region to another.
- No support for moving SLBs from one NEN to another.

NEN 2.3.0 New Features

IMPORTANT:
NEN 2.3.0 was a Limited Availability (LA) release. However, these features are also available in NEN 2.3.10.

The NEN 2.3.0 release includes the following features and enhancements.

Reduced Load on F5 Authentication

To reduce the load on the F5 login authentication mechanism, beginning with this release NENs now use F5 token authentication for F5 API calls. Prior to this change, the NEN used basic authentication, which requires the F5 to use the login authentication mechanism to validate every API call. In contrast, token authentication creates a 20 minute window during which the NEN can reuse the token repeatedly for API calls until the token expires. When the token expires, the NEN requests a new token.

Faster Checks for Policy Tampering for Managed F5 Virtual Servers

Beginning with this release, the NEN sends fewer API calls to the F5 Advanced Firewall Manager SLB to check for policy tampering on Virtual Servers, resulting in faster checking for policy tampering.

Faster Policy Programming for Managed F5 Virtual Servers

Beginning with this release, the NEN sends fewer API calls to the F5 AFM SLB to program policy for managed F5 Virtual Servers, resulting in faster policy programming.

NEN 2.2.0 New Features

> IMPORTANT:
> NEN 2.2.0 was a Limited Availability (LA) release. However, these features are also available in NEN 2.3.10.

The NEN 2.2.0 release includes the following features and enhancements.

Standalone NEN configuration with HA support

The NEN 2.2.0 standalone NEN configuration provides a High Availability (HA) architecture with separate standalone Primary and Secondary nodes sharing the work queue. Either node, if it has capacity, can tackle work in the queue. Both nodes can program any SLB as long as the NEN is up and communicating with the SLB.

Unique duties of each role include:

- **Primary node:** Communicates with the PCE; receives configuration information from the PCE and reconciles it with information in its database; determines the work that is placed in the shared work queue.
- **Secondary node:** If the Primary node can't communicate with the PCE for whatever reason, the Secondary node temporarily assumes the role of Primary until communication between the PCE and the original Primary node is re-established.

NEN critical events automatically reported to the PCE console

The NEN automatically reports status about the following events through the PCE console (**Troubleshooting > Events**).

- High CPU usage
- High memory usage
- Critical disk space utilization
- The PCE logs an event if it hasn't received a heartbeat from the NEN in the preceding 15 minutes

NEN health status reporting available through NEN CLI

You can generate a NEN health status report through a CLI. A NEN health report displays onscreen only.

illumio-nen-ctl health

NEN support report available through the NEN CLI

To help Illumio Support troubleshoot your implementation, you can generate a NEN support report. A NEN support report is a unique file that includes a health report as well as NEN logs.

illumio-nen-ctl support-report

NEN host selector available when adding an SLB

When adding or editing an SLB from the PCE console (**Infrastructure > Load Balancers**) the new NEN hostname option allows you to select which NEN you want to manage policy programming for this particular SLB.

Support for UDP virtual servers

NEN 2.2.0 supports managing policy programming on Virtual Servers that utilize the UDP transport protocol.

NEN 2.1.0 New Features

The NEN 2.1.0 release includes the following features and enhancements.

Policy on Both Members of SLB cluster

The policy can be applied to both the configured members of an SLB cluster:

- You can create and update rules on both members of an AFM/LTM cluster, with up to two load balancers.
- Both members must be in sync before informing the PCE that the policy has been applied.
- If only one SLB is available, the operation will fail. You can retry to apply the policy only after both are in sync.
- If one member fails to program the rules, you should not retry.

Remove Filtering of F5 VIPs

You can view all types of Virtual Services configured on F5 load balancers, by running a specific command during the NEN installation. To disable (enabled, by default) the built-in filter running on the NEN on the leader PCE cluster, run the following command:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl slb-enable --virtual-server-filtering disabled
```

Manage NEN on Supercluster Leader

For Supercluster deployment, you can install the NEN only on the 2 database nodes of the Supercluster leader. You cannot install on a standalone system or on non-Supercluster leader nodes.

Scale

The NEN 2.1.0 release supports up to 500 VIPs and up to 15 SLBs.

NEN 2.0.0 New Feature

The NEN 2.0.0 release includes support for AVI Vantage load balancers.

Chapter 2

NEN Installation and Configuration

This chapter contains the following topics:

This section provides an overview of supported NEN architectures, and how to install the NEN RPM package standalone hosts. This section also provides the procedure to upgrade the NEN (either deployed as a service on the PCE or as a standalone installation) to the latest version.

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- To review the documentation for NEN 2.3.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 21.5 Documentation Portal: HTML | PDF

About NEN Installation and Architecture

This topic explains how the NEN is installed and the supported architectures.

PCE-based versus Standalone NEN Installation

IMPORTANT:
Beginning in NEN 2.3, the NEN is deployed as a standalone NEN installation only. New PCE-based installations are not supported.

In NEN 2.1.*x*, two types of NEN installations were supported:

- **PCE-based installation**

  You installed the NEN on one of the PCE data nodes so that the NEN ran as a service on the PCE. When you installed the NEN as a service on a PCE data node, you had the option of installing it on both data nodes (data node 0 and data node 1) so that the NEN operated as a high availability (HA) pair.

- **Standalone NEN installation**

  You installed the NEN on a separate Linux host. When you installed a standalone NEN in NEN 2.1.*x*, you did not have the option to configure the NEN deployment as an HA pair.

Beginning in NEN 2.3, you must install the NEN on a separate Linux host (standalone installation). NEN 2.3 does not support installing the NEN on a PCE data node. The new standalone installation has the following benefits:

- Provides full (optional) HA support for Illumio On-Premises customers and Illumio Cloud customers.
- Allows you to deploy NENs closer to your network devices, namely load balancers.
- Supports higher scale with multiple NEN HA pairs paired to a single PCE cluster.

IMPORTANT:
Because NEN releases from 2.3 and later don't support a PCE-based installation, customers with existing installations (NEN 1.0.1 through NEN 2.1.0) must upgrade to NEN 2.3 or later. For information, see Upgrade Standalone NEN 2.1.0 to Standalone NEN 2.3.x or later.

NEN High Availability Support

Prior to NEN 2.1.0, when NENs had to be installed on a PCE data node, High Availability (HA) on NENs was achieved by using the PCE's HA capabilities. Beginning with the move to a standalone NEN installation in NEN 2.2.0, the NEN now features full HA support independently of the PCE.

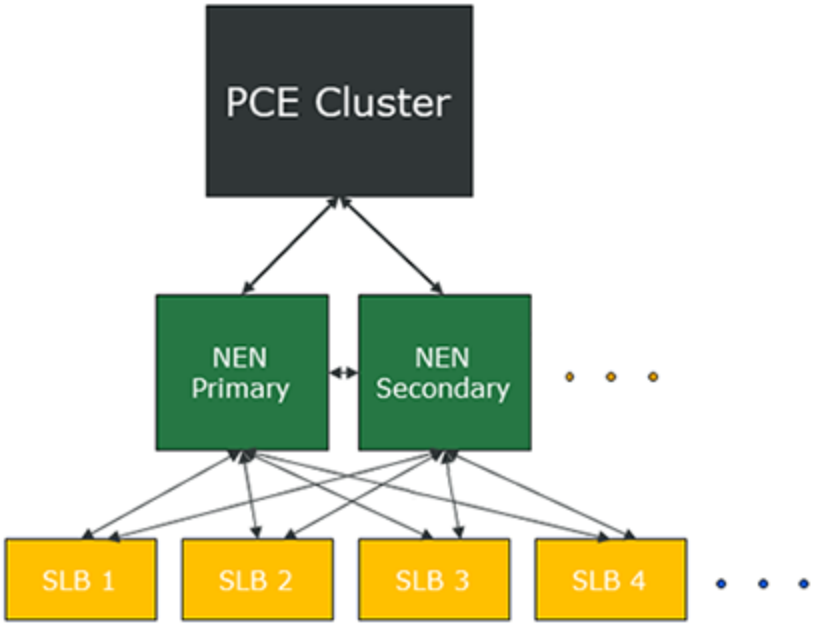
The following diagram illustrates how to plan your NEN installation to provide full HA support by installing it on two Linux hosts (node 1 and node 2). In an HA configuration, the primary NEN performs the following actions:

- Retrieves configuration information from the PCE and reconciles it with the PCE database.
- Determines what work needs to go into the work queue for the NEN HA pair.

If the primary NEN (on node 1) looses connectivity to the PCE, the secondary NEN (on node 2) becomes the primary NEN until the NEN on node 1 re-establishes connectivity with the PCE.

NOTE:
For hardware requirements in an HA Pair implementation, see CPU, Memory, and Storage Requirements in this topic.

When using the NEN for SLB integration, both NENs (primary and secondary) can program any load balancer because they share the work queue. Either NEN can accept the next job from the work queue depending on their available capacity. This capability is available when the primary NEN has connectivity with the PCE.



A PCE cluster supports multiple NENs per PCE, which can consist of multiple single node NENs, multiple NEN HA pairs, or a combination of both.

NEN Supercluster Support

In NEN 2.1.*x* (when installed as part of Illumio Core 20.2.0, 21.1.0, or 21.2.*x*), Illumio provided limited support for the NEN with PCE Supercluster deployments. For information see, Manage NEN on Supercluster Leader in "NEN 2.1.0 New Features." NEN releases prior to 2.1.0 did not include Supercluster support.

NEN 2.3.10 extended support for installing a NEN within a PCE Supercluster as follows:

- **NEN Installation on Supercluster Members**

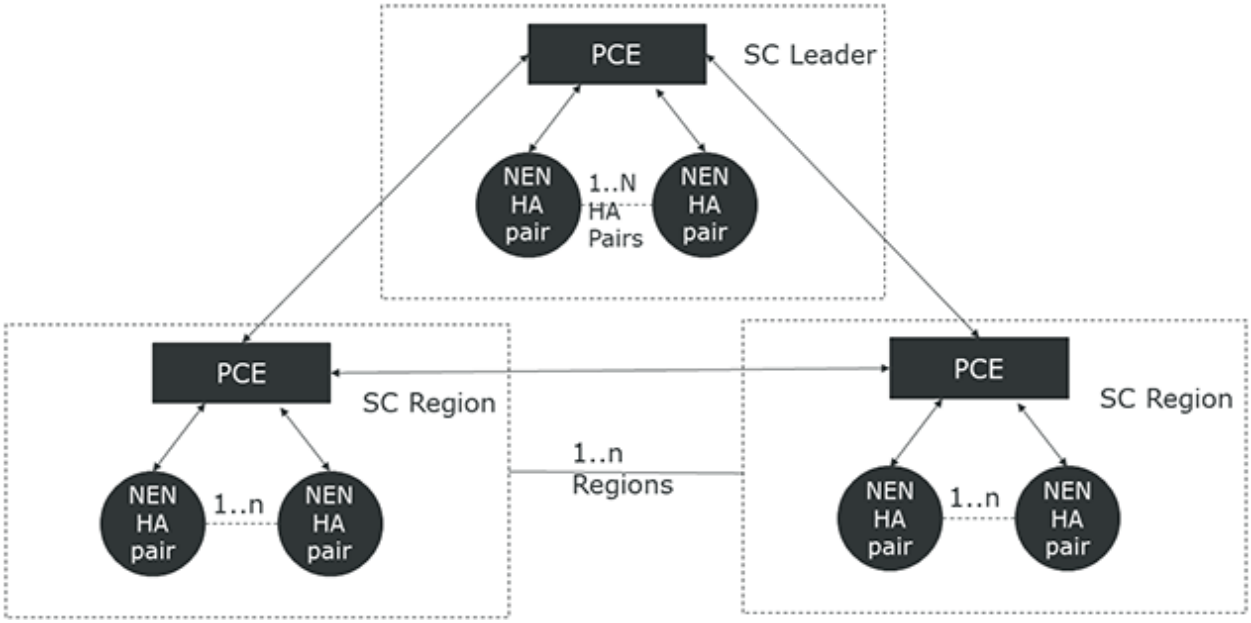
  You can pair the NEN to the other regions in the Supercluster; referred to as Supercluster "members." Prior to NEN 2.3.10, you could only install the NEN on the Supercluster leader. For more information about PCE Supercluster deployment architecture, see "Design Supercluster Deployment" in the *PCE Supercluster Deployment Guide*.

- **Multiple NEN HA Pairs in a Supercluster Member**

Depending on your scale requirements and the location of your network devices (such as SLBs), you can connect multiple NEN HA pairs to any cluster in a PCE Supercluster deployment (not just the PCE Supercluster leader). This enhancement is necessary to support environments with large numbers of SLBs and virtual servers that are geographically distributed.

NOTE:
At a minimum, you must install a primary and secondary NEN HA pair in one of the Supercluster regions.

The following diagram illustrates how to plan your NEN installation in a PCE Supercluster deployment:



CPU, Memory, and Storage Requirements

This section presents hardware requirements for supporting SLBs and switches.

Hardware requirements to support SLBs and VIPs

To install NEN(s) to support a given number of server load balancers and Virtual IPs, your hardware must meet the hardware requirements detailed in this

section.

Server Load Balancers (SLBs)	Virtual IPs (VIPs)	Cores/Clock Speed[1]	RAM per Node[2]	Storage Device Size[3] and IOPS[4]	Network
Up to 6 SLBs	• Max 1,000 VIPs per SLB • Max 3,000 VIPs across all SLBs	• 2 cores • Intel® Xeon(R) CPU E5-2695 v4 at 2.10GHz or equivalent	8 GB	A single node including both core and data: • 1 x 50 GB • 100 IOPS per device	1 Gb Ethernet
Up to 50 SLBs	• Max 1,000 VIPs per SLB • Max 12,000 VIPs across all SLBs	• 4 cores • Intel® Xeon(R) CPU E5-2695 v4 at 2.10GHz or equivalent	16 GB	A single node including both core and data: • 1 x 50 GB • 100 IOPS per device	1 Gb Ethernet
NEN HA implementation considerations: The two nodes in an HA pair must match the size specified in this table. This is necessary because in the event of a failover, a single node must be able to manage the entire load. • For an HA Pair for up to 3000 VIPs, use the sizing detailed in the first row. • For an HA pair for 3000+ VIPs, use the sizing detailed in the second row.					

Footnotes:

[1] CPUs:

- The recommended number of cores is based only on physical cores from allocated CPUs, irrespective of hyper-threading or virtual cores. For example, in AWS one vCPU is only a single hyper-thread running on a physical core, which is half a core. 16 physical cores equates to 32 vCPUs in AWS.
- Full reservations for vCPU. No overcommit.

[2] Full reservations for vRAM. No overcommit.

[3] Additional disk notes:

- Storage requirements for network traffic data can increase rapidly as the amount of network traffic increases. Allocating a separate, large storage device for traffic data can accommodate these rapid changes without potentially interrupting the service.
- Network File Systems (NFS) is not supported.

[4] Input/output operations per second (IOPS) are based on 8K random write operations. IOPS specified for an average of 300 flow summaries (80% unique src_ip, dest_ip, dest_port, proto) per workload every 10 minutes. Different traffic profiles might require higher IOPS.

Hardware requirements to support switches

To install NEN(s) to support a given number of switches, your hardware must meet the hardware requirements detailed in this table.

Switches	Cores/Clock Speed[1]	RAM per Node[2]	Storage Device Size[3] and IOPS[4]	Network
Up to 30 switches	• 2 cores • Intel® Xeon(R) CPU E5-2695 v4 at 2.10GHz or equivalent	8 GB	A single node including both core and data: • 1 x 50 GB	1 Gb Ethernet

Switches	Cores/Clock Speed[1]	RAM per Node[2]	Storage Device Size[3] and IOPS[4]	Network
			• 100 IOPS per device	
More than 30 switches	• 4 cores • Intel® Xeon(R) CPU E5-2695 v4 at 2.10GHz or equivalent	16 GB	A single node including both core and data: • 1 x 50 GB • 100 IOPS per device	1 Gb Ethernet

Footnotes:

[1] CPUs:

- The recommended number of cores is based only on physical cores from allocated CPUs, irrespective of hyper-threading or virtual cores. For example, in AWS one vCPU is only a single hyper-thread running on a physical core, which is half a core. 16 physical cores equates to 32 vCPUs in AWS.
- Full reservations for vCPU. No overcommit.

[2] Full reservations for vRAM. No overcommit.

[3] Additional disk notes:

- Storage requirements for network traffic data can increase rapidly as the amount of network traffic increases. Allocating a separate, large storage device for traffic data can accommodate these rapid changes without potentially interrupting the service.
- Network File Systems (NFS) is not supported.

[4] Input/output operations per second (IOPS) are based on 8K random write operations. IOPS specified for an average of 300 flow summaries (80% unique

src_ip, dest_ip, dest_port, proto) per workload every 10 minutes. Different traffic profiles might require higher IOPS.

Machine Resource Requirements for NEN VMs

Storage Device	Partition mount point	Size to Allocate
Device 1, Partition A	/	8 GB
Device 1, Partition B	/var/log	16 GB[1]
Device 1, Partition C	/var/lib/illumio-nen	Balance of Device 1

Footnote:

[1] The size of this partition assumes that NEN application logs and system logs are both stored in /var/log/illumio-nen.

Install and Activate the NEN

This section describes how to:

- Install and activate a new standalone NEN deployment
- Upgrade a PCE-based NEN installation to the standalone NEN installation required for NEN 2.3.x and later.

Illumio recommends that you have the following knowledge before installing and administering the NEN:

- A thorough understanding our organization's security goals.
- A thorough understanding of Illumio Core.
- When integrating the NEN with your organization's load balancers and switches, know how to configure and manage these network devices.

NEN Software

For the complete list of OS support for the NEN, see NEN OS Support and Package Dependencies on the Illumio Support portal.

To download the NEN software:

1. Log into the Illumio Support portal and go to **Software** > **NEN**.
2. From the **Download NEN Software** page, select the latest version.
3. Click the filename in the table to download the software locally.

Optional Configurations

Consider configuring the following optional functionality when you install NEN software.

Verify the NEN RPM digital signature

You can verify the signature of the NEN RPM package before installation to ensure that the package hasn't been modified since it was signed.

1. Download the NEN RPM.
   a. Go to Illumio Support software download page.
   b. Select the NEN version you want to verify.
   c. Click the RPM package you plan to install.
2. Import the Illumio NEN Public Key.

   ```
   % gpg --import illumio_nen_pub.key
   ```

   The imported file is placed in your `/home` directory.
3. List the keys in the imported file.

   ```
   % gpg --list-keys illumio
   ```

   In the output, locate the last 16 digits in the signature line.

   `pub rsaXXXX 2022-06-31 [SC]`

   `8C34J70E2D13F9332AD1F49Dxxxxxxxxxxxxyyyy` ← Last 16 digits of the public key
4. List signatures in the RPM

```
% rpm -qpi illumio-nen-xxx-x.xx.x86_64.rpm | grep ^Signature
```

where `xxx-x.xx` is the version number of the package.

5. Visually compare the last 16 digits in the RPM with the last 16 digits in the imported Public Key.

   `Signature : RSA/SHA256, Key ID xxxxxxxxxxxxyyyy` ← Last 16 digits of the RPM.

   If the signatures don't match, don't install the package. Contact Illumio Support.

Configure Proxy Support for NENs

Beginning with NEN release 2.6.10, you can configure proxy support for NENs by adding environment variables to the runtime_env file. This support defines an HTTP/HTTPS proxy for communication between the NEN and the PCE or between the NEN and managed devices (such as Server Load Balancers (SLB)). There's also support for specifying a list of IP address that are not allowed to communicate via a proxy server. You can configure these options by adding a field to the runtime_env.yml file.

Modify the template runtime_env file

NOTE:
The NEN will honor the environment variables `http_proxy`, `https_proxy`,and `no_proxy` if they are present. However, you can override these variable values by setting appropriate values in the `proxy_config` variables in the NEN `runtime_env.yml` file.

The NEN will honor the environment variables `http_proxy`, `https_proxy`, and `no_proxy` if they are present. However, you can override these variable values by setting appropriate values in the `proxy_config` variables in the NEN `runtime_env.yml` file.

You can modify the `runtime_env.yml` file either during an interactive installation or later by copying and modifying the template runtime file.

- Modify during an interactive installation.
- Modify post-installation.

Configuration scenarios

Under the proxy_config option, configure proxy support for any of the following scenarios in the runtime_env.ymlfile.

PCE	Managed Devices (SLBs)	Scenario	Proxy Environment Variable
The PCE is proxied.	No SLBs are installed.	Configure the NEN to communicate with the proxied PCE.	`pce_https_proxy:`
The PCE is proxied.	SLBS are installed but not proxied.		
The PCE is proxied.	SLBs are installed and proxied.	Configure the NEN to communicate with the proxied PCE and proxied SLBs.	`pce_https_proxy:` and `device_http_proxy:` or `device_https_proxy:`
The PCE is not proxied.		Configure the NEN to communicate with proxied SLBs.	`device_http_proxy:`
N/A		Specify a list of IP address that are not allowed to communicate via a proxy server.	`no_proxy:`

Configure a PCE policy request timeout

Beginning with NEN 2.5.2.A1, you can configure a PCE policy request timeout. This may be needed If your NEN SLB implementation will involve large policy calculations. The timeout ensures that the NEN doesn't wait too long for the PCE to respond to policy requests in scenarios involving large policy calculations.

To configure the timeout, use the following runtime environment variable:

```
pce_policy_request_timeout_minutes
```

- Default value: 10 minutes
- Minimum value: 3 minutes

Configure a PCE connect timeout

Beginning with NEN 2.6.1, you can configure a PCE policy connect timeout. This may be necessary because the shortness of the default connect timeout in the CURL library (5 minutes) may make the NEN susceptible to timing out when trying to connect to the PCE. This in turn will prevent the NEN from updating policy on the SLB.

To configure the timeout, use the following runtime environment variable:

```
pce_policy_connect_timeout_minutes
```

- Default value: 10 minutes
- Minimum value: 3 minutes

Install a New Standalone NEN

NOTE:
This procedure describes how to perform a **new** NEN standalone installation where you have **not** previously installed the NEN as a service on a PCE data node or you have not installed the NEN 2.1.0 standalone service on your own host.

- For the steps to upgrade standalone NEN 2.1.0 to standalone NEN 2.3.x or later, see Upgrade Standalone NEN 2.1.0 to Standalone NEN 2.3.x or later.
- For the steps to upgrade a previously-installed PCE-based NEN to NEN 2.3.x or later, see Install and Activate the NEN.

To install a NEN as a standalone NEN:

NOTE:
For standalone NEN hardware requirements, see CPU, Memory, and Storage Requirements.

1. Download the NEN software from the Illumio Support portal.
2. Run the following command to install the NEN RPM on the host:

```
sudo yum install -y <path_to_Illumio_NEN_rpm>/illumio-nen-<release_
number>-<build_number>.x86_64.rpm
```

3. Configure the NEN runtime environment settings in **one** of the following ways:
   - By running the NEN `setup` command to launch an interactive installation and answering the prompts to configure the NEN runtime environment. (This method creates the NEN runtime environment file and saves it in the correct NEN directory.)
   - By copying a template of the NEN runtime environment file to the required location and then modifying that file

To perform an interactive installation:

a. Enter the following command to start the installation and run the environment set up:

```
sudo /opt/illumio-nen/illumio-nen-env setup
```

b. Complete the installation by providing the values at the prompts.

To modify the template runtime environment file:

a. Copy the NEN runtime environment file from:

```
/opt/illumio-nen/illumio/config/templates
```

b. Paste it to:

```
/etc/illumio-nen/runtime_env.yml
```

c. Update the file with the host FQDNs and service discovery certificate information.

IMPORTANT:
A standalone NEN cannot communicate with the PCE by using a self-signed service discovery certificate. The NEN requires an X.509 public certificate in PEM format for TLS communication with the PCE.

```
# Configuration generated <timestamp>
install_root: “/opt/illumio-nen”
runtime_data_root: “/var/lib/illumio-nen/runtime”
persistent_data_root: “/var/lib/illumio-nen/data”
ephemeral_data_root: “/var/lib/illumio-nen/tmp”
```

```
log_dir: “/var/log/illumio-nen”

private_key_cache_dir: “/var/lib/illumio-nen/keys”

nen_fqdn: <example.com>

service_discovery_fqdn: <example.com>

cluster_type: snc0

service_discovery_private_key: “/var/lib/illumio-nen/cert/server.key”

service_discovery_certificate: “/var/lib/illumio-nen/cert/server.crt”

service_discovery_encryption_key: <key>
```

Where:

- `nen_fqdn` is the hostname of the node where the NEN is installed.
- `service_discovery_fqdn` is the hostname of the NEN FQDN.
- `service_discovery_private_key` is the directory path of the RSA private key file.
- `service_discovery_certificate` is the directory path of the certificate file.
- `service_discovery_encryption_key` is a 16 byte hexadecimal base-64 encoded value

When adding the encryption key to the template runtime environment file, you create your own value. However, if you are using the interactive NEN installation, the NEN CTL `setup` command automatically creates this value in the file.

NOTE:
Beginning in NEN release 2.4.10, you can add a field to the runtime environment file to configure how frequently the NEN polls Server Load Balancers (SLBs) to discover new virtual servers (VS). For details, see Load Balancers and Virtual Servers for the NEN.

4. Start the NEN and set the runlevel to 5. The option `-svw` shows the status of the start operation.

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl start --runlevel 5 -
svw
```

NEXT STEPS

1. Activate the NEN with a pairing key from the PCE. See Obtain Pairing Key and Activate the NEN.
2. To enable the NEN to integrate with a load balancer, see Enable load balancer support.
3. (Optional) To configure the NEN as an HA pair, perform the steps in Configure HA Support for the NEN.

Obtain Pairing Key and Activate the NEN

When the NEN is installed as part of a NEN HA pair, you only pair the NEN primary node with the PCE.

1. Log into the PCE web console.
2. From the left navigation menu, choose **Workloads and VENS > Workloads**.
3. Click **Add > Pair Workload with Pairing Profile**.
4. Select any existing pairing profile from the "Pick a Pairing Profile" drop-down menu.
5. Copy the pairing **Key** value (alphanumeric).
6. Log in to the NEN host and run the `illumio-nen-ctl activate` command:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl activate <pairing_
key_value> --host <pce-address>:<pce-port>
```

Enable load balancer support

After installing the NEN RPM and activating it with the PCE, enable load balancer support by running the following command on the NEN node:

NOTE:
If the NEN is configured as an HA pair, run this command on the primary node.

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl slb-enable
```

Move a NEN from one PCE to another PCE

You can move a NEN from one PCE to another PCE in the same supercluster. When a NEN is moved in this way, associated Server Load Balancers maintain policy for managed virtual servers. After the PCE database is restored, the moved NEN remains connected to the new PCE. The command for moving a NEN is:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl pce-host-update <pce-
host-addr>:<port>
```

Upgrade Standalone NEN 2.1.0 to Standalone NEN 2.3.x or later

Keep in mind that if you perform this procedure, you **don't** need to:

- Restore the NEN database because the NEN upgrade doesn't impact it.
- Activate the NEN with the PCE if you are upgrading an existing NEN installation; that is, if you are upgrading a NEN 2.1.0 standalone installation to NEN 2.3.xor later standalone installation.

1. Run the following upgrade command:

   ```
   sudo yum update -y <path to Illumio NEN rpm>/illumio-nen-<release_
   number>-<build-number>.x86_64.rpm
   ```

2. Enable load balancer support by running the following command on the NEN node:

NOTE:
If the NEN is configured as an HA pair, run the command on the primary node.

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl slb-enable
```

3. (Optional) To configure an HA pair for the NEN in the PCE cluster, see Configure HA Support for the NEN. (The steps are the same whether you are installing a new standalone NEN or upgrading an existing NEN.)

Configure HA Support for the NEN

This optional procedure describes how to install the NEN on a secondary node to provide HA support for the NEN in a PCE cluster. For information about running the NEN as an HA pair, see NEN High Availability Support For information about upgrading nodes in an HA pair, see Upgrade a NEN HA pair.

Prerequisites for HA support

- You have already installed the NEN on the primary node.
- `service_discovery_fqdn` must be the hostname or IP address of the primary node.
- Network latency between DB nodes must not exceed 10ms.
- `nen_fqdn` in the `runtime_env.yml` file:
  - Both nodes must have the same `nen_fqdn` so that the PCE knows they are part of the same NEN HA pair.
  - The `nen_fqdn` can be anything you choose as long as it is unique among NEN clusters paired to the PCE.
  - The `nen_fqdn` doesn't need to match the actual hostname of either node nor be resolvable via DNS.
- Each NEN node's actual hostname must be resolvable from the actual hostname of the other node in the pair.

NOTE:
You cannot change the `nen_fqdn` once the NEN has been paired to the PCE.

To set up a NEN HA Pair

1. Install the NEN on the secondary node:

```
sudo yum install -y <path_to_Illumio_NEN_rpm>/illumio-nen-<release_
number>-<build_number>.x86_64.rpm
```

2. Set up NEN runtime environment on the secondary node using one of the following methods:
   - Copy `/etc/illumio-nen/runtime_env.yml` file from primary node to `/etc/illumio-nen/runtime_env.yml` on the secondary node, and change the node_type: value to `network_enforcement1`
   - `sudo -u ilo-nen /opt/illumio-nen/illumio-nen-env setup`.
3. Start the NEN on the secondary node:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl start
```

Upgrade a NEN HA pair

To upgrade the nodes in a NEN pair, you must do so in the proper sequence when the nodes are in the proper state.

Before you begin

- A rolling upgrade is not supported. Perform the upgrade in the order described in the steps below.
- Make sure that the nodes can communicate with each other (that is, that the network connection between them is up). The nodes need to be able to share the same database information. This is to avoid a "split brain"

state where both nodes can communicate with the PCE but not with each other.

To upgrade a NEN HA pair:

1. Stop the secondary NEN node.
2. Stop the primary node.
3. Upgrade the primary NEN node.
4. Wait for the primary NEN node to be online (in the RUNNING state).
5. Upgrade the secondary NEN node.

Upgrade a PCE-based NEN 2.1.0 to Standalone NEN 2.3.x or later

If you are upgrading Illumio Core to 21.5.0-PCE or later, you must upgrade the NEN to 2.3.x or later. Illumio Core 21.3.0-PCE is not backwards compatible with NEN 2.1.0 and earlier releases.

Upgrade prerequisites

Before taking the NEN database back up, ensure that no asynchronous jobs have been submitted right before you begin the upgrade. As a best practice, wait until all asynchronous jobs have finished before upgrading the PCEs and associated NENs.

NOTE:
When to back up the NEN database and uninstall the NEN software from the PCE

You must back up the NEN database and uninstall the NEN RPM from your PCE-based NEN installation before you upgrade to Illumio Core 21.3.0-PCE and later. Be aware that you must set the PCE to runlevel 1 before backing up the NEN database on the PCE primary data node and uninstalling the NEN RPM from both PCE data nodes.

Notes about the upgrade

- Upgrading the NEN in a single PCE cluster versus a PCE Supercluster deployment

  The steps to install and configure a NEN in a PCE Supercluster deployment are the same as for a single PCE cluster. You perform the procedure to install a NEN in each individual region (PCE Supercluster members).

- Restoring the NEN database in a Supercluster deployment

  When upgrading the NEN that is part of a PCE Supercluster deployment, restore the NEN database from the PCE-based installation; you must restore he NEN database on the NEN paired to the PCE Supercluster leader. You do not need to restore the database for the NENs paired with the PCE Supercluster members.

- When to back up the NEN database and uninstall the NEN software from the PCE

  You must back up the NEN database and uninstall the NEN RPM from your PCE-based NEN installation before you upgrade to Illumio Core 21.3.0-PCE and later. You must set the PCE to runlevel 1 before backing up the NEN database on the PCE primary data node and uninstalling the NEN RPM from both PCE data nodes.

Upgrade NEN 2.1.0 PCE-based installation to NEN 2.2.0 and later standalone installation

1. Back up the NEN database on the PCE primary data node.

   For the requirements and syntax to run PCE commands, see “PCE Control Interface and Commands” in the *PCE Administration Guide*.

   ```
   sudo -u ilo-pce illumio-pce-ctl set-runlevel 1
   sudo -u ilo-pce /opt/illumio-pce/illumio-nen-db-management dump --
   file <filename>
   sudo -u ilo-pce /opt/illumio-pce/illumio-pce-ctl stop
   ```

2. Uninstall the NEN from the PCE data node(s).

```
sudo rpm -e illumio-nen
```

3. Upgrade the PCE to Illumio Core 21.3.0-PCE and later.

   For the steps to upgrade a single PCE cluster, see “Upgrade the PCE” in the *PCE Installation and Upgrade Guide*.

   For the steps to upgrade the PCEs in a PCE Supercluster deployment, see “Upgrade Supercluster” in the *PCE Supercluster Deployment Guide.*

   After upgrading your single PCE cluster or PCE Supercluster, ensure that all PCEs are started at runlevel 5 before installing the NEN RPM package.

4. Install and configure the NEN software. See Install a New Standalone NEN. (This is the procedure for installing a new NEN standalone installation, but the steps are the same whether you are installing a new standalone NEN or upgrading an existing NEN. In the NEN upgrade procedure, you will have uninstalled the previous NEN by this step and must install the new NEN release.)

5. Set the NEN to **runlevel 1** and restore the NEN database that you copied from the PCE primary data node:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl set-runlevel 1
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-db-management restore --
file <path to file to restore>
```

   If you are performing this step for a NEN that is part of a PCE Supercluster deployment, restore the NEN database for the NEN node paired with the PCE Supercluster leader. You don't need to restore the NEN database in each Supercluster member region.

6. Set the NEN to runlevel 5 and activate the NEN with a pairing key from the PCE by using the --repair option:

```
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl set-runlevel 5
sudo -u ilo-nen /opt/illumio-nen/illumio-nen-ctl activate <pairing-
key> --host <PCE_host address:port> --repair
```

If you are performing this step for a NEN that is part of a PCE Super-cluster deployment, repair the NEN with the Supercluster leader PCE. Additionally, pair any new NEN installations in each region with the Super-cluster member in that region.

For the steps to obtain a pairing key from the PCE, see Obtain Pairing Key and Activate the NEN.

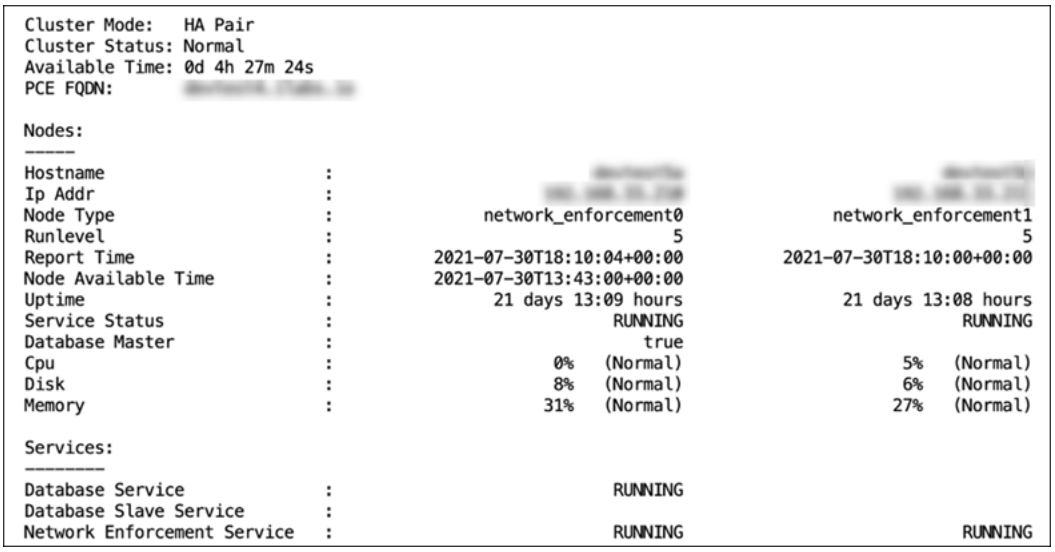
7. To configure an HA pair for the NEN in the PCE cluster, see Configure HA Support for the NEN. (The steps are the same whether you are installing a new standalone NEN or upgrading an existing NEN.)

Generate NEN Reports

You can generate NEN health and support reports as well as enable/disable debug mode logging. These provide information useful for troubleshooting issues with your NENs.

Health Report

- Appears onscreen only
- Includes the following information

- 

```
Cluster Mode:   HA Pair
Cluster Status: Normal
Available Time: 0d 4h 27m 24s
PCE FQDN:       [redacted]

Nodes:
------
Hostname                    :                                [redacted]                                [redacted]
Ip Addr                     :                                [redacted]                                [redacted]
Node Type                   :                network_enforcement0                network_enforcement1
Runlevel                    :                                  5                                   5
Report Time                 :      2021-07-30T18:10:04+00:00           2021-07-30T18:10:00+00:00
Node Available Time         :      2021-07-30T13:43:00+00:00
Uptime                      :           21 days 13:09 hours                 21 days 13:08 hours
Service Status              :                        RUNNING                             RUNNING
Database Master             :                           true
Cpu                         :                     0%   (Normal)                      5%   (Normal)
Disk                        :                     8%   (Normal)                      6%   (Normal)
Memory                      :                    31%   (Normal)                     27%   (Normal)

Services:
---------
Database Service            :                        RUNNING
Database Slave Service      :
Network Enforcement Service :                        RUNNING                             RUNNING
```

To generate a NEN health report only:

1. Establish a secure shell connection (SSH) to the NEN you want to investigate
2. Issue the following command:

```
illumio-nen-ctl health
```

Support Report

A Support Report is a unique generated file saved to the /tmp directory. It includes the following information and data:

- A Health Report (see the image above)
- NEN logs

To generate a NEN support report:

1. Establish a secure shell connection (SSH) to the NEN you want to investigate.
2. Run the following command:

```
illumio-nen-ctl support-report
```

3. On successful completion, the command indicates where you can find the file so that you can copy the support report off the NEN.

Debug Mode Logging

You can turn debug mode logging on or off. When enabled, debug mode logging provides detail for the network_enforcement_service. The following command allows you to show the current debug mode node status or turn debug logging mode on or off dynamically:

```
illumio-nen-ctl debug-mode status/on/off [--all-nodes]
```

Chapter 3

NEN Integration with Load Balancers

This chapter contains the following topics:

This section describes how to create security policy and apply those policies on the load balancers for use with the NEN.

IMPORTANT:
This Documentation Portal for Illumio Core 21.5.x – 24.1.x contains the documentation for NEN 2.6.x; however, Illumio Core 21.5.x – 24.1.x also supports NEN 2.5.2, NEN 2.4.10, and NEN 2.3.10.

- To review the documentation for NEN 2.5.2 (even if you are running Illumio Core21.5.x – 24.1.x), go to the 22.25 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.4.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 22.2 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.3.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 21.5 Documentation Portal: HTML | PDF

Load Balancers and Virtual Servers for the NEN

Illumio Core supports activation of enforcement on a number of load balancers as listed below.

Supported Load Balancers

- F5 BIG-IP 11.5x or later
- AVI Vantage 18.23 or later
- Citrix ADC (NetScaler) 13.1 or later

Load Balancer and Virtual Server Concepts

- **Load balancer (SLB)**: Either a physical machine or a virtual machine performing load balancing functions. An SLB object represents a standalone device or an HA Pair and includes management of IP/port, user-/password, and so on. These values are used by an Illumio NEN to read information from and manage the device. In case of HA, it may include multiple SLB devices.
- **Illumio Virtual Server**: The same as a load balancer Virtual Server.
- **Discovered Virtual Server**: An Illumio NEN queries the load balancer for VIPs and specifies the client-facing VIP with port + protocol combination.
- **Created Virtual Server**: Is a provisionable policy object with labels used in policy writing. In the UI, the Virtual Server creation process is called VIP Management. Virtual Server providers (backend servers) are specified using labels and can optionally specify backend port independently of the port used by the VIP.
    - **VIP**: Is a virtual IP or a local IP (a front-end IP that clients can connect to).
- **SNAT pool**: Is a group of IPs that the Virtual Servers use to connect to the backend servers. A Virtual Server can only have a single VIP connected to it, on a single port. It can also be accessed by the SLBs local IPs.

About Load Balancers

Illumio Core supports activation of enforcement on a number of load balancers listed below.

IMPORTANT:
Network Function Controller (NFC) discontinued

Beginning with Illumio Core 19.3.0 release, the Network Function Controller (NFC) is no longer supported. The F5 interface has been moved from the PCE in to the Network Enforcement Node (NEN). Because the NFC has been discontinued, you need to use the NEN to interface with Load Balancers.

By applying labels to your load balancer's virtual servers, you can write rules that allow client workloads in front of the load balancer to communicate with the virtual IP address of the load balancer's virtual servers. By adding labels to the pool members behind a virtual sever, you can allow communication from the load balancer to the members of the pool. The source for this communication is determined by the load balancer. The Illumio Core programs policies on the load balancer to enforce security policy. The NEN uses the load balancer's REST APIs to read and write security policies to configure security rules.

The PCE supports configuration of two load balancer units if they are configured in Active/Standby or Active/Active modes. The PCE needs to be configured with the user name and password of an administrative user who has read-write access to all configurations on the load balancer.

The NEN configures new objects on the load balancer and does not alter any existing configurations. When an Illumio-created object in the load balancer configuration is modified, the NEN detects it as tampering and modifies the configuration back to the intended state so that the correct security policy is enforced.

The Illumio Core dynamically adjusts policies on the load balancer based on application and topology changes in the datacenter so that the Illumio Core

can enforce consistent security policy on load balancers across the datacenter and cloud environments, as well as show the application traffic in Illumination. The Illumio Core keeps track of the policy it programmed and reconfigures policy if it was altered on the load balancer manually or by other means.

The NEN makes use of the following constructs on load balancers:

- **F5 LTM:** iRules or LTP policies on the LTM provide capability to restrict application access. When the LTM is used as enforcement mechanism, the NEN uses virtual-server based iRules/LTP policies and Datagroup Lists.
- **F5 AFM:** AFM provides stateful firewalling on BIG-IP. When AFM is used as an enforcement mechanism, the NEN uses Network Firewall policies in the virtual server section and address-lists in the network firewall. The NEN also **supports the F5 BIG-IP Application Services 3 Extension (referred to as BIG-IP AS3) when it is used to define virtual servers on the F56 AFM**.
- **AVI**: The NEN uses the Network Security Policy rules to program AVI Vantage.
- **Citrix ADC (NetScaler)**: The NEN uses responder policies to control access to the Virtual Servers.

NOTE:
Configuring two SLB units in Active/Standby mode is supported. However, clustering is **not supported**.

F5 BIG-IP Requirements

The NEN uses its REST API to program F5 load balancers, which means that F5 needs to be running a software version that supports REST-API. The requirements include:

- BIG-IP 11.5.x or higher
- Utilize SNAT or Auto-map mode

AVI Vantage Requirements

- AVI Vantage 18.2.3 or higher

Citrix ADC (NetScaler) Requirements

- Citrix ADC 13.1 or higher

Configure Load Balancers

You can add a load balancer using the PCE web console. However, before you add a load balancer, you need to pair the NEN with the load balancer functionality enabled with the PCE.

NOTE:
A load balancer does not need to be provisioned to work. However, the virtual servers you associate with this load balancer do need to be provisioned.

Add an SLB from the PCE Web Console

You can add a load balancer using the PCE Web Console. However, before you add a load balancer, you need to pair the NEN with the load balancer functionality enabled with the PCE.

1. From the PCE Web Console menu, choose **Infrastructure** > **Load Balancers**.
2. Click **Add**.
3. Specify a name for the load balancer and provide a description.
4. From *NEN hostname*, select the NEN that you want to manage policy programming for this particular SLB.
5. From *Device Type*, select appropriate load balancer device type.
6. From number of devices, select **(1) Standard** or **(2) HA Pair**.

   The load balancer details are displayed.
7. Specify the following settings to enable the PCE to connect to the load balancer:
   - Management IP address or FQDN of the load balancer
   - Port on which to connect

- Username
- Password

8. Select **Verify TLS** to verify the trust of the TLS certificate provided by the load balancer before connecting to it.
9. Click **Save**.

Move an SLB to a different NEN host (single and super cluster)

> NOTE:
> Requires Core PCE version 22.2.0 or later.

You can move a Server Load Balancer to a different NEN host from the PCE Web Console. This capability preserves – on the moved SLB – all policies already assigned to the managed virtual server.

1. From the PCE Web Console, go to **Infrastructure > Server Load Balancers**.
2. In the **Name** column, click the link for the SLB you want to move.
3. On the **Summary** tab for the selected SLB, click **Edit**.
4. In **NEN hostname**, click the drop down list to select the destination NEN host where you want to move the SLB.
5. Click **Save**. The PCE recognizes that the SLB has been moved to the chosen NEN host.

About Virtual Servers

Virtual servers in the Illumio Core contain two parts:

- A virtual IP address (VIP) and port through which the service is exposed
- Local IP address(es) used to communicate with backend servers (pool members).

A virtual server is similar to a workload. It can be assigned labels and has IP addresses, but does not report traffic to the Illumio Core. Each virtual server has only one VIP. The local IP addresses are used as a source IP address for connections to the pool members (backend servers) when the virtual server is

operating in SNAT mode or Auto mode. These IP addresses are likely to be shared by multiple virtual servers on the server load balancer.

A virtual server is identified by a set of labels. The consumers and providers for a virtual server can be assigned different labels, which could place them in the same group or a different group in Illumination. See **Groups in Illumination** in the *Visualization Guide* for information.

Providers are allowed to have an incomplete label set (for example, only a Location label), so the providers can be in all groups within the specified location. As a result, a single virtual server can have providers in any group or in any number of groups in Illumination.

Virtual Server Members and Labels

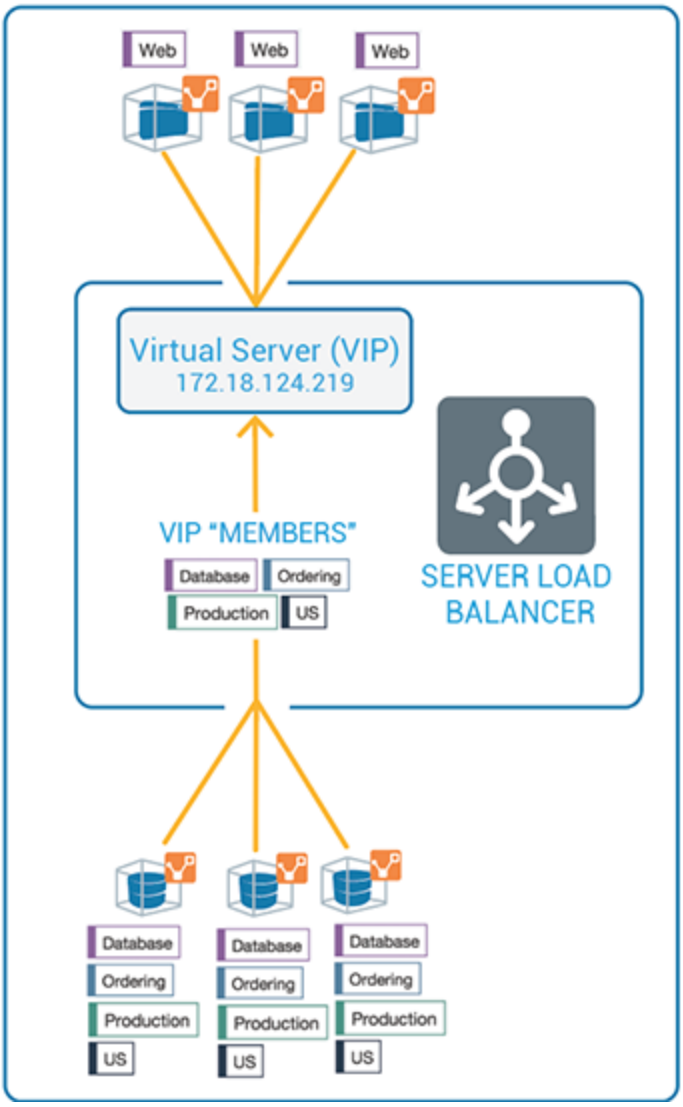
The Illumio Core allows you to write rules to allow communication with workloads managed by a load balancer using labels.

Virtual Server Members

When you configure load balancers in the PCE, it connects to the load balancer using the Illumio Core REST API. The PCE reads all the load balancer virtual servers configurations and populates the Discovered Virtual Servers tab of a load balancer's details page. Any virtual servers associated with the load balancer can be converted to a managed virtual server for use with the PCE. When you configure the virtual server in the PCE web console, you can apply labels to the virtual servers. After configuring a virtual server, you can write a rule that allows other clients to communicate with it.

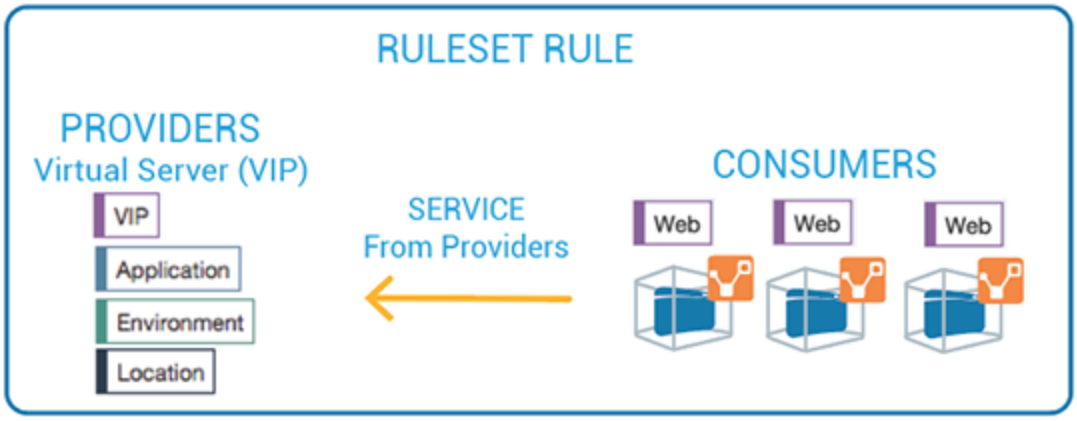
The members behind a virtual server are specified by configuring a set of labels in the virtual server configuration. A set of four Illumio labels can be applied on the Virtual Server Members tab, which is used to match the same set of labels on workloads in the virtual server's pool. If any of the workloads in the virtual server pool share the same set of four labels specified under the Virtual Server Members tab, then any rule you write with the virtual server also applies to the workload members.

In this diagram, you can see how the workloads that belong to the virtual server pool have the same labels specified on the Virtual Server Members tab:



Ruleset Rule for Virtual Server

This diagram illustrates the rule you can write after you label a virtual server and its members:



Configure Virtual Servers

After adding a load balancer to the PCE, you can manage its virtual servers. For each virtual server, you can add a complete set of the four Illumio labels: Role, Application, Environment, and Location. Adding labels to the virtual server enables you to add it in a rule.

You add the four Illumio labels to the Virtual Server's Members tab. When the labels specified under Virtual Server Members match labels of workloads in the virtual server pool, any rule you write with the virtual server is applied to the workload members.

Configuring a load balancer's virtual servers consists of these three settings:

- **Enforced or Not Enforced:** When you select Enforced, any rules you write using the labels associated with the virtual servers and any of its members are enacted. Selecting Not Enforced disables the labels and any policy written that affects the virtual server or its members is disabled.
- **Service:** Select the service to use for the rules that allow access to the virtual server. For example, HTTPD 80 TCP.
- **Labels:** You must apply one each of the four Illumio labels to the virtual server: Role, Application, Environment, and Location. Assigning labels enables the virtual server to be used in rules.

NOTE:
Virtual servers are considered a security policy item, so any changes to a virtual server configuration must be provisioned before any of those changes take effect and become active.

Virtual Server Limitations

- Illumination does not support location-level and application-level maps.
- If a single SNAT pool is shared between multiple virtual servers, the Illumination map does not render correctly.
- SNAT and Auto-map modes of F5 virtual servers are supported. Transparent mode is not supported.

NOTE:
Before any virtual server configuration can go into effect, you need to provision your changes. See **Provisioning** in the *Security Policy Guide* for information.

Configure the polling interval for discovering new virtual servers

Beginning in release NEN 2.4.10, you can configure how frequently the NEN polls Server Load Balancers (SLBs) to discover new virtual servers (VS). You do this by adding a field to the runtime_env.yml file. In previous releases the timeout value was fixed at 5 minutes, which was too long for some use cases. SLB discovery events are customer-configurable as follows:

- **Default** = 5 minutes. You don't have to modify the runtime environment file if you want to keep the default setting.
- **Minimum** = 2 minutes
- **Maximum** = none

The NEN reads the timeout value at startup and polls SLBs accordingly. If you add this field and/or update the timeout value in the field, you must restart the NEN for the change to take effect.

Procedure

You can modify the runtime environment file on an already-running NEN or when installing a NEN. For details, see Install a New Standalone NEN.

1. Locate the NEN runtime environment file in the following directory:

   ```
   /etc/illumio-nen/runtime_env.yml
   ```

2. If it's not already present, add the line slb_discovery_timeout_minutes to the file.
3. Add a space, a colon (:), and value of 2 or higher at the end of the line. For example, to configure the SLB discovery timeout to **3 minutes**, you'd enter:

   ```
   slb_discovery_timeout_minutes: 3
   ```

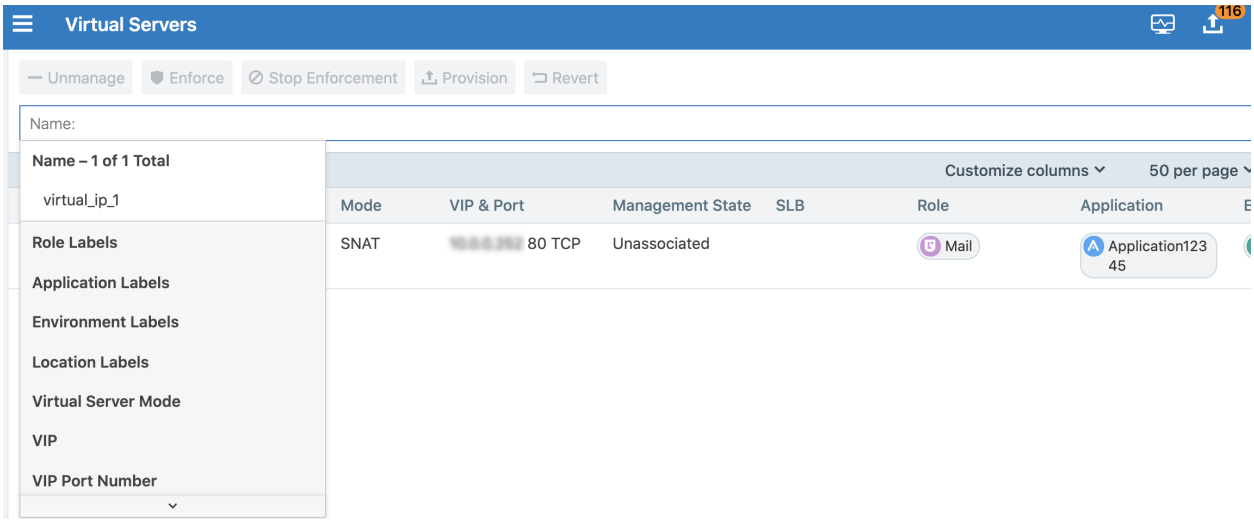
4. Restart the NEN for the new setting to take effect.

If you've updated the timeout value on an already-running NEN, you're done at this point. If you've configured the timeout value as part of a new NEN installation, continue to Load Balancers and Virtual Servers for the NENbelow.

Filter the Virtual Server List

You can filter the Virtual Servers list by using the properties filter at the top of the list. For example, you can filter and search by label. You can also filter and search by the following objects:

- Virtual server mode
- Virtual IP address, the VIP port number, or VIP Protocol
- Server Load Balancer



Configure a Load Balancer's Virtual Servers

1. From the PCE web console menu, choose **Infrastructure** > **Load Balancers**.
2. Select the load balancer for which you want to configure virtual servers.
3. Select the **Virtual Servers** tab.
4. Select one of the load balancer's virtual servers and click **Manage**.
5. Select one of the virtual servers and click **Edit**.
6. Enter a name and description for the virtual server.
7. To enable the virtual server's policy, select **Enforced**.
8. Select a service to associate with the virtual server. The service selected enables that service to be used in rules you write for this virtual server.
9. Select one each of the four labels to assign to the virtual server.
10. Click **Save**.
11. Before any virtual servers can go into effect, they must be provisioned.

Write SLB Policy

Writing a policy for a load balancer is similar to writing a policy for a workload, except for the following differences:

- Leave the service as unspecified and the port and protocol of the discovered VIP will determine the service automatically.
- Specify “Uses Virtual Services” in the rule.

A rule that is provided between a virtual server (or its labels) and a set of consumers implicitly programs two sets of rules:

- Rules between the consuming workloads or labels and the frontend VIP of the F5 on the discovered VIP port and protocol: Traffic flows between consuming workloads and the VIP are enforced on both ends if the virtual server is managed and enforced.
- Rules between the F5 pool and the virtual server providers on the service specified in the virtual server object (usually All Services): These rules are enforced for inbound traffic to the virtual server provider if the virtual server provider workloads are enforced.

SLB Methods

The SLB APIs are used to enable automation for F5 policy management.

Functionality	HTTP	URI
Get the list of SLBs	GET	[api_version][org_href]/slbs
Get a specified SLB	`GET`	`[api_version][org_href]/slbs/:uuid`
Create an SLB object	`POST`	`[api_version][org_href]/slbs`

SLB Parameters

The parameters for the SLB methods are:

Parameter	Description	Type
`name`	The short friendly name of the server load balancer	String
`nfc`	Network Function Controller managing this SLB	String
`device_type`	Device type of the server load balancer	String
`devices`	Configuration and runtime state of the devices backing this SLB Network VF.	String

Configure an SLB Object

Step 1. Create an SLB object and instruct the NEN to sync with it.

```
POST /api/v2/orgs/{org id}/slbs
```

```
{
       "devices" : [
       {
              "config" : {
                     "username" : "admin",
                     "port" : 443,
                     "credential" : "admin",  # never replayed in northbound API
                     "host" : "10.2.32.6",
                     "credential_type" : "password",
                     "check_certificate" : false
              }
       }
],
       "device_type" :“F5 Big-IP LTM”
       "name" : "Illumio Test SLB"
}
```

Step 2. GET an SLB response.

```
GET /orgs/{org id}/slbs/{UUID of SLB object
```

```
{
       "name" : "Illumio Test SLB",
       "devices" : [
       {
              "status" : {"connection_state" : "pending"},    # will become successful
when NEN syncs w/ device
              "href" : "/orgs/1/slb_devices/9349ff36-ab38-42bf-909a-eb5aa3baf187",
              "config" : {
              "username" : "admin",
              "check_certificate" : false,
              "credential_type" : "password",
              "host" : "10.2.32.6",
              "credential" : null,
              "port" : 443
       }
```

```
}
],
       "href" : "/orgs/1/slbs/8a82a1b0-c2ce-43ec-abf7-77bd8a3fd22c",
       "device_type" : "f5_bigip_afm"
       [ ... ]  # created_at, updated_at, etc.
}
```

Step 3. GET a list of Discovered Virtual Servers.

```
GET /orgs/1/discovered_virtual_servers
```

```
{
       "snat_type" : "snat_pool",
       "dvs_identifier" : "d3b784c2fd24ad364c5adb3319169bd2",
       "mode" : "snat",
       "vip_port" : {"port" : 8080, "protocol" : 6, "vip" : "172.16.27.88" },
       "service_checks" : [{"protocol" : 1}],
       "name" : "Common/QL_VIP_1",
       "slb" : {
              "href" : "/orgs/1/slbs/8a82a1b0-c2ce-43ec-abf7-77bd8a3fd22c"
       },
       "snat_pool_ips" : ["172.16.26.27", "172.16.26.18", "172.16.27.18"],
       "local_ips" : ["172.16.26.18", "172.16.27.18"],
       "href" : "/orgs/1/discovered_virtual_servers/2c460b98-2176-4a44-9ba4-
e77f3eacd0f1"
       [ ... ]  # created_at, updated_at, etc.
}
```

Step 4. Manage a VIP by creating a Virtual Server object.

```
POST /orgs/1/sec_policy/draft/virtual_servers
```

```
{
       "name" : "Common/chris-VIP1",
       "service" : {
              "href" : "/orgs/1/sec_policy/draft/services/1"
```

```
        },
        "labels" : [],
        "providers" : [],
        "mode" : "unmanaged",  # enforced
        "discovered_virtual_server" : {
                "href" : "/orgs/1/discovered_virtual_servers/23338ceb-7580-466a-bbcf-
a645b82ce97b"
        }
}
```

Step 5. Modify the enforcement mode, labels, and backend/provider labels of the Virtual Server.

```
PUT /orgs/1/sec_policy/draft/virtual_servers/84bae9dd-f1f6-4322-bffc-
f07354b0622a
```

```
{
        "mode" : "enforced",
        "labels" : [{"href" : "/orgs/1/labels/448"}, {"href" :
"/orgs/1/labels/444"}],  # any RAEL tuple
        "providers" : [{"label":{"href":"/orgs/1/labels/449"}}]   # note:
providers may have different labels
}
```

Step 6. Provision the Virtual Server into an active policy.

```
POST /orgs/1/sec_policy
```

```
{
        "update_description" : "Provision my first VS",
        "change_subset" : {
                "virtual_servers" : [{"href" : "/orgs/1/sec_policy/draft/virtual_
servers/84bae9dd-f1f6-4322-bffc-f07354b0622a"}]
        }
}
```

```
/orgs/1/sec_policy/draft/virtual_servers/84bae9dd-f1f6-4322-bffc-
f07354b0622a
/orgs/1/sec_policy/active/virtual_servers/84bae9dd-f1f6-4322-bffc-
f07354b0622a
```

Step 7. Write rules that apply to the Virtual Server.

```
POST /orgs/1/sec_policy/draft/rule_sets/1480/sec_rules
```

```
{
       "enabled" : true,
       "providers" : [
              {"label" : {"href" : "/orgs/1/labels/444"}},
              {"label" : {"href" : "/orgs/1/labels/448"}}
       ],
       "resolve_labels_as" : {
              "consumers" : ["workloads"],
              "providers" : ["virtual_services"]    # NOTE: Must be virtual_services
       },
       "consumers" : [
              {"actors" : "ams"}  # All Workloads
       ]
}
{
       "consumers" : [
              {"label" : {"href" : "/orgs/1/labels/444"}}
       ],
       "providers" : [
       {
              "virtual_server" :
              {"href" : "/orgs/1/sec_policy/draft/virtual_servers/84bae9dd-f1f6-4322-
bffc-f07354b0622a"}
       }
],
"enabled" : true,
"resolve_labels_as" : {
```

```
"consumers" : ["workloads"],
"providers" : ["virtual_services"]
       }
```

Remove Filtering

Some types of virtual servers are not visible, such as those without default server pools. From the NEN 2.1.0 release onwards, you can do filtering related to such virtual servers. You can see VIPs that do not have a pool associated with them or are not SNAT/Auto-SNAT.

To view all types of virtual servers configured on the F5 load balancers, you must enter specific commands during the NEN installation (on a NEN by NEN basis). These commands disable (enabled by default) the built-in filter running on the NEN on the Leader PCE cluster.

1. Enter the following command:

   ```
   sudo -su ilo-nen /opt/illumio-nen/illumio-nen-ctl slb-enable --
   virtual-server-filtering disabled
   ```

2. Restart the NEN on both db0 and db1 nodes:

   ```
   sudo -u ilo-nen /opt/illumio-nen/illumio-pce-ctl restart
   ```

Chapter 4

NEN Integration with Switches

This chapter contains the following topics:

This section describes how to create security policy and apply those policies on the switches for use with the NEN.

IMPORTANT:
This Documentation Portal for Illumio Core 21.5.x – 24.1.x contains the documentation for NEN 2.6.x; however, Illumio Core 21.5.x – 24.1.x also supports NEN 2.5.2, NEN 2.4.10, and NEN 2.3.10.

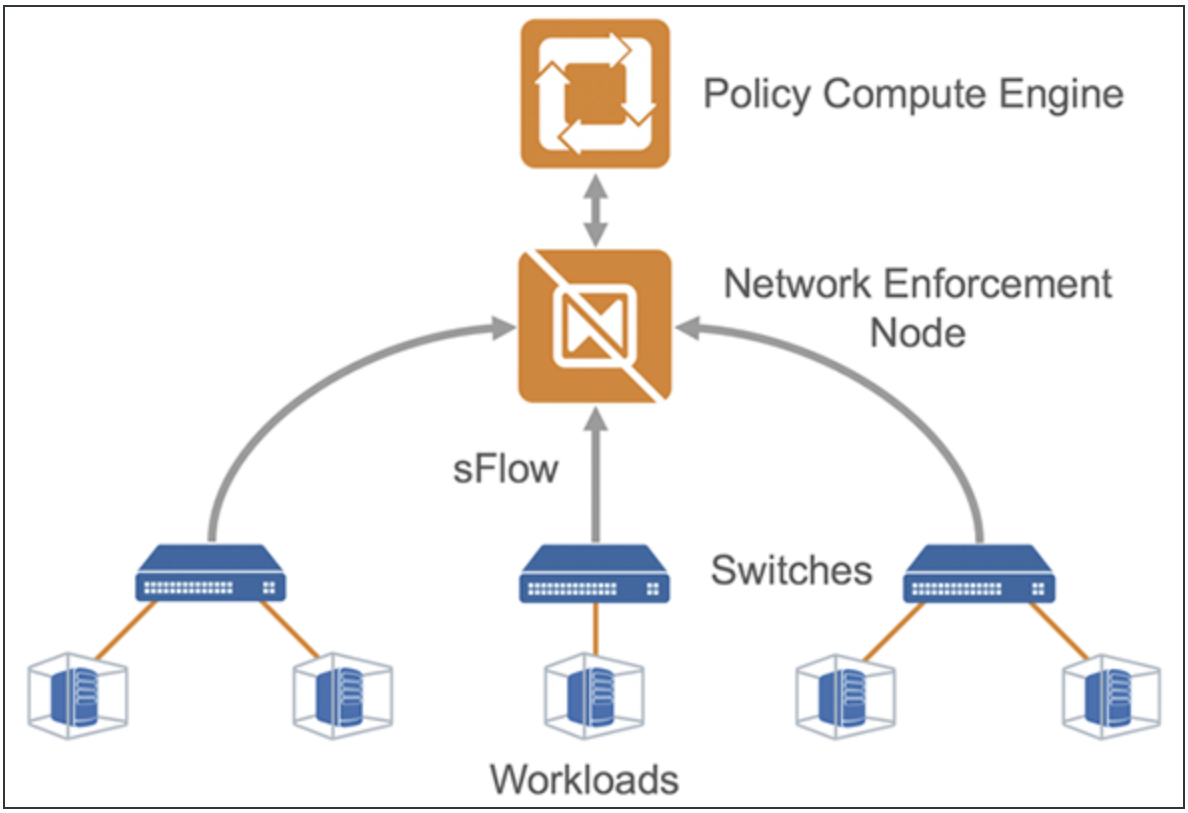
- To review the documentation for NEN 2.5.2 (even if you are running Illumio Core21.5.x – 24.1.x), go to the 22.25 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.4.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 22.2 Documentation Portal: HTML | PDF
- To review the documentation for NEN 2.3.10 (even if you are running Illumio Core 21.5.x – 24.1.x), go to the 21.5 Documentation Portal: HTML | PDF

Overview of Switch Integration

The Illumio Network Enforcement Node (NEN) is the Illumio Core switch interface, which allows you to get visibility and enforcement on switches. Using the NEN, you can secure workloads that are attached to network switches. You can use the NEN to generate access control lists (ACLs) and load those on your switches to protect the ports to which your workloads are attached.

How the NEN Receives Switch Data

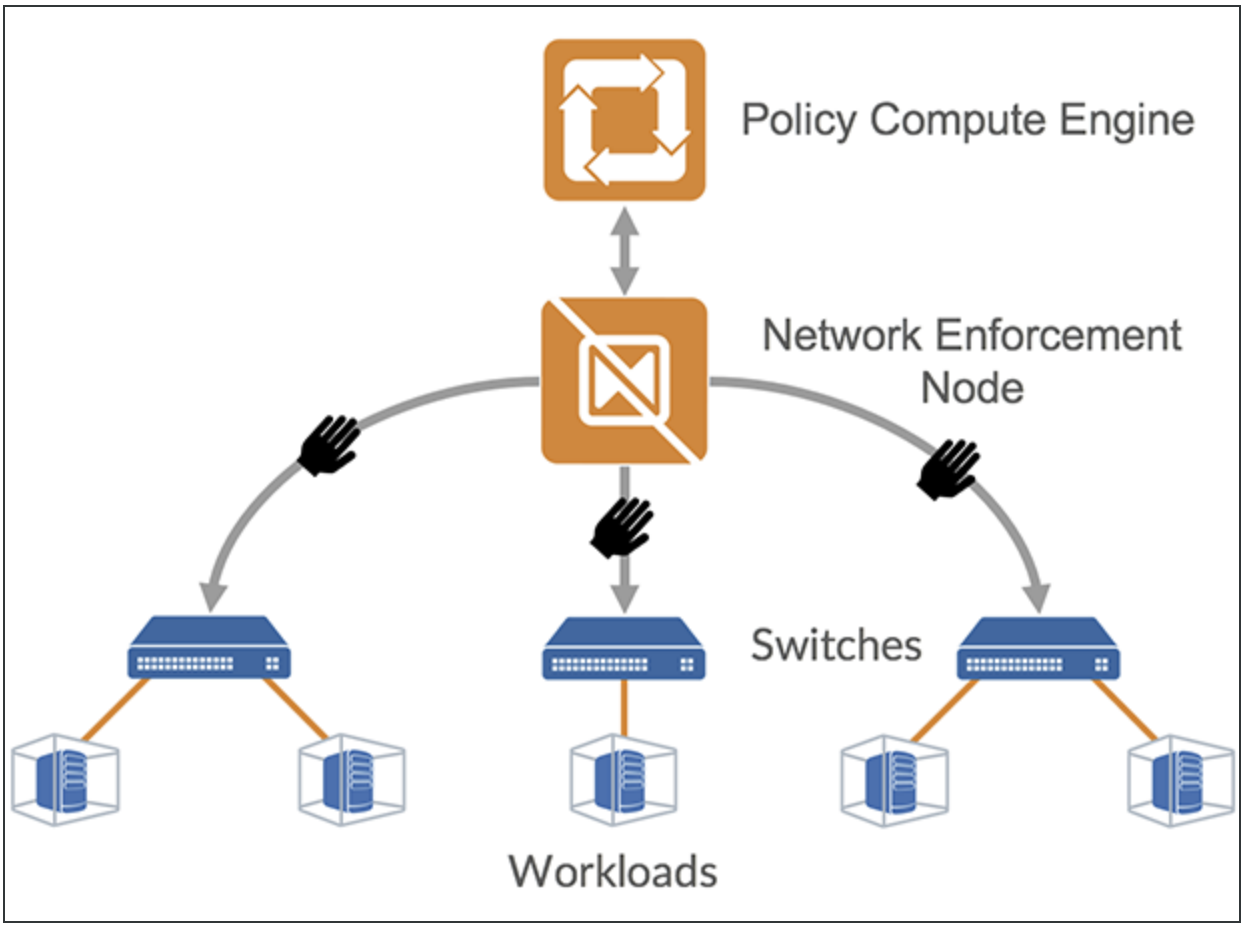
With the NEN, network administrators can configure their switches to send sFlow data to an sFlow collector, such as the NEN. An Illumio Core administrator can configure the NEN to listen for sFlow data from switches and associate workloads to those switches. The NEN receives sFlow data directly from the switches, summarizes it, and uploads it to the PCE. You can view this traffic flow in the Illumination® map and stream it out of the PCE through UDP in Splunk, CEF, or LEEF formats.



Extended Policy Model

The Illumio policy model encompasses workloads with native stateful firewalls built-in, such as Linux iptables or Windows Filtering Platform. Although all systems might not have a firewall built in, they still have segmentation requirements. To solve this use case, Illumio has extended its policy model to switches.

Illumio administrators can use the NEN to convert natural language policies into ACLs, which the switches understand natively. Your organization's teams that use Illumio Core can download ACLs from the PCE and provide them to the networking team for review before applying new policies to the switches.



Limitations for Switch Integration

This release is subject to the following limitations:

- You must provide a switch IP address and an interface traffic flow ID for interfaces that need to be monitored for sFlow data.
- The NEN discards sFlow data from an interface that it does not monitor.
- The Illumio Core generates only IPv4 ACLs that can be applied to either the L3/Routed interfaces or Switch Virtual Interface (SVI) for L2 interfaces when they are a member of a VLAN. Whenever ACLs are applied to

the SVI, workloads within the same VLAN can freely communicate regardless of policy.

This is a limitation of IPv4 ACLs on switches. Inter-VLAN or routed traffic will still be filtered by ACLs.

Requirements for Switch Integration

- Illumio-provided PCE 20.2.0 or later and NEN 2.1.0 (includes NFC) software packages.
- Cisco Nexus 9200 or 9300 or Arista 7000 series switch.
- Workloads that are directly attached to the switch on L2 or L3 ports or on port channels.

NOTE:
The NEN targets top-of-rack (TOR) switches that are directly attached to the workload and not the core switches. For example, Cisco Nexus 9200 and 9300 (TOR) switches are supported, but the Cisco 9500 series switches are not supported.

Workflow for Setting up NEN Switch Integration

This following is an overview of the steps required for working with the NEN for switch integration:

1. In the PCE web console:
   a. Define the switches.
   b. Create unmanaged workloads.
   c. Assign those unmanaged workloads to switch interfaces.
   d. Create security policy rules to protect the workloads attached to the switches.
2. Use the PCE REST API or the PCE web console to generate switch ACLs based on your organization's security policies.
3. Copy and paste the generated ACLs to configure the switch via the switch's command line.

4. Using the PCE REST API or the PCE web console, inform the PCE that the ACLs have been loaded.

Result: The PCE-generated ACLs on the switch will protect the target workloads.

Supported Switches and Configurations

The following switches are supported in this release:

- Cisco Nexus 9200 and 9300 series
- Arista 7000 series

Switch Configuration

The following ACL and interface configurations are supported for the Illumio NEN integration:

ACL Implementation	Switch Interfaces	ACL Type
Router ACL (RACL) RACLs support both inbound and outbound enforcement.	• VLAN interface (SVI) • Layer 3 physical interface • Layer 3 port-channel interface	IPv4

IMPORTANT:
Unsupported interface and ACL configurations

The NEN does not support:

- VLAN ACL (VACL) or Virtual Teletype (VTY) ACL as the ACL implementation
- VLAN trunk port (switchport mode trunk) or sub-interface as the switch interface
- MAC ACL type
- IPv6 ACL type
- PACLs for Layer 2 interfaces.

Administrative Access to the Switch

You or your network administrators need administrative access to your switches to configure them and load the NEN-generated ACLs.

NOTE:
The PCE and the NEN do not send any communication to the switch and never log into the switch. The PCE and the NEN do not require root or admin privileges on the switch.

Sufficient TCAM

Your switch's ternary content-addressable memory (TCAM) must be sufficient to store the IPv4 RACLs generated by the NEN.

NOTE:
Illumio does not provide a mechanism to check the TCAM depth or available memory for each platform. Your network or security administrators need to check whether the generated IP ACLs can be handled by the switch.

Enable sFlow

The NEN relies on sFlow to provide network traffic flow data for Illumination. Your switch must be configured with sFlow. See your vendor documentation for information.

Configure sFlow Output

The output of sFlow from the switch must be sent to the PCE so it can be monitored. The well-known port for sFlow is port UDP 6343. See Configure Switches for the NEN for information.

Network Connectivity between Switches and NEN

The NEN listens for sFlow from the switches.

> IMPORTANT:
> Ensure that your network is configured to allow communication between your switches and the NEN.

Switch Information

You need to provide switch-related information in the PCE web console. See the table listed in Add Unmanaged Workloads and Switch Definitions in the PCE Web Console for information.

Configure Switches for the NEN

sFlow on the switch must be configured to send its output to the NEN. In addition, the sFlow-monitored interfaces on the switch must be configured in the NEN service via the PCE web console. If the NEN service receives sFlow information from an unrecognized or undefined network endpoint (or interface), it will reject that information. The NEN service continually aggregates the sFlow traffic and sends the aggregated information to the PCE traffic collector every 10 minutes.

NOTE:
sFlow is only a sampling protocol, so all the flows might not be recorded. If the default sampling rate is not sufficient for your use case, see your vendor documentation.

Configure sFlow on Cisco Switch

Use the following (config)# commands to configure sFlow on a Cisco 9000 series switch:

1. Enable sFlow:

```
(config)# feature sflow
```

2. In the following command, the NEN_ip_address variable is the IP address of the NEN primary node:

```
(config)# sflow collector-ip NEN_ip_address vrf default
```

3. In the following command, the switch_IP_address variable is the IP address of the switch, which you will also use in the PCE web console. switch_IP is a management IP address.

```
(config)# sflow agent-ip switch_IP_address
```

4. In the following command, the interface_name_to_monitor variable is a mnemonic name that you have already defined on the switch for the interface, which you will also use in the PCE web console.

```
(config)# sflow data-source interface interface_name_to_monitor
```

5. Repeat the above sflow data-source interface command for all interfaces on the switch that you want to secure.

See Add Unmanaged Workloads and Switch Definitions in the PCE Web Console for information.

Example of sFlow Configuration for Cisco

```
nexus9000(config)# show run sflow

!Command: show running-config sflow

feature sflow

sflow collector-ip 10.10.10.1 vrf default
sflow agent-ip 10.20.20.1

sflow data-source interface Ethernet1/7
```

In this example:

- The IP address on the switch that can communicate with the PCE is 10.20.20.1.
- The PCE/NEN IP address (sFlow collector) is 10.10.10.1.
- A workload is directly attached to interface Ethernet 1/7.

Collect SNMP ifIndex Value for Cisco

When the switch reports sFlow to the NEN, it includes interface index details in the flow records. When the NEN receives sFlow, it parses the records and retains the records only for the interfaces you specify in the NEN configuration. You need to collect the ifindex IDs and add them to the NEN configuration later. You can determine your switches' SNMP ifIndex values using the following command:

```
# show interface snmp-ifindex
```

Manufacturer/Model	Command	Notes
Cisco 9000	In privileged mode: `show interface snmp-ifindex`	This command outputs the IFMIB (decimal) and the ifIndex (hex) values. You

Manufacturer/Model	Command	Notes
		need the IFMIB (decimal) value later. This value is required to configure **Monitor Traffic** for the NEN.

Example of Command Output

```
nexus9000# show interface snmp-ifindex
-------------------------------------------------------------------------------
------
Port   IFMIB      Ifindex (hex)
-------------------------------------------------------------------------------
------
mgmt0  83886080  (0x5000000)
Eth1/1 436207616 (0x1a000000)
Eth1/2 436208128 (0x1a000200)
Eth1/3 436208640 (0x1a000400)
Eth1/4 436209152 (0x1a000600)
Eth1/5 436209664 (0x1a000800)
Eth1/6 436210176 (0x1a000a00)
Eth1/7 436210688 (0x1a000c00)
Eth1/8 436211200 (0x1a000e00)
```

This example uses Ethernet 1/7 interface as an sFlow source interface. To enter the interface information in the PCE, collect the decimal value of the ifIndex. In case of the Cisco Nexus 9000, this value is in the **IFMIB** column of the command output. The command output above shows 436210688 as the IFMIB value for Ethernet 1/7 interface. This value is required to configure the **Monitor Traffic** field in the PCE configuration page.

Configure sFlow on Arista Switch

Use the following commands to configure sFlow on an Arista 7000 series switch:

1. Run sFlow (this command is similar to enabling sFlow on a Cisco switch):

```
sflow run
```

2. In the following command, the IP address is the destination PCE IP to which the sFlow information should be sent:

```
sflow destination 10.6.1.158
```

3. In the following command, the IP address is the source IP from where the sFlow information is sent:

```
sflow source 10.21.6.1
```

On an Arista switch, the list of sFlow command options are:

Command	Description
`destination`	Set sFlow collector destination.
`extension`	Configure sFlow extension settings.
`polling-interval`	Set polling interval (secs) for sFlow.
`qos`	Configure QoS parameters.
`run`	Run sFlow globally.
`sample`	Set sample characteristics for sFlow.
`source`	Set the source IP address.
`source-interface`	Configure the source interface for sFlow datagrams.
`vrf`	Configure VRFs.

Collect SNMP ifIndex Value for Arista

You can determine your Arista switches' SNMP ifIndex values using the following command:

```
arista7000# show snmp mib ifmib ifindex
Ethernet1: Ifindex = 1
Ethernet2: Ifindex = 2
```

```
Ethernet3: Ifindex = 3
Ethernet4: Ifindex = 4
Ethernet5: Ifindex = 5
Ethernet6: Ifindex = 6
Ethernet7: Ifindex = 7
Ethernet8: Ifindex = 8
```

Add Unmanaged Workloads and Switch Definitions in the PCE Web Console

To create a security policy, the switches and the workloads attached to them should be defined in the PCE web console as follows:

1. Log into the PCE web console.
2. Define the unmanaged workloads that are attached to the switch by selecting **Workloads and VENs > Workloads > Add > Add Unmanaged Workload**. You will associate these unmanaged workloads with their switches later.

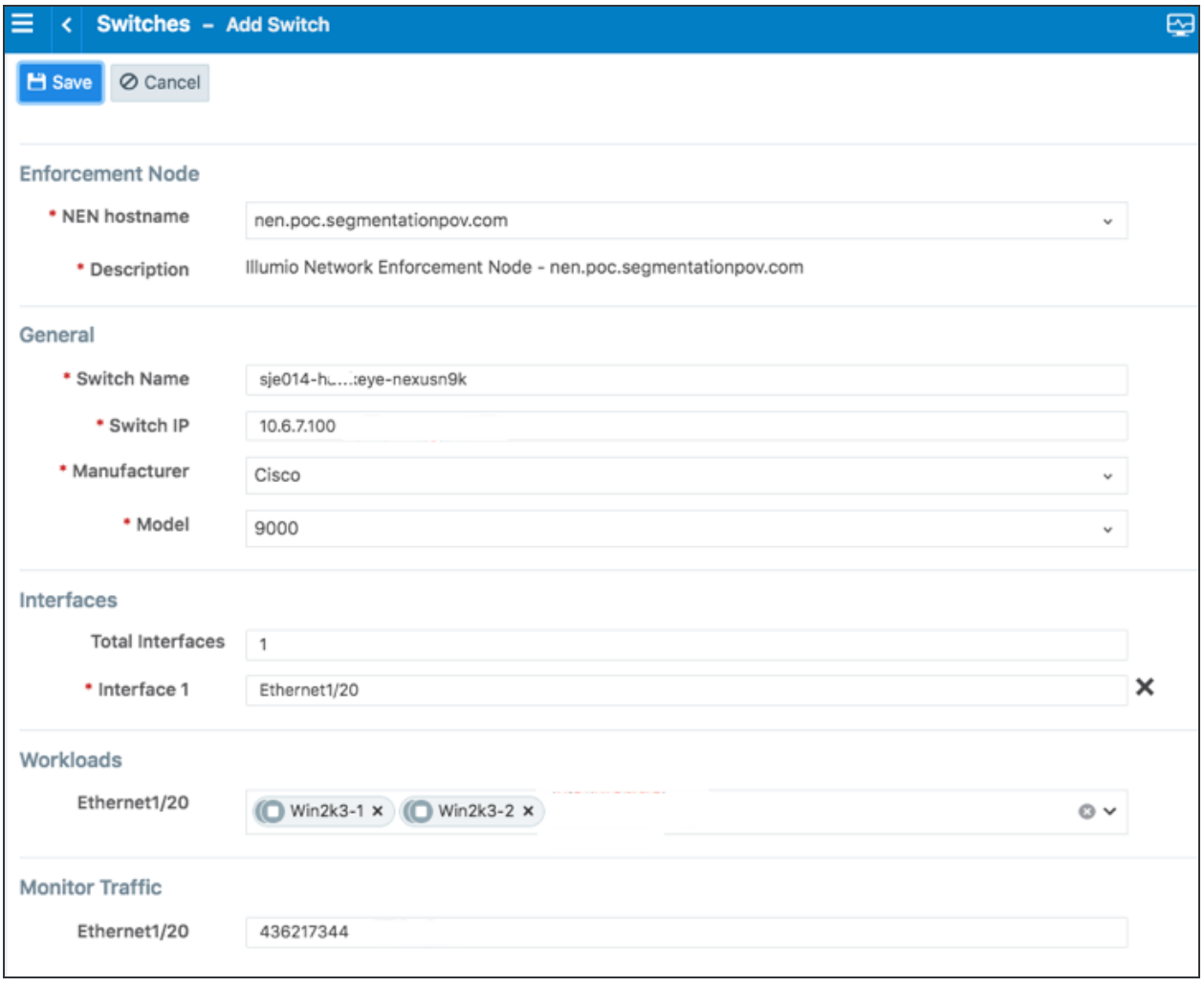
   See the *Security Policy Guide* for information on adding unmanaged workloads.
3. Define the switches and associated workloads, by selecting **Infrastructure > Switches**.
4. Click **Add**.
5. Enter the details in the displayed fields as described in the table below.
6. After entering or selecting values for all the required fields, click **Save**.

Fields in the **PCE web console > Infrastructure > Switches > Add Switch** page:

Field Name	Description	Required	Notes
NEN host-name	FQDN of the NEN that runs the NEN service	Yes	This field is populated with the FQDN of your NEN. You cannot edit this field.
Description	Description of the NEN service	Yes	This field is populated with "Illumio Network Enforcement

Field Name	Description	Required	Notes
			Node" and the FQDN of your PCE. You cannot edit this field.
Switch Name	A free-form, mnemonic name of your choice for the switch	Yes	Make this name easy to remember and distinguishable from other switch names.
Switch IP	IP address of the switch	Yes	Corresponds to switch_IP_address that you defined in Configure sFlow on Cisco Switch. It is also known as sflow agent-ip in Cisco switches.
Manufacturer	Name of the switch manufacturer	Yes	Select Cisco.
Model	Model number of the switch	Yes	Select 9000.
Interfaces	Defined interfaces on the switch	No	Corresponds to interface_name_to_monitor you defined on the switch and configured in Configure sFlow on Cisco Switch. This can be a custom string. You can also add interfaces that are not monitored by sFlow.
Workloads	Names of workloads connected to the switch's defined interfaces	No	Only those workloads assigned to the switch interfaces are secured. You can attach one or more workloads to an interface.

Field Name	Description	Required	Notes
Monitor Traffic	SNMP ifIndex of the switch interface See Collect SNMP ifIndex Value for Cisco and Collect SNMP ifIndex Value for Arista.	Yes/No	If the interface is monitored by sFlow, the **Monitor Traffic** field is required.



NEN Switch Configuration Using REST API

To manage network switches reporting data flows to the NEN and to get the generated ACLs to enforce policies based on what's been defined in the PCE, you need to complete these tasks:

1. Get the list of switches and their details.
2. Generate the ACLs for one or all switches.
3. Print the ACLs in the desired format.

The sections below describe the manual steps, which can be inserted in any script to automate this process.

Get List of Switches and Details

To get the list of all the network switches registered against the NEN, run the following curl command:

```
curl -u api_xxx:xxx -H "Accept: application/json" -X
GET https://mypce.domain.io:8443/api/v2/orgs/1/network_devices
```

Result: Returns a list of switches with all the reported endpoints (ports, workloads) to the NEN.

Curl Command of Get List of Switches

```
curl -u api_
1853ebfcb1187acb4:9c2a381773a44e3a609448109278c02c4ec1fe597f9643af71a832c0
a8b0c0d0 -H "Accept: application/json" -X GET
https://mypce.domain.io:8443/api/v2/orgs/1/network_devices
```

Response

```
[
   {
      "network_enforcement_node" : {
```

```
         "href" : "/orgs/1/network_enforcement_nodes/f64e78b7-2917-409f-
9093-9d6ddaa35799"
      },
      "href" : "/orgs/1/network_devices/f07a077a-70ad-4b57-b82a-
f1d204fcfd99",
      "configure" : false,
      "network_endpoints" : [
         {
            "href" : "/orgs/1/network_devices/f07a077a-70ad-4b57-b82a-
f1d204fcfd99/network_endpoints/1ff6f037-d644-438e-ab32-019a45a7d8d5"
         },
         {
            "href" : "/orgs/1/network_devices/f07a077a-70ad-4b57-b82a-
f1d204fcfd99/network_endpoints/dd687e16-6998-4a39-8bde-a7fb445f18d9"
         },
         {
            "href" : "/orgs/1/network_devices/f07a077a-70ad-4b57-b82a-
f1d204fcfd99/network_endpoints/7345aed3-1fbd-4596-ada9-f6cbfb361dfe"
         },
         {
            "href" : "/orgs/1/network_devices/f07a077a-70ad-4b57-b82a-
f1d204fcfd99/network_endpoints/be58f614-7cc7-4132-a409-97ea8334dfeb"
         }
      ],
      "enforcement_instructions_data_timestamp" : "2019-05-06T15:45:02Z",
      "enforcement_instructions_data_href" : "/orgs/1/datafiles/49b11cf6-
d6f9-4efc-8cb2-c1a444cb9c02",
      "supported_endpoint_type" : "switch_port",
      "config" : {
         "model" : "9000",
         "name" : "cisco-n9k",
         "rules_format" : "cli",
         "ip_address" : "10.1.2.3",
         "device_type" : "switch",
         "manufacturer" : "Cisco"
      },
      "status" : "unmonitored"
```

```
  }
]
```

Generate ACLs for Switches

To generate ACLs for a specific switch registered against the NEN, run the following curl command:

```
curl -u api_xxx:xxx -H "Content-Type: application/json" -d {} -X POST
https://mypce.domain.io:8443/api/v2/orgs/1/network_devices/xxxxxxx-xxxx-
xxxx-xxxx-xxxxxxxx/enforcement_instructions_request
```

NOTE:
Replace the xxx-...-xxx value with the value of the switch for which you intend to generate ACLs.

Curl Command Using Generate ACLs

```
curl -u api_
1853ebfcb1187acb4:9c2a381773a44e3a609448109278c02c4ec1fe597f9643af71a832c0
a8b0c0d0 -H "Content-Type: application/json" -d {} -X POST
https://mypce.domain.io:8443 -d {} -X POST
https://mypce.domain.io:8443/api/v2/orgs/1/network_devices/f07a077a-70ad-
4b57-b82a-f1d204fcfd99/enforcement_instructions_request
```

Result: Response with a 202 status code = Accepted.
The ACLs are generated on the NEN and are ready for use in a few minutes.

IMPORTANT:
API POST Requirements

While sending a POST request, you must include the header (-H) flag and the data (-d) flag. Even if you do not have any data to send, you must insert an empty data flag, as shown in the above example.

NOTE:
Illumio recommends that you insert a pause in any script to allow the NEN to generate the new ACLs for the specific switch. It takes approximately 30 seconds to generate all the ACLs.

The PCE will not send any update or acknowledgment to the REST client once it is finished generating the new ACLs for the switch.

Alternatively, you might want to generate ACLs for all the switches in your inventory to deliver them to your network team, by using the all_devices: true key-value pair in your JSON payload while sending the POST request.

To generate ACLs for all the switches registered against the NEN, run the following curl command:

```
curl -u api_xxx:xxx -H "Content-Type: application/json" -d '{"all_
devices": true}' -X POST
https://mypce.domain.io:8443/api/v2/orgs/1/network_devices/multi_
enforcement_instructions_request
```

Get List of ACLs

To download ACLs for a specific switch registered against the NEN, get the updated value of the enforcement_instructions_data_href key. This value keeps changing because each time the NEN generates new ACLs for a switch, it is considered to be a new datafile.

1. To get the updated enforcement_instructions_data_href value for a network switch, run the following curl command:

```
curl -u api_xxx:xxx -H "Accept: application/json" -X
GET https://mypce.domain.io:8443/api/v2/orgs/1/network_
devices/enforcement_instructions_data_href'
```

   The above command returns a list of switches. You have to then parse the JSON output and filter on the enforcement_instructions_data_href key to get the updated value. You can use the JQ tool to filter outputs on any JSON file.

2. After you retrieve the updated value, use it in the following curl command to get the generated ACLs:

```
curl -u api_xxx:xxx -H "Accept: application/json" -X
GET https://mypce.domain.io:8443/api/v2/orgs/1/datafiles/xxxxxx-xxxx-
xxxx-xxxx-xxxxxxxxxxx
```

   Replace the xxx-...-xxx value with the value of the enforcement_instructions_data_href key that you got by running the previous GET request.

Example of Get List of ACLs

```
curl -u api_
1853ebfcb1187acb4:9c2a381773a44e3a609448109278c02c4ec1fe597f9643af71a832c0
a8b0c0d0 -H "Accept: application/json" -X GET
https://mypce.domain.io:8443/api/v2/orgs/1/network_devices/enforcement_
instructions_data_href' "/orgs/1/datafiles/d1bdbb23-60c4-439e-bd74-
ca0d03d959a7"
```

Output:

```
no ip access-list ILLUMIO_ACLS-Ethernet1-21-Inbound
p access-list ILLUMIO_ACLS-Ethernet1-21-Inbound
!---Inbound ACL Rules ---
       permit ip host 10.10.100.201 host 10.10.100.202
```

```
       permit ip host 10.10.100.201 host 10.10.100.203
       permit ip host 10.10.100.201 host 10.10.100.204
       permit tcp any any established
       permit udp any eq 68 any eq 67
       permit udp any range 1024 65535 any eq 53
       exit
                        ...
no ip access-list ILLUMIO_ACLS-VLAN-20-Outbound
ip access-list ILLUMIO_ACLS-VLAN-20-Outbound
!---Outbound ACL Rules ---
       permit ip host 10.10.100.201 host 10.10.100.204
       permit ip host 10.10.100.202 host 10.10.100.204
       permit ip host 10.10.100.203 host 10.10.100.204
       permit tcp any any established
       permit udp any eq 67 any eq 68
       permit udp any eq 53 any range 1024 65535
       exit
```

IBM iSeries Integration (AS/400)

This topic describes how to integrate IBM iSeries (AS/400) computers running Precisely Assure Security with your Illumio PCE. This integration differs from the typical switch integration in the following ways:

- Although the IBM iSeries is not a switch, you will use the PCE switch integration user interface to perform the integration.
- Instead of generating ACLs as you would do when integrating a switch, you'll generate a Precisely-formatted CSV file to configure relevant policy on your IBM iSeries AS/400 computer that is running Precisely.
- No flow information is collected from iSeries computers.

Add Unmanaged Workloads and IBM iSeries Definitions

To create a security policy, add unmanaged workloads representing each iSeries computer included in the PCE policy. A set of csv data is generated for

each configured iSeries unmanaged workload. To define the IBM iSeries computers and the workloads attached to them as unmanaged workloads in the PCE web console, complete the following steps:

1. Log into the PCE web console.
2. Define the iSeries computers as unmanaged workloads by selecting Workloads and **VENs > Workloads > Add > Add Unmanaged Workload**. You will associate these unmanaged workloads with their IBM Precisely integration later. See Workload Setup Using PCE Web Console in the *Security Policy Guide* for information on adding unmanaged workloads.
3. Define the IBM Precisely integration and associated workloads by selecting **Infrastructure > Switches**.
4. Click +Add.
5. Enter details:
    - **NEN hostname:** This field is populated with the FQDNs of the NENs paired with your organization's PCE. Select the appropriate NEN.
    - **Description:** This field is populated with "Illumio Network Enforcement Node" and the FQDN of the NEN. You cannot edit this field.
    - **Switch Name:** Enter a unique name that's easy to remember.
    - **Switch IP:** IP address of the IBM iSeries computer.
    - **Manufacturer:** Select IBM.
    - **Model:** Select Precisely.
6. Click **Save**.
7. Click **Interfaces**.
8. Click **Edit** and then enter details:
    - **Total Interfaces:** Enter 1.
    - **Interface 1:** Enter a name. For example, interface 1.
    - **Workloads:** Select the unmanaged workload representing the appropriate iSeries computer. Only workloads assigned to the IBM iSeries

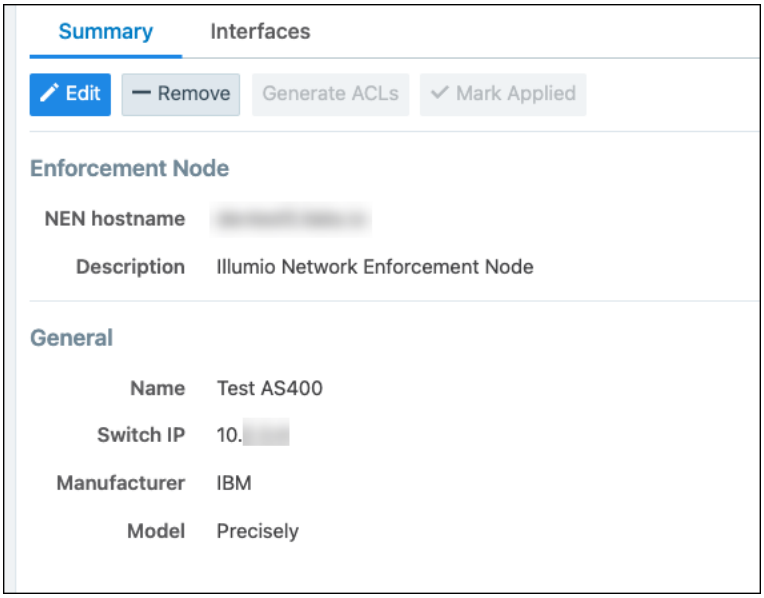
computer interfaces are secured. You can attach one or more workloads to an interface.

- **Monitor Traffic:** Ignore this setting. It doesn't apply to this integration.

9. Click **Save**.

NOTE:
If your unmanaged AS 400 computer has two or more network interfaces (workload/computer interfaces), the generated ACL file will include duplicate entries for Inbound Rules, one pair of entries for each interface. This is expected behavior.

Fields in the **PCE web console > Infrastructure > Switches > Add Switch page**:



Apply Policy for Switches

To apply the security policy, you need to:

1. Create the policy and generate ACLs for loading onto the switch.
2. Load the generated ACLs onto the switch.
3. Inform the PCE that the ACLs have been loaded onto the switch.

Create Security Policy

In the PCE web console, create label-based policies for the workloads that are bound to the switch ports. For information on how to create policies, see the *Security Policy Guide*.

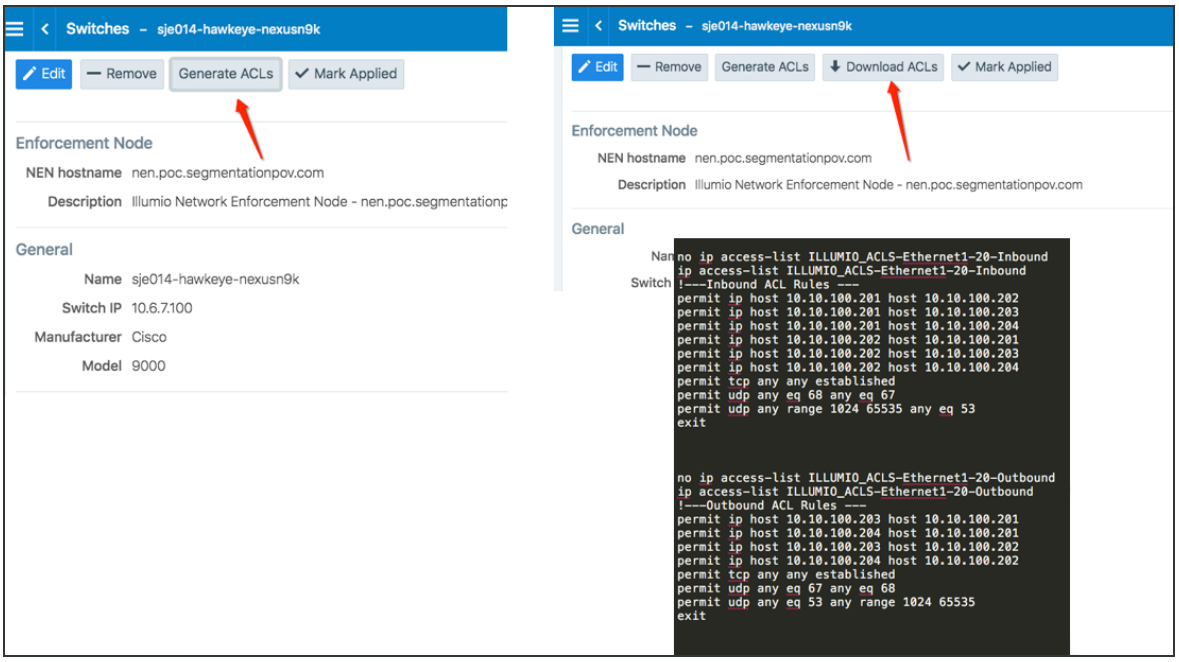
NOTE:
Make sure you provision the policies before generating the ACLs.

Generate and Download ACLs

After you have created new policies for the NEN-managed workloads and provisioned them in the PCE, you can generate the ACLs. The PCE writes those ACLs to its local files.

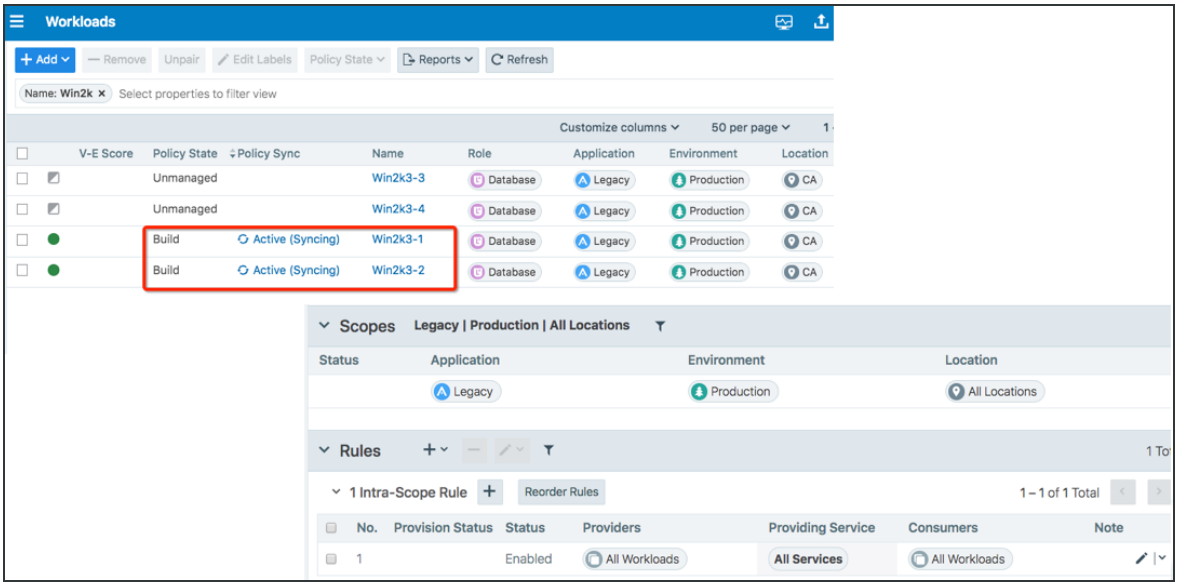
Create the associated switch ACLs as follows:

1. Log into the PCE web console.
2. From the PCE web console menu, choose **Infrastructure** > **Switches**.
3. Select the switch.
4. On the Switches page, click **Generate ACLs**. It takes a moment for the ACL generation to complete.
5. After the ACLs have been generated, click **Download ACLs** to download a .txt file of the updated ACLs from your web browser.
6. Go to the Downloads folder on your computer and open the .txt file. This file contains a list of inbound and outbound ACLs.



The workloads associated with the switch remain in an **Active (Syncing)** policy sync state until you click the **Mark Applied** button on the Switches page.

NOTE:
You might see a “Syncing” notification appear in the PCE web console until you mark the ACLs as **Applied**.



Apply ACLs on the Switch

After generating the ACLs from the NEN, you can copy the text of the ACLs from the PCE-generated files and paste them into the switch's command line to configure the ACLs on the switch. Each interface per direction requires a separate text file.

Example of Inbound and Outbound ACLs

The following ACLs are generated for only Ethernet 1/7 interface of a Cisco Nexus 9000:

```
no ip access-list ILLUMIO_ACLS-Eth1-7-Inbound
ip access-list ILLUMIO_ACLS-Eth1-7-Inbound
!---Inbound ACL Rules ---
permit tcp any any established
permit udp any eq 68 any eq 67
permit udp any range 1024 65535 any eq 53
exit


no ip access-list ILLUMIO_ACLS-Eth1-7-Outbound
ip access-list ILLUMIO_ACLS-Eth1-7-Outbound
!---Outbound ACL Rules ---
permit tcp host 10.6.4.94 host 10.0.17.17 eq 5432
permit tcp any any established
permit udp any eq 67 any eq 68
permit udp any eq 53 any range 1024 65535
exit
```

NOTE:
By default, the NEN generates ACLs to allow basic infrastructure services such as DHCP and DNS from all IP addresses in addition to the policies defined on the PCE. You cannot prevent DNS and DHCP ACLs from being generated by the NEN. If your network administrator does not want DHCP or DNS rules added to the switch, you can remove those ACL lines while copying the ACLs over to the switch.

To configure the ACLs on to the switch, the network administrator must log into the Cisco Nexus 9000 command line and go into configuration mode. Once in configuration mode, the ACLs can be copied from the NEN in to the switch command line as shown in this example:

```
nexus9000# conf
Enter configuration commands, one per line. End with CNTL/Z.
nexus9000(config)# no ip access-list ILLUMIO_ACLS-Eth1-7-Inbound
nexus9000(config)# ip access-list ILLUMIO_ACLS-Eth1-7-Inbound
nexus9000(config-acl)# !---Inbound ACL Rules ---
nexus9000(config-acl)# permit icmp host 10.0.17.17 0.0.0.0/0
nexus9000(config-acl)# permit tcp any any established
nexus9000(config-acl)# permit udp any eq 68 any eq 67
nexus9000(config-acl)# permit udp any range 1024 65535 any eq 53
nexus9000(config-acl)# exit
nexus9000(config)#
nexus9000(config)#
nexus9000(config)#
nexus9000(config)# no ip access-list ILLUMIO_ACLS-Eth1-7-Outbound
nexus9000(config)# ip access-list ILLUMIO_ACLS-Eth1-7-Outbound
nexus9000(config-acl)# !---Outbound ACL Rules ---
nexus9000(config-acl)# permit tcp host 10.6.4.94 host 10.0.17.17 eq 5432
nexus9000(config-acl)# permit tcp 0.0.0.0/0 host 10.0.17.17 eq 22
nexus9000(config-acl)# permit tcp any any established
nexus9000(config-acl)# permit udp any eq 67 any eq 68
nexus9000(config-acl)# permit udp any eq 53 any range 1024 65535
nexus9000(config-acl)# exit
```

After the ACLs have been added to the switch, they must be applied to an interface on the switch as either a PACL or a RACL. To take advantage of both inbound and outbound ACLs, this example uses RACLs. If the workload is directly attached to a Layer 2 interface (switchport mode access), you must apply the RACL to the VLAN/SVI interface. If the workload is directly attached to a Layer 3 interface (no switchport), the ACL can be directly applied to the physical interface (or port).

Optional Command to Verify the Interface Configuration

```
# show run interface ethernet x/y
```

Example of Command Usage for Ethernet 1/7

```
nexus9000(config)# show run int eth1/7

!Command: show running-config interface Ethernet1/7
!Time: Tue Oct 16 17:32:52 2018

version 7.0(3)I5(1)

interface Ethernet1/7
switchport
switchport access vlan 17
no shutdown
```

This interface is a Layer 2 interface and is part of VLAN 17. You must apply this to VLAN 17 interface (SVI).

NOTE:
For L2 interfaces, the VLAN must have a Switch Virtual Interface (SVI).

```
nexus9000(config)# interface vlan 17
nexus9000(config-if)# ip access-group ILLUMIO_ACLS-Eth1-7-Inbound in
nexus9000(config-if)# ip access-group ILLUMIO_ACLS-Eth1-7-Outbound out
```

Result: The ACLs are now configured on the switch and any communication through VLAN 17 will be denied if it is not permitted in the ACLs.

Mark ACLs as Applied

You have to inform the PCE after you have loaded the ACLs because the NEN service does not configure the generated ACLs on the switch.

1. Log into the PCE web console.
2. From the PCE web console menu, choose **Infrastructure** > **Switches**.
3. Select the switch.
4. On the Switch page, click **Mark Applied**.