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This documentation has all the details needed to fully configure your TNSR platform, from the basics of TNSR all the way to the complexities of implementing different applications. For quotes, updates, and more information about TNSR, please contact sales@netgate.com.
TNSR is an open-source based packet processing platform that delivers superior secure networking solution performance, manageability, and services flexibility. TNSR can scale packet processing from 1 to 10 to 100 Gbps, even 1 Tbps and beyond on commercial-off-the-shelf (COTS) hardware - enabling routing, firewall, VPN and other secure networking applications to be delivered for a fraction of the cost of legacy brands. TNSR features a RESTCONF API - enabling multiple instances to be orchestration managed - as well as a CLI for single instance management.

1.1 TNSR Secure Networking

TNSR is a full-featured software solution designed to provide secure networking from 1 Gbps to 400 Gbps. With graduated pricing based on performance increments, TNSR it a viable option for users with moderate bandwidth needs to the demanding requirements of enterprise and service providers.

Each licensed instance comes bundled with TNSR Technical Assistance from our 24/7 world-wide team of support engineers. Find out more about the included support available with TNSR.

Contact us to begin a conversation about how TNSR can help meet your needs.

1.2 TNSR Trial

A 120-day trial version is also available. You can visit the Trials page of tnsr.com to find out full details on how the trial works.

1.3 TNSR Architecture

TNSR runs on a Linux host operating system. Initial configuration of TNSR includes installing associated services and configuring network interfaces. It is important to note that network interfaces can be managed by the host OS or by TNSR, but not by both. In other words, once a network interface is assigned to TNSR, it is no longer available - or even visible - to the host OS.

A little background. TNSR is the result of Netgate development, using many open source technologies to create a product that can be supported and easily implemented in production environments.

Without TNSR, Linux systems use drivers to plumb the connections from hardware interfaces (NICs) to the OS kernel. The Linux kernel then handles all I/O between these NICs. The kernel also handles all other I/O tasks, as well as memory and process management.
In high I/O situations, the kernel can be tasked with servicing millions of requests per second. TNSR uses two open source technologies to simplify this problem and service terabits of data in user space. Data Plane Development Kit (DPDK) bypasses the kernel, delivering network traffic directly to user space, and and Vector Packet Processing (VPP) accelerates traffic processing.

In practical terms, this means that once a NIC is assigned to TNSR, that NIC is attached to a fast data plane, but it is no longer available to the host OS. All management - including configuration, troubleshooting and update - of TNSR is performed either at the console or via RESTCONF. In cloud or virtual environments, console access may be available, but the recommended configuration is still to dedicate a host OS interface for RESTCONF API access.

The recommended configuration of a TNSR system includes one host NIC for the host OS and all other NICs assigned to TNSR.
This is important and bears repeating:

- The host OS cannot access NICs assigned to TNSR
- In order to manage TNSR, you must be able to connect to the console

1.4 Technology Stack

TNSR is designed and built from the ground up, using open source software projects including:

- Vector Packet Processing (VPP)
- Data Plane Developer Kit (DPDK)
- YANG for data modeling
- Clixon for system management
  - Command Line Interface (CLI)
  - RESTCONF for REST API configuration
- FRR for routing protocols
- strongSwan for IPsec key management
- Kea for DHCP Services

See also:

What is Vector Packet Processing? Vector processing handles more than one packet at a time, as opposed to scalar processing which handles packets individually. The vector approach fixes problems that scalar processing has with cache efficiency, read latency, and issues related to stack depth/misses.

For technical details on how VPP accomplishes this feat, see the VPP Wiki.

1.5 Basic Assumptions

This documentation assumes the reader has moderate to advanced networking knowledge and some familiarity with the CentOS Linux distribution.
Use the following instructions to install TNSR 19.05 from an .ISO image. Ensure that the target hardware meets the minimum specifications for a TNSR Supported Platform.

1. Obtain the TNSR .iso image file from Netgate®.
2. Write the .iso image to bootable media (DVD or USB drive).
3. Connect to the system console.

**Note:** The installer supports both VGA and serial console output, with VGA as the default.

4. Boot the system using the TNSR image on DVD or USB.

**Note:** If the optical drive or removable media is not set as the primary boot device for the hardware, then use the system boot menu to manually select the boot device.

5. After a few seconds, the installer displays a TNSR 19.05 screen.
6. **Press any key**, such as `space`, to stop the 60-second timer. The menu contains, at minimum, the following two choices:
   - **Install TNSR (serial-console) <version>**: Select this option for hardware that uses serial port 0 for its console.
   - **Install TNSR <version>**: Select this option for installation via VGA console
7. Highlight the correct option for this hardware and press `Enter` to begin the installation of TNSR. It may take a few seconds for the installer to display output to the console.

**Note:** If the console does not display a visual indication of which item is selected, reboot the device and use the BIOS boot selection menu to choose UEFI as the boot method. For example, on the SG-5100, press `Esc` during POST to access this menu, and of the two entries in the menu for the USB drive, choose the line that starts with **UEFI:***.

8. Once Anaconda launches, it displays a menu labeled **Installation** with nine choices. All options marked with `[!]` must be configured to resolve all installation requirements.

**Note:** Some items marked with a `!` will resolve on their own a few moments after the installer launches, such as options 3 and 4. Wait a few moments and enter `r` to refresh the screen.
At a minimum, configure 2) **Time Settings**, 5) **Installation Destination**, and an administrator account with 9) **User creation** to allow the installer to proceed. These are covered next.

9. Configure the time zone
   - Enter 2 to start the time zone configuration process.
   - Enter 1 to enter the time zone selection screen.
   - Continue through the available options until the correct zone is located. For example, Enter 3 for America, then 36 for Chicago.
   - Enter the number corresponding to the region and zone, or type out the zone name. After selecting a zone, the installer will return to the main menu.

10. Configure the installation destination.
    - Enter 5 to start the installation destination configuration process.
    - Select the correct target disk on the next screen. The installer will select the disk automatically when only one is present.
    - Enter c to continue.
    - Choose how to partition the disk. The default **Use All Space** is the best practice.
    - Enter c to continue.
    - Choose the partition scheme. The default **LVM** is the best practice.
Starting installer, one moment...

anaconda 21.48.22.147-1 for TNSR started.

* installation log files are stored in /tmp during the installation
* shell is available on TTY2
* when reporting a bug add logs from /tmp as separate text/plain attachments

18:03:25 Not asking for UNC because we don't have a network

Installation

1) [x] Language settings
   (English (United States))
2) [ ] Time settings
   (Timezone is not set.)
3) [x] Installation source
   (Local media)
4) [x] Software selection
   (TNSR Install)
5) [ ] Installation Destination
   (No disks selected)
6) [x] Kdump
   (Kdump is enabled)
7) [ ] Network configuration
   (Not connected)
8) [x] Root password
   (Root account is disabled.)
9) [ ] User creation
   (No user will be created)

Please make your choice from above ['q' to quit | 'b' to begin installation | 'r' to refresh]:

Fig. 2: TNSR 19.05 Setup Menu
• Enter c to finish and return to the main menu.

11. Add an administrator account.

**Note:** Security best practices dictate that it is best not to enable interactive logon for the root account. As such, the root account will be locked out after the installation. Use this process to add at least one alternate administrator account.

• Enter 9 to start the user configuration process.
• Enter 1 to create a new user.
• Enter 3 to enter the username.
• Enter 4 to configure the account to use a password.
• Enter 5 to set and confirm the password for the user.
• Enter 6 to mark the user as an Administrator.
• Enter c to finish and return to the main menu.

12. Optionally configure a Host OS interface.

This will enable a network interface in the host OS for use as a management interface. This interface can then be used to access the system for troubleshooting or maintenance.

**Warning:** Though this is technically optional, using a management interface is the best practice.

• Enter 7 to start the interface configuration.
• Choose one of the listed network interfaces.
• Configure interface parameters on this screen as needed, such as a static IP address.

**Note:** The default behavior is to use DHCP to obtain the interface address. If this is the desired behavior, then leave the address options as-is.

• Enter 7 to enable **Connect automatically after reboot**.
• Enter 8 to enable **Apply configuration in installer**.
• Enter c to complete the interface configuration and continue back to the interface list.
• Enter c again to exit the network configuration.

13. Once all options with [!] have been resolved, enter b from the main menu to begin the installation. Messages are displayed indicating the progress of the installation. When the installer finishes its tasks, it displays message that says **Installation complete. Press return to quit**. At that point, press Enter and the system will reboot.

**Note:** The installer may spend several minutes displaying the message **Performing post-installation setup tasks**, but it will eventually continue.

14. When the system is restarting, remove the DVD or USB drive while the system reboots. CentOS 7 will start up automatically from the disk to which it was installed. If the installation media remains inserted, the system may boot into the installer again.
Note: The boot options in the system BIOS may need changed if it does not boot automatically into CentOS 7.

15. After the system finishes rebooting, log in with the user and password chosen during the installation.

Note: Once the system reboots, network interfaces not configured in the installer will be disabled in CentOS. Depending on the hardware, these interfaces may automatically be enabled in TNSR. If TNSR does not see any interfaces, they will need to be manually configured in TNSR. See Setup NICs in Dataplane for details.

Tip: One network interface should be enabled in the host OS as a management interface to allow access to the system for troubleshooting or maintenance. This can be configured in the installer, as mentioned above, or afterward.
After the installation completes and TNSR boots for the first time, TNSR has an empty default configuration. This means that TNSR has no pre-configured interfaces, addresses, routing behavior, and so on.

The host OS defaults are set during installation, and depend on the base OS, CentOS 7.5. For example, host management interfaces may have been configured by the installer.

### 3.1 Default Accounts and Passwords

By default, the TNSR installation includes host OS accounts for `root` with interactive login disabled, and a `tnsr` account.

For ISO installations, the best practice is to create at least one additional initial administrator account during the installation process. That user is custom created by the person performing the installation, and thus is not a common default that can be listed here.

**Warning:** When installing TNSR from an ISO image, the installer allows the `root` account to be unlocked and assigned a password. The best practice, however, is to leave the `root` account locked and create at least one additional administrator account using the installer. These additional accounts may use `sudo` to elevate privileges. Any users added to the `wheel` group later may also use `sudo` to execute commands as `root`.

The default behavior of the `tnsr` account varies by platform:

- **ISO/Bare Metal** The `tnsr` user is available with a default password of `tnsr-default`.

- **Appliances Shipped with TNSR Pre-installed** The `tnsr` user is available with a default password of `tnsr-default`.

- **AWS** The `tnsr` account is present but restricted to key-based authentication via ssh, using a key selected when launching the TNSR instance.

- **Azure** The `tnsr` account is present but restricted to key-based authentication via ssh, using a key selected when launching the TNSR instance.

The password for the `tnsr` account can be reset by any other account with access to `sudo`. For example, the command `sudo passwd tnsr` will prompt to set and confirm a new password for the `tnsr` user. The same action may also be performed for the `root` account (`sudo passwd root`). As mentioned in the previous warning, it is best to leave interactive logins for `root` disabled.

**Warning:** Change default passwords, even randomized default passwords or passwords pre-configured when launching a cloud-based instance, after the first login. Do not leave default passwords active!
Note: User authentication is performed by the host OS. Though users may be created inside TNSR (User Management), these users are propagated to the host. To control what users may access, see NETCONF Access Control Model (NACM).

3.2 Default TNSR Permissions

By default, there is no TNSR configuration present. As such, there are no pre-configured access permissions for users to restrict access to TNSR. Thus, any operating system user on the TNSR host will be able to reach the TNSR CLI and make changes.

To restrict which accounts have access to TNSR, see NETCONF Access Control Model (NACM).

3.3 Default Allowed Traffic

For the default behavior of allowed traffic to and from TNSR, there are two separate areas to consider:

- Traffic flowing through TNSR
- Traffic for the host OS management interface

3.3.1 TNSR

By default, there is no TNSR configuration present. As such, there are no default access lists (ACLs) and once TNSR is able to route traffic, all packets flow freely. See Access Lists for information on configuring access lists.

3.3.2 Host OS

The TNSR installation configures a default set of Netfilter rules for the host OS management interface. The following traffic is allowed to pass into and out of the host operating system interfaces:

- ICMP / ICMP6
- ssh (TCP/22)
- HTTP (TCP/80)
- HTTPS (TCP/443)
- BGP (TCP/179)
- ISAKMP (UDP/500)
- NTP (UDP/123, TCP/123)
- DNS (UDP/53, TCP/53)
- SNMP (UDP/161)
- DHCP Server (UDP/67)
- UDP Traceroute (UDP ports 33434-33524 with TTL=1)

To manage host ACLs which can override this behavior, see Host ACLs.
This document is a crash course in getting TNSR up and running quickly after installation. The topics included here are covered in more detail throughout the remainder of the documentation.

Each section contains a list of additional related resources with more detail in a See Also box. Follow these links for more information on each topic.

### 4.1 First Login

When TNSR boots, it will present a login prompt on the console (video and serial). Login at this prompt using either the default tnsr account or an administrator account created during the installation process.

**Note:** For installations from ISO and for hardware shipped with TNSR preinstalled, the default password for the tnsr user is tnsr-default. For cloud-based installs such as AWS and Azure, by default the tnsr account can only login with key-based ssh authentication. See Default Accounts and Passwords for more information.

The tnsr user automatically enters the TNSR CLI when used to login interactively. Manually created administrative users do not have this behavior, and using them to login interactively will result in a login shell.

Alternately, if the host OS management interface was configured in the installer, login using an SSH client connecting to that interface.

**See also:**
- Installation
- Default Accounts and Passwords

#### 4.1.1 Changing the Password

The password for administrator accounts was set during the installation process, but the default tnsr account should have its password reset before making other changes.

Login to the tnsr account with the default tnsr-default password and change it using the shell passwd command from the TNSR CLI:

```
tnsr# shell passwd
Changing password for user tnsr.
Changing password for tnsr.
(current) UNIX password:
New password:
```

(continues on next page)
Retype new password: 
passwd: all authentication tokens updated successfully. 
tnsr# 

Alternately, login in as an administrator and change the password for the default tnsr account using sudo from the shell:

```
$ sudo passwd tnsr
Changing password for user tnsr.
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
```

**Warning:** Use a strong password for this account as it will be able to make changes to the TNSR configuration, unless restricted by a custom NACM configuration.

See also:
- Installation
- Default Accounts and Passwords
- NETCONF Access Control Model (NACM)

### 4.2 Interface Configuration

There are two types of interfaces on a TNSR system: Host OS interfaces for managing the device and dataplane interfaces which are available for use by TNSR.

#### 4.2.1 Host OS Management Interface

A host management interface must be configured manually in the installer, or later in CentOS. See Installation for the full procedure to configure a host OS management interface during installation.

At a minimum, the host OS must have an interface address, subnet mask, and a default gateway configured. The default gateway is necessary so that the host OS may retrieve updates as that traffic does not flow through TNSR, but over the management interface. Additionally, other host traffic may flow through the management interface, such as the ping command from within the TNSR CLI.

If an interface was not configured for management in the installer, it will need to be manually changed back to host OS control and then configured for network access. See Remove TNSR NIC for Host Use for instructions on how to return an interface from TNSR back to host OS control so it can be used for management. This procedure will require rebooting the TNSR device.

Consult CentOS 7.5 documentation for the specifics of network configuration for other environments.

See also:
- Installation
- Disable Host OS NICs for TNSR
- Remove TNSR NIC for Host Use
4.2.2 Dataplane Interfaces

Interfaces not configured for host OS management control in the installer will be setup in such a way that they are available for use by the dataplane and thus TNSR.

Enter the TNSR CLI (Entering the TNSR CLI) and configure the network interfaces:

```
      tnsr# configure
      tnsr(config)# dataplane dpdk dev ?
      0000:00:14.0 Ethernet controller: Intel Corporation Ethernet Connection I354 (rev 03)
      0000:00:14.1 Ethernet controller: Intel Corporation Ethernet Connection I354 (rev 03)
      0000:00:14.2 Ethernet controller: Intel Corporation Ethernet Connection I354 (rev 03)
      0000:00:14.3 Ethernet controller: Intel Corporation Ethernet Connection I354 (rev 03)
      0000:03:00.0 Ethernet controller: Intel Corporation I211 Gigabit Network Connection (rev 03)
      0000:04:00.0 Ethernet controller: Intel Corporation I211 Gigabit Network Connection (rev 03) ( Active Interface enp4s0 )
      tnsr(config)# dataplane dpdk dev 0000:00:14.1 network
      tnsr(config)# dataplane dpdk dev 0000:00:14.2 network
      tnsr(config)# service dataplane restart
      tnsr(config)# exit
```

See also:

- Installation
- Setup NICs in Dataplane

4.3 TNSR Interfaces

Next, the interfaces inside TNSR must be configured with addresses and routing.

4.3.1 WAN DHCP Client

In this example, WAN will be set as a DHCP client and configured as the outside NAT interface:

```
      tnsr# configure terminal
      tnsr(config)# interface GigabitEthernet0/14/1
      tnsr(config-interface)# description Internet
      tnsr(config-interface)# dhcp client ipv4
      tnsr(config-interface)# enable
      tnsr(config-interface)# ip nat outside
      tnsr(config-interface)# exit
      tnsr(config)# exit
```

See also:

- DHCP Client Example
- Configure Interfaces
4.3.2 LAN Interface

Next, configure an address for the internal network and set it as the inside NAT interface:

```
tnsr(config)# interface GigabitEthernet0/14/2
tnsr(config-interface)# ip address 172.16.1.1/24
tnsr(config-interface)# description Local
tnsr(config-interface)# ip nat inside
tnsr(config-interface)# enable
tnsr(config-interface)# exit
```

See also:

- Configure Interfaces

4.4 NAT

Configure TNSR to use the WAN interface address for NAT, and enable NAT forwarding:

```
tnsr(config)# nat pool interface GigabitEthernet0/14/1
tnsr(config)# nat global-options nat44 forwarding true
```

See also:

- Network Address Translation
- NAT Pool Addresses
- NAT Forwarding

4.5 DHCP Server

Setup a basic DHCP server on the LAN side to hand out addresses, also instruct clients to use TNSR as their gateway and DNS server.

```
tnsr(config)# dhcp4 server
tnsr(config-kea-dhcp4)# description LAN DHCP Server
tnsr(config-kea-dhcp4)# interface listen GigabitEthernet0/14/2
tnsr(config-kea-dhcp4)# subnet 172.16.1.0/24
tnsr(config-kea-subnet4)# pool 172.16.1.100-172.16.1.245
tnsr(config-kea-subnet4-pool)# exit
tnsr(config-kea-subnet4)# interface GigabitEthernet0/14/2
tnsr(config-kea-subnet4)# option domain-name-servers
  tnsr(config-kea-subnet4-opt)# data 172.16.1.1
  tnsr(config-kea-subnet4-opt)# exit
tnsr(config-kea-subnet4)# option routers
  tnsr(config-kea-subnet4-opt)# data 172.16.1.1
  tnsr(config-kea-subnet4-opt)# exit
tnsr(config-kea-subnet4)# exit
tnsr(config-kea-dhcp4)# exit
```

See also:

- Dynamic Host Configuration Protocol
4.6 DNS Server

Configure TNSR to act as a DNS server for local clients, using upstream forwarding DNS servers of 8.8.8.8 and 8.8.4.4:

```
    tnsr# configure
    tnsr(config)# unbound server
    tnsr(config-unbound)# interface 127.0.0.1
    tnsr(config-unbound)# interface 172.16.1.1
    tnsr(config-unbound)# access-control 172.16.1.0/24 allow
    tnsr(config-unbound)# forward-zone .
    tnsr(config-unbound-fwd-zone)# nameserver address 8.8.8.8
    tnsr(config-unbound-fwd-zone)# nameserver address 8.8.4.4
    tnsr(config-unbound-fwd-zone)# exit
    tnsr(config-unbound)# exit
    tnsr(config)# unbound enable
```

See also:

- DNS Resolver

4.7 Ping

4.7.1 From the Host

The TNSR CLI includes a ping utility which will send an ICMP echo request out.

```
    tnsr# ping 203.0.113.1
    PING 203.0.113.1 (203.0.113.1) 56(84) bytes of data.
    64 bytes from 203.0.113.1: icmp_seq=1 ttl=64 time=0.680 ms
    64 bytes from 203.0.113.1: icmp_seq=2 ttl=64 time=0.176 ms
    64 bytes from 203.0.113.1: icmp_seq=3 ttl=64 time=0.505 ms
    64 bytes from 203.0.113.1: icmp_seq=4 ttl=64 time=0.453 ms
    64 bytes from 203.0.113.1: icmp_seq=5 ttl=64 time=0.420 ms
    64 bytes from 203.0.113.1: icmp_seq=6 ttl=64 time=0.144 ms
    64 bytes from 203.0.113.1: icmp_seq=7 ttl=64 time=0.428 ms
    64 bytes from 203.0.113.1: icmp_seq=8 ttl=64 time=0.494 ms
    64 bytes from 203.0.113.1: icmp_seq=9 ttl=64 time=0.163 ms
    64 bytes from 203.0.113.1: icmp_seq=10 ttl=64 time=0.346 ms

    --- 203.0.113.1 ping statistics ---
    10 packets transmitted, 10 received, 0% packet loss, time 9000ms
    rtt min/avg/max/mdev = 0.144/0.380/0.680/0.167 ms

    tnsr#
```

By default this will follow the host OS routing table, but by specifying a source address, it will use addresses from TNSR:

```
    tnsr# ping 203.0.113.1 source 203.0.113.2
    PING 203.0.113.1 (203.0.113.1) from 203.0.113.2 : 56(84) bytes of data.
    64 bytes from 203.0.113.1: icmp_seq=1 ttl=64 time=0.700 ms
    64 bytes from 203.0.113.1: icmp_seq=2 ttl=64 time=0.353 ms
    64 bytes from 203.0.113.1: icmp_seq=3 ttl=64 time=0.590 ms
    64 bytes from 203.0.113.1: icmp_seq=4 ttl=64 time=0.261 ms
```

(continues on next page)
64 bytes from 203.0.113.1: icmp_seq=5 ttl=64 time=0.395 ms
64 bytes from 203.0.113.1: icmp_seq=6 ttl=64 time=0.598 ms
64 bytes from 203.0.113.1: icmp_seq=7 ttl=64 time=0.490 ms
64 bytes from 203.0.113.1: icmp_seq=8 ttl=64 time=0.790 ms
64 bytes from 203.0.113.1: icmp_seq=9 ttl=64 time=0.155 ms
64 bytes from 203.0.113.1: icmp_seq=10 ttl=64 time=0.430 ms

--- 203.0.113.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 900ms
rtt min/avg/max/mdev = 0.155/0.476/0.790/0.187 ms

See also:
  • Diagnostic Utilities

4.7.2 From LAN Client

At this stage a LAN client will be able to connect to the network (port or switch) connected to the LAN interface. It can pull an IP address and other configuration via DHCP, resolve domain names via DNS, and reach hosts beyond TNSR using it as a gateway.

A ping executed on a client will flow through TNSR and replies will return.

4.8 Save the TNSR Configuration

TNSR maintains three separate configuration databases: startup, candidate, and running. The running copy is the active configuration. TNSR loads the startup copy at boot time.

To ensure the expected configuration is loaded when TNSR is rebooted, copy the running configuration to the startup configuration after making changes:

```
tnsr# configure
tnsr(config)# configuration copy running startup
```

Optionally, create a backup copy of the configuration which can be loaded later if necessary:

```
tnsr(config)# configuration save running backup.xml
```

See also:
  • Configuration Database
  • Configuration Backups

4.9 Next Steps

From here, click the Next button at the bottom of the page to continue on to the next section of the documentation, or choose a topic from the table of contents to the left.

Other suggested next steps include:
  • Configure updates (non-trial version only)
  • See more practical examples, such as setting up the RESTCONF API

4.8. Save the TNSR Configuration
• Configure *IPsec tunnels*
• Configure *time synchronization*
CHAPTER FIVE

COMMAND LINE BASICS

The TNSR command line interface (CLI) may seem familiar to administrators who are familiar the CLI of other routers or networking equipment. However, the specific behavior and structure of the TNSR CLI differs in several aspects.

Tip: For a full TNSR CLI command reference, visit Commands.

5.1 Working in the TNSR CLI

5.1.1 Command Prompt

The TNSR CLI command prompt has a several components:

<hostname> tnsr<(mode)># <user input>

These components are:

- **hostname** The fully qualified hostname of the router.
- **mode** This section of the prompt changes depending on the current mode to indicate that a different subset of commands is available.

See also:
For a list of modes and prompt strings, see Mode List.

- **user input** This area is where a user enters commands and other input.

In this brief example, the router hostname is router, and the mode section of the prompt is shown changing when a command enters or exits a mode.

```
router tnsr# configure
router tnsr(config)# interface GigabitEthernet3/0/0
router tnsr(config-interface)# description Management
router tnsr(config-interface)# exit
router tnsr(config)# exit
router tnsr#
```

5.1.2 Command History

The TNSR CLI stores the last 300 commands across sessions. This command history is kept in ~/.tnsr_history.
The command history is accessed by pressing Ctrl-P (previous command), Ctrl-N (next command), or by using the up and down arrow keys.

5.1.3 Autocomplete

The TNSR CLI supports case-sensitive tab expansion and prediction for input to speed up interactive work. For example, the first few letters of a command or entity may be typed, depending on context, and then pressing the tab key will complete a portion or all of the remaining input where possible. Additionally, in cases when there is an existing entry or only one possible choice, pressing tab will automatically insert the entire entry. Commands or entities may also be shortened provided the input is not ambiguous.

Tip: Press ? to show possible completions of the current command when in the middle of a word, or press it between words to show the next available parameter (Finding Help).

5.1.4 Keyboard Shortcuts

The TNSR CLI supports several CLI navigation and editing key combinations, including:

<table>
<thead>
<tr>
<th>Command</th>
<th>Keys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous History Command</td>
<td>Ctrl-P or up arrow</td>
</tr>
<tr>
<td>Next History Command</td>
<td>Ctrl-N or down arrow</td>
</tr>
<tr>
<td>Erase Character</td>
<td>Backspace or Ctrl-H</td>
</tr>
<tr>
<td>Erase Word</td>
<td>Ctrl-W</td>
</tr>
<tr>
<td>Cursor to Start of Line</td>
<td>Ctrl-A</td>
</tr>
<tr>
<td>Cursor to End of Line</td>
<td>Ctrl-E</td>
</tr>
<tr>
<td>Clear and Redraw Screen</td>
<td>Ctrl-L</td>
</tr>
<tr>
<td>Exit the CLI</td>
<td>Ctrl-D</td>
</tr>
<tr>
<td>Context-Sensitive Help</td>
<td>?</td>
</tr>
</tbody>
</table>

5.2 Finding Help

The CLI includes context-sensitive help. At any point, enter a ? and TNSR will print a list of available commands or keywords that are valid in the current context. Enter a space before the ? to ensure correct context.

Additionally, the help command can be issued in any mode. There are three variations:

- **help, help commands** These are equivalent and print a list of available commands in the current mode.
- **help mode** Prints information about the current mode, including whether or not exiting the mode will cause a commit (Configuration Database).

5.3 Starting TNSR

The services required by TNSR to run are enabled by the installer, and they will automatically start at boot time. There is no need to manually stop or start TNSR services during normal operation.
5.3.1 TNSR Service Relationships

TNSR requires the vpp, clixon-backend, and clixon-restconf services. The clixon-backend service is configured to depend on vpp, thus:

- If the vpp service is restarted, clixon-backend will also restart if it is running.
- If the vpp service is stopped, clixon-backend will stop if it is running.
- If both vpp and clixon-backend are stopped, then starting clixon-backend will also start vpp.

**Note:** TNSR may require additional services depending on features enabled by the TNSR configuration. These will be automatically managed as needed.

5.3.2 Manual TNSR Service Operations

Stop TNSR services:

```
$ sudo systemctl stop vpp clixon-restconf
```

Start TNSR services:

```
$ sudo systemctl start clixon-backend clixon-restconf
```

Restarting TNSR services if they are already running:

```
$ sudo systemctl restart vpp clixon-restconf
```

These services are all daemons and not interactive. To configure TNSR, the administrator must initiate the TNSR CLI separately, as described in *Entering the TNSR CLI*.

**Convenience Alias**

For convenience, an alias in the shell can be used to handle this task. For example, the following single line can be added to ~/.bashrc:

```
alias restarttnsr='sudo systemctl stop vpp clixon-restconf;
            sudo systemctl start clixon-backend clixon-restconf'
```

**Note:** The changes to ~/.bashrc will not take effect immediately. Either logout and login again, or source the file by running `source ~/.bashrc` or `. ~/.bashrc`.

The above actions can then be accomplished all at once by running `restarttnsr`.

5.4 Entering the TNSR CLI

The TNSR CLI can be started a few different ways. The command to start the CLI is /usr/bin/clixon_cli, but the exact method varies, as discussed in this section.

When started, the TNSR CLI will print the hostname followed by the prompt:
From that prompt, commands can be entered to view status information or perform other tasks. Throughout this documentation, the router hostname will typically be omitted unless it is required for clarification.

### 5.4.1 Using the tnsr account

TNSR includes a `tnsr` user by default, and this user will automatically load the TNSR CLI at login. To take advantage of this user, login to it directly using `ssh`, or switch to it using `sudo` or `su` from another account.

The behavior of the `tnsr` account varies by platform, and its password can be reset using any account with access to `sudo` (See Default Accounts and Passwords).

To switch from another user to the `tnsr` user, use `sudo`:

```bash
$ sudo su - tnsr
```

Alternately, use `su` and enter the password for the `tnsr` user:

```bash
$ su - tnsr
Password: 
```

### 5.4.2 Using another account

The TNSR CLI can also be started manually from any user.

This command will start the TNSR CLI as the current user, which is ideal to use in combination with `NACM`:

```bash
$ /usr/bin/clixon_cli
```

### 5.4.3 Using root

This command will start the TNSR CLI as root, which generally should be avoided unless absolutely necessary (for example, recovering from a flawed NACM configuration):

```bash
$ sudo /usr/bin/clixon_cli
```

### 5.4.4 Current User

From inside TNSR, check the current user as seen by TNSR with `whoami`:

```
tnsr# whoami
   real UID/GID: 996/992
   effective UID/GID: 996/992
   user name: tnsr
   home dir: /var/lib/tnsr
   shell: /bin/bash
```
5.4.5 Shell Alias

For convenience, the command to launch the TNSR CLI can be added to an alias in the shell. For example, the following line can be added to ~/.bashrc to run TNSR as the current user:

```
alias tnsrcli='/usr/bin/clixon_cli'
```

**Note:** The changes to ~/.bashrc will not take effect immediately. Either logout and login again, or source the file by running `source ~/.bashrc` or `. ~/.bashrc`.

Then the TNSR CLI may be accessed using the alias from the shell, tnsrcli.

5.5 Configuration Database

TNSR maintains three separate configuration databases: startup, candidate, and running. These files are stored as XML in plain text files.

- **startup** The configuration loaded when the host boots up.

  **Note:** A restart of TNSR services is not the same as a reboot. If, for example, the clixon services are restarted, TNSR will still be using the running database.

- **candidate** An in-process potential configuration that exists while the TNSR configuration is being actively edited. When committed, this configuration will be accepted as the running configuration by TNSR if it is free of errors.

- **running** The active running configuration, which reflects the current state of TNSR.

**Note:** These databases are located in /var/tnsr/ on the host, but these files are not intended to be accessed outside of TNSR.

The configuration database is managed using the `configuration` command from within config mode.

5.5.1 Saving the Configuration

For changes to persist between reboots of the TNSR host, the running configuration must be copied to the startup configuration as shown in this example:

```
tnsr# configure
tnsr(config)# configuration copy running startup
```

5.5.2 Viewing the Configuration

To view the configuration databases, use the `show configuration` command followed by the database name, for example:

```
tnsr# show configuration running
```
or:

```bash
tnsr# show conf run
```

The default output is XML, but the configuration may also be printed in json format by adding `json` to the end of the command.

### 5.5.3 Reverting to the Startup Configuration

TNSR can also revert to the previously saved startup configuration to remove undesirable changes to the running configuration, should a regression in behavior occur.

For example:

```bash
tnsr# configure
tnsr(config)# configuration copy startup candidate
tnsr(config)# configuration candidate commit
tnsr(config)# exit
```

**Warning:** It is not possible to copy the startup configuration directly to the running configuration as that will not result in the settings being active. The configuration must be committed after copying to the candidate.

### 5.5.4 Configuration Database Commands

These brief examples show other available configuration database management commands.

Delete the candidate database entirely, which if committed will leave TNSR with an empty configuration:

```bash
tnsr(config)# configuration candidate clear
```

Commit changes made to the candidate database, which if successful will become the running database:

```bash
tnsr(config)# configuration candidate commit
```

Discard the current candidate database to remove a change that has failed to validate, returning to the running configuration without the attempted changes:

```bash
tnsr(config)# configuration candidate discard
```

Attempt to validate the current candidate configuration to locate errors:

```bash
tnsr(config)# configuration candidate validate
```

Load a file from the host into the candidate database. The contents of the file can replace the candidate entirely, or merge a new section into an existing configuration. After loading, the candidate must be committed manually.

```bash
tnsr(config)# configuration candidate load <filename> [(replace|merge)]
```

Copy the candidate configuration to the startup configuration:

```bash
tnsr(config)# configuration copy candidate startup
```

Copy the running configuration to either the candidate or startup configuration:
tnsr(config)# configuration copy running (candidate|startup)

Copy the startup configuration to the candidate configuration:

tnsr(config)# configuration copy startup candidate

Save either the candidate or running configuration to a file on the host.

tnsr(config)# configuration save (candidate|running) <filename>

While not a configuration database command directly, the TNSR CLI automatically discards the candidate database if it fails to validate. This behavior can be changed using the following command:

tnsr(config)# no cli option auto-discard

### 5.6 Configuration Mode

After starting the TNSR CLI, the administrator is in basic mode and not configuration mode. To enter configuration mode, enter the `configure` command. This command may be abbreviated to `config` and it is also acceptable to write `terminal` after, as a convenience for administrators familiar with IOS who type it out of habit.

**All** of the following commands are equivalent:

```plaintext
tnsr# configure
 tnsr# configure terminal
 tnsr# config
 tnsr# conf t
```

After entering any **one** of the above commands, the prompt changes to reflect the new configuration mode:

```plaintext
 tnsr# configure
 tnsr(config)#
```

After entering other configuration commands, the new configuration is stored in the candidate database (*Configuration Database*). A candidate database may be committed either when all of the required information is present, or when exiting the current context. Some commands are committed immediately.

### 5.6.1 Navigating Configuration Modes

Certain commands in configuration mode enter other modes, for example, the `interface` command will enter `config-interface` mode when used on an existing interface:

```plaintext
 tnsr(config)# interface GigabitEthernet3/0/0
 tnsr(config-interface)#
```

To leave a mode, use the `exit` command. This will return to the previous, lower mode:

```plaintext
 tnsr(config-interface)# exit
 tnsr(config)#
```

From `config` mode, using `exit` will return to basic mode:
From any mode, the `exit` command may be repeated until the prompt returns to basic mode.

At that point, if no errors have been encountered by TNSR, all changes will have been committed to the running database. If an error occurs, TNSR will print a message indicating the problem. Solving such problems is covered in *Troubleshooting* later in this section.

### 5.6.2 Removing Configuration Items

Items are removed or negated using `no`, followed by the option to remove. For example, to remove an interface description:

```
tnsr(config)# interface GigabitEthernet0/14/1
tnsr(config-interface)# no description
```

In this case, since there is only one description, removing the description does not require the existing content of that option. In most cases, the `no` command only requires enough parameters to uniquely identify an entry to be removed or negated.

In certain cases, a partial command may remove multiple items or may be used as a shorthand method of removing a longer entry when the details do not uniquely identify an entry.

For example, this command removes one input ACL from an interface:

```
tnsr(config-interface)# no access-list input acl idsblock
```

Where this shorter version will remove all input ACL entries on an interface:

```
tnsr(config-interface)# no access-list input acl
```

Finally, this form would remove all ACLs of any type from an interface:

```
tnsr(config-interface)# no access-list
```

The `?` help command (*Finding Help*) is useful in determining when these actions are possible. For example, the CLI will show `<cr>` (“carriage return”) as an available keyword when testing a command:

```
tnsr(config-interface)# no access-list ?
<cr>
  acl     ACL Rule
  input   ACL applies to ingress packets
  macip   MACIP Rule
  output  ACL applies to egress packets
```

Since the help request printed `<cr>` among the choices, the command may be completed by pressing *Enter*.

### 5.6.3 Troubleshooting

If a change to the candidate database fails a validation check or application of the change to the system fails for some reason, it is discarded automatically by default. TNSR resets the candidate database to the current contents of the running database to avoid further attempts to apply the faulty configuration contained in the candidate database.

This automatic behavior can be changed, however, in cases where power users want more control to troubleshoot failed configuration transactions.

---

5.6. Configuration Mode
When auto-discard is disabled, if a configuration commit fails the candidate database retains the faulty configuration data. Further configuration commands may apply additional changes to the candidate database. However, until the configuration data which caused the failure is removed or set to a value which can be successfully applied, no further commit will succeed.

Disabling the auto-discard feature only persists for the duration of the current CLI session in which it was disabled. At the start of a new CLI session, auto-discard will again be enabled by default.

To view the status of the auto-discard option, use `show cli`:

```
    tnsr# show cli
    Discard erred candidate database: true
```

A faulty candidate can be viewed with the `show configuration candidate` command, as described in Configuration Database.

There are three approaches to rectify this situation:

- Issue alternate commands that directly correct the faulty configuration.
- Abandon the attempted configuration:

```
    tnsr# configure
    tnsr(config)# configuration candidate discard
```

- Remove the fault from the candidate configuration by reverting to the running configuration:

```
    tnsr# configure
    tnsr(config)# configuration copy running candidate
    tnsr(config)# configuration candidate commit
```

### 5.7 Configuration Backups

The candidate and running databases can be saved to or loaded from files in the host OS. This can be used to make backups, copy configurations to other routers, or similar purposes.

The filenames can take an absolute path and filename, or the path may be omitted to save the file in the directory from which the TNSR CLI was invoked by the administrator. When saving, this file must be writeable by the TNSR backend daemon. When loading, this file must be readable by the TNSR backend daemon.

**Tip:** The best practice is to store backup configuration files in a secure location to prevent unauthorized access to sensitive information.

Saving the running configuration as a backup:

```
    tnsr# config
    tnsr(config)# configuration save running backup.xml
```

Loading a configuration file from a backup:
### 5.8 Viewing Status Information

Status information can be viewed using the `show` command from either basic or configuration mode.

For a full list of possible `show` commands, enter `show ?`:

```plaintext
tnsr# show ?
 acl                      Access Control Lists
 bfd                      Bidirectional Forwarding Detection
 cli                      State of per-session CLI options
 clock                    Show the current system date and time
 configuration            Config DB configuration state
 counters                 Interface counters
 ds-lite                  DS-Lite
 gre                      GRE tunnels
 host                     Host information
 http                     HTTP
 interface                Interface details
 ipsec                    IPsec
 kea                      Kea/DHCP
 macip                    MACIP Access Control Lists
 map                      MAP-E/MAP-T
 nacm                     NACM data
 nat                      Network Address Translation
 neighbor                 Neighbors (ARP/NDP)
 ntp                      NTP
 packet-counters          Packet statistic and error counters
 route                    Show routing info.
 span                     SPAN mirrors
 sysctl                   Sysctl parameters
 system                   System information
 unbound                  Unbound DNS
 version                  Show version of system components
 vxlan                    VXLAN tunnels
```

```plaintext
tnsr# show version
Version: tnsr-v19.02-1
Build timestamp: Thu Feb 21 17:12:00 2019 CST
Git Commit: 0x40204091
```

### 5.9 Service Control

Services controlled directly by TNSR can be restarted from within the TNSR CLI in configuration mode.

To control a service, use the `service` command as follows:

```plaintext
tnsr# configure
 tnsr(config)# service <name> <action>
```

The service `name` must be one of the following:
**backend**  Configuration backend (clixon_backend)

**bgp**  BGP routing (bgpd, zebra)

**dataplane**  Dataplane (vpp)

**dhcp**  DHCP (kea)

**http**  HTTP for RESTCONF API (nginx)

**ntp**  Time service (ntpd)

**restconf**  RESTCONF API (clixon_restconf)

**unbound**  DNS Resolver (unbound)

The following **action** types are available:

- **start**  Start the service if it is not already running.
- **stop**  Stop the service if it is currently running.
- **restart**  Stop and restart the service, or start the service if it is not running. This action is not available for the **dhcp** service.
- **reload**  Reload the service configuration without restarting. This action is available for the **dhcp** and **unbound** services.
- **status**  Show the current status of the service daemon(s) and the last few log entries.

## 5.10 Diagnostic Utilities

The TNSR CLI includes convenience utilities for testing connectivity.

### 5.10.1 Diagnostic Routing Behavior

The utilities in this section behave the same with regard to routing. These utilities will send traffic using the host OS routing table by default unless a specific source address is passed to the command.

### 5.10.2 Ping

To perform a basic ICMP echo request, use the **ping** command:

```
tnsr# ping <destination host> source <interface IP address>
```

TNSR will send 10 ICMP echo requests to the destination host, waiting a maximum of 12 seconds for a reply. The source address would be a TNSR interface address, which will allow **ping** to send its request using the routing table in TNSR.

The **ping** command supports a number of additional parameters which alter its behavior:

```
tnsr# ping (<dest-host>|<dest-ip>) [ipv4|ipv6] [interface <if-name>] [source <src-addr>] [count <count>] [packet-size <bytes>] [ttl <ttl-hops>] [timeout <wait-sec>]
```

- **dest-host|dest-ip**  The target of the ICMP echo request. This may be a hostname, IPv4 IP address, or IPv6 IP address.
ipv4|ipv6  When a hostname is used for the destination, this parameter controls the address family used for the ICMP echo request when the DNS response for the hostname contains both IPv4 (A) and IPv6 (AAAA) records.

interface  The TNSR interface from which the ICMP echo requests will originate.

source  The source IP address for the ICMP echo requests. This is required to initiate an ICMP echo request using the routing table in TNSR. If omitted, the ICMP echo request will use the host OS routing table.

count  The number of ICMP echo requests to send. Default value is 10.

packet-size  The size of the ICMP echo request payload, not counting header information. Default value is 56.

ttl  The Time To Live/Hop Limit value for ICMP echo requests, which can limit how far they may travel across the network. Default value is 121 hops.

timeout  The total time to wait for the command to complete.

5.10.3 Traceroute

To perform a network routing trace to a destination host, use the traceroute command:

```plaintext
tnsr# traceroute <destination host> source <interface IP address>
```

The source address would be a TNSR interface address, which will allow traceroute to send its request using the routing table in TNSR.

As with the ping command, there several additional parameters to change the behavior of the trace:

```plaintext
tnsr# traceroute (<dest-host>|<dest-ip>) [ipv4|ipv6] [interface <if-name>] [source <src-addr>] [packet-size <bytes>] [no-dns] [timeout <seconds>] [ttl <ttl-hos>] [waittime <wait-sec>]
```

Most parameters are the same as those found in ping (Ping). Only the items that differ are listed here:

- **no-dns**  Do not attempt to use DNS to reverse resolve hosts that respond to probes.
- **waittime**  Amount of time the command will wait for individual probe responses to return.

**Warning:** The traceroute command requires `/usr/bin/traceroute` to be present in the base operating system. The TNSR package set includes a dependency which will automatically install a package for traceroute. It may also be installed manually using `sudo yum install -y traceroute` or a similar command, depending on the host OS package management configuration.

5.11 Basic System Information

The TNSR CLI can set several basic elements about the system itself, which also serves as a good introduction to making changes on TNSR. These settings are made in `config` mode.

The following parameters are available:

- **system contact <text>**  System contact information, such as an e-mail address or telephone number.
system description <text>  A brief description of this TNSR instance, for example its role or other identifying information.

system location <text>  The location of this TNSR instance, for example a physical location (building, room number, rack number and position, VM host)

system name <text>  The hostname of this TNSR instance.

Warning: This setting also changes the hostname in the host operating system to match, replacing any previously configured hostname.

This example shows how to set the above parameters, starting from master mode:

```bash
gw tnsr# configure
gw tnsr(config)# system contact support@example.com
gw tnsr(config)# system description TNSR Lab Router
gw tnsr(config)# system location HQ MDF/Rack 2 Top
gw tnsr(config)# system name labrtr01
labrtr01 tnsr(config)# exit
```

To view the values of these parameters, along with uptime and memory usage, use the show system command from either master or config mode:

```bash
labrtr01 tnsr# show system
System Parameters:
  description: TNSR Lab Router
  contact: support@example.com
  name: labrtr01
  location: HQ MDF/Rack 2 Top
  object-id: 1.3.6.1.4.1.13644
  uptime: 1303615 seconds
  total-ram: 8004488 KiB
  free-ram: 3236820 KiB
  total-swap: 2932732 KiB
  free-swap: 2932732 KiB
```
Now that TNSR is installed, it needs additional manual setup.

**Note:** This section assumes TNSR was installed as described in *Installation*. Devices pre-loaded with TNSR by Netgate do not require these extra steps.

This section contains information for a manual setup of interfaces. It can also serve as a reference for activating additional hardware added to an existing installation.

## 6.1 Setup Interfaces

TNSR requires complete control of the network interfaces that it will use. This means that the host operating system must not be attempting to use or control them in any way. The device ID of the interface(s) also must be obtained to inform VPP and TNSR what interfaces to use. The interface link can be tuned through VPP and configured through TNSR.

**Warning:** The host management interface must remain under the control of the host operating system. It must not be configured as an interface to be controlled by TNSR.

Network interfaces not configured in the installer will be disabled in CentOS during the installation process. The interfaces will need to be re-enabled in TNSR. For a fresh installation of TNSR, skip ahead to *Setup NICs in Dataplane*. Interfaces added to the TNSR instance after the initial setup will need to be disabled using the following procedure.

### 6.1.1 Identify NICs to use with TNSR

To start, locate the network interfaces in use by the host operating system. View a list of network interfaces known to the host OS with this command:

```
$ ip link
```

To determine if a network interface is in use by the host OS, run the following command:

```
$ ip link show up
```

If an interface shows in that list, and its name does not start with `vpp`, then it is under control of the host.
Note: The TNSR installer will automatically mark any interface not configured in the installer for use by TNSR.

Make a note of the network interfaces and their purpose. Note which interface will be used for host management, and which interfaces will be used by TNSR. The host management interface will be left under the control of the operating system, while the remaining interfaces may be used by TNSR. In this example, the host contains four network interfaces: `enp0s20f0`, `enp0s20f1`, `enp0s20f2`, and `enp0s20f3` and TNSR will use `enp0s20f1` and `enp0s20f2`.

6.2 Disable Host OS NICs for TNSR

In order for TNSR to control network interfaces, they must be disabled in the host OS. In most cases this is not necessary, as network interfaces not configured in the installer will be automatically disabled in CentOS during the installation process. For a fresh installation of TNSR, skip ahead to Setup NICs in Dataplane. This section remains to explain how to change interfaces added after initial installation, or for installations which do not contain whitelisted network interfaces.

This is a two-step process. First, the link must be forced down, and then the network interface must be disabled in Network Manager.

**Warning:** The host management interface must remain under the control of the host operating system. It must not be configured as an interface to be controlled by TNSR. Do not disable the management interface during this step.

For each of the interfaces noted in the last section, manually force the link down:

```bash
$ sudo ip link set <interface name> down
```

For example:

```bash
$ sudo ip link set enp0s20f1 down
$ sudo ip link set enp0s20f2 down
```

Next, disable these network interfaces in Network Manager. For each of these interfaces, edit the corresponding startup script:

```bash
$ sudo vi /etc/sysconfig/network-scripts/ifcfg-<interface name>
```

In each of these files, ensure the following values are set. Add lines if they are not already present in the file:

```
ONBOOT=no
NM_CONTROLLED=no
```

**Note:** To change an interface from being usable by TNSR to back under host OS control, see Remove TNSR NIC for Host Use.
6.3 Setup NICs in Dataplane

Next, determine the device ID for the interfaces. Start the CLI (Entering the TNSR CLI) and run the following command to output the device IDs as seen by the dataplane:

```bash
# tnsr# configure
# tnsr(config)# dataplane dpdk dev ?
0000:02:01.0 Ethernet controller: Intel Corporation 82545EM Gigabit Ethernet Controller (Copper) (rev 01) (Active Interface eth0)
0000:02:02.0 Ethernet controller: Intel Corporation 82545EM Gigabit Ethernet Controller (Copper) (rev 01)
0000:02:03.0 Ethernet controller: Intel Corporation 82545EM Gigabit Ethernet Controller (Copper) (rev 01)
```

Interfaces under host control will be noted in the output with **Active Interface**. Other listed interfaces are usable by TNSR.

For a fresh installation of TNSR, skip ahead to Configuring Interfaces for TNSR, otherwise continue on to identify host interfaces added after TNSR was installed.

### 6.3.1 Host Interface Name to Dataplane ID Mapping

The output of the `dataplane dpdk dev ?` command includes the device IDs in the first column. The device IDs will map to the network cards in a way that is typically easy to determine. For example:

**Table 1: Interface Identifiers**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>enp0s20f0</td>
<td>0000:00:14.0</td>
</tr>
<tr>
<td>enp0s20f1</td>
<td>0000:00:14.1</td>
</tr>
<tr>
<td>enp0s20f2</td>
<td>0000:00:14.2</td>
</tr>
<tr>
<td>enp0s20f3</td>
<td>0000:00:14.3</td>
</tr>
<tr>
<td>enp3s0</td>
<td>0000:03:00.0</td>
</tr>
<tr>
<td>enp4s0</td>
<td>0000:04:00.0</td>
</tr>
</tbody>
</table>

The host OS interface name and VPP identifiers contain the same information represented in different ways. They both reference the PCI bus number, slot number, and function number. The Interface name contains the values in decimal while the identifier shown in VPP uses hexadecimal.

Deconstructing the first interface name, it contains the following:

**Table 2: Interface Name Components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Interface Value</th>
<th>VPP ID Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Type</td>
<td>en (Ethernet)</td>
<td>n/a</td>
</tr>
<tr>
<td>PCI Bus</td>
<td>p0</td>
<td>00</td>
</tr>
<tr>
<td>Bus Slot</td>
<td>&lt;=20</td>
<td>14 (Decimal 20 in Hex)</td>
</tr>
<tr>
<td>Function</td>
<td>f0</td>
<td>.0</td>
</tr>
</tbody>
</table>

Using this pattern, make a note of the VPP identifiers for the next step. In this example, since `enp0s20f1` and `enp0s20f2` are the interfaces to use, the corresponding VPP IDs are `0000:00:14.1` and `0000:00:14.2`. 
6.3.2 Configuring Interfaces for TNSR

Next, edit the dataplane configuration. Start the CLI (Entering the TNSR CLI) and enter configuration mode:

```
tnsr# configure
tnsr(config)#
```

Add the device IDs of the interfaces to be used by the VPP dataplane, determined above:

```
tnsr(config)# dataplane dpdk dev 0000:00:14.1 network
tnsr(config)# dataplane dpdk dev 0000:00:14.2 network
```

Then commit the configuration:

```
tnsr(config)# configuration candidate commit
```

Restart the VPP dataplane:

```
tnsr(config)# service dataplane restart
tnsr(config)# exit
```

The interfaces will now be available for TNSR. Start the CLI again and run `show interface` and verify that the interfaces appear in the output. The output example below has been shortened for brevity:

```
tnsr# show interface
Interface: GigabitEthernet0/14/1
[...]
Interface: GigabitEthernet0/14/2
[...]
Interface: local0
[...]
```

The TNSR interface name also reflects the type, followed by the PCI Bus/Slot/Function ID of each interface, using the same hexadecimal notation as VPP.

**Note:** Once TNSR attaches to interfaces in this way, they will no longer be shown as devices in the host OS. To return a network interface back to host OS control, see *Remove TNSR NIC for Host Use*.

One exception to this behavior is Mellanox network interfaces as they use the same driver for both host OS and DPDK, they still appear in the host OS.

**Customizing Interface Names**

The default interface names, such as `GigabitEthernet0/14/1`, may be customized by an administrator. To customize the names, the PCI ID of the device must be known. The custom names can be used anywhere that an interface name is necessary in TNSR.

**Note:** Only dataplane hardware interface names may be customized in this way. Interfaces from virtual sources such as loopback, IPsec, and GRE cannot be renamed.

The command to rename interfaces is `dataplane dpdk dev <pci-id> network name <name>`. To activate the change, the dataplane must be restarted after making the name change.

This example changes the name of `GigabitEthernet0/14/1, PCI ID 0000:00:14.1`, to DMZ:
First, look at the list of interfaces. Note that the interface is in the list with its original name:

```
  tnsr# show interface
  Interface: GigabitEthernet0/14/1
  [...]  
  Interface: GigabitEthernet0/14/2
  [...]  
  Interface: local0
  [...]  
```

Next, remove any references to the interface from TNSR, and then remove the interface configuration entirely:

```
  tnsr(config)# no interface GigabitEthernet0/14/1
```

Now set the name of the device, then restart the dataplane:

```
  tnsr(config)# dataplane dpdk dev 0000:00:14.1 network name DMZ
  tnsr(config)# service dataplane restart
```

After the dataplane restarts, the interface will appear in the list with its new name:

```
  tnsr# show interface
  Interface: DMZ
  [...]  
  Interface: GigabitEthernet0/14/2
  [...]  
  Interface: local0
  [...]  
```

To change the name back at a later time, all references to the interface must first be removed, and then the name can be reset:

```
  tnsr(config)# no interface DMZ
  tnsr(config)# no dataplane dpdk dev 0000:00:14.1 name
  tnsr(config)# service dataplane restart
```

### 6.3.3 Troubleshooting

If the interfaces do not appear in the `show interface` output, the default driver did not attach to those interfaces and they may require a different driver instead. To see a list of available drivers, use the following command from `config` mode:

```
  tnsr(config)# dataplane dpdk uio-driver ?
  igb_uio  UIO igb driver
  uio_pci_generic  Generic UIO driver
  vfio-pci  VFIO driver
```

To enable a different driver, complete the command using the chosen driver name, then commit the configuration and restart the dataplane.

---

**Note:** Mellanox devices use RDMA and not UIO, so changing this driver will not have any effect on their behavior. If a Mellanox device does not appear automatically, TNSR may not support that device.

---

### 6.3. Setup NICs in Dataplane
tnsr(config)# dataplane dpdk uio-driver igb_uio
tnsr(config)# configuration candidate commit
tnsr(config)# service dataplane restart
tnsr(config)# exit

Then attempt to view the interfaces with `show interface` again. If they are listed, then the correct driver is now active.

### 6.4 Setup QAT Compatible Hardware

TNSR Supports hardware compatible with Intel® QuickAssist Technology, also known as QAT, for accelerating cryptographic and compression operations.

This hardware can be found in CPIC cards as well as many C3000 and Skylake Xeon systems. Netgate XG-1541 and XG-1537 hardware has an add-on option for a CPIC card.

#### 6.4.1 Setup Process

**Enable SR-IOV in the BIOS**

SR-IOV is required for QAT to function in TNSR. SR-IOV enables Virtual Functions which are required for binding by crypto devices.

The procedure to enable SR-IOV varies by platform. Generally this involves rebooting the hardware and entering the BIOS setup, making the change, and then saving and rebooting. The exact location of the SR-IOV option also varies in different BIOS implementations.

**Note:** Netgate devices which ship with a CPIC card preinstalled will have this step completed at the factory, but double check the BIOS to ensure it is set as expected.

**Enable IOMMU in grub**

IOMMU (Input–Output Memory Management Unit), which in this context is also known as Intel VT-d, must be enabled in `grub` for QAT to function. It functions similar to PCI passthrough, allowing the dataplane to access the QAT device.

To enable IOMMU in `grub`:

- Open `/etc/default/grub` in a text editor (as root or with `sudo`)
- Locate the line starting with `GRUB_CMDLINE_LINUX`
- Check if that line includes `intel_iommu=on iommu=pt`
- If those parameters are not included on the line, append them to the end, before the end quote.
- Save and exit the text editor
- Run one following commands (depending on how the device boots):
  - Legacy: `sudo grub2-mkconfig -o /boot/grub2/grub.cfg`
  - UEFI: `sudo grub2-mkconfig -o /boot/efi/EFI/centos/grub.cfg`
- Reboot the device
Change the uio driver to igb_uio

Next, change the TNSR dataplane uio driver to igb_uio:

```
tnsr# configure
tnsr(config)# dataplane dpdk uio-driver igb_uio
```

Configure the QAT PCI device in TNSR

Next, configure the QAT device in TNSR.

To configure this device, first locate its PCI ID. TNSR will print the PCI ID when viewing possible parameters for dataplane devices

```
tnsr(config)# dataplane dpdk dev ?
0000:03:00.0   Ethernet controller: Intel Corporation Ethernet Connection
    ➔ X552 10 GbE SFP+
0000:03:00.1   Ethernet controller: Intel Corporation Ethernet Connection
    ➔ X552 10 GbE SFP+
0000:04:00.0   Co-processor: Intel Corporation DH895XCC Series QAT
0000:05:00.0   Ethernet controller: Intel Corporation I350 Gigabit Network
    ➔ Connection (rev 01) ( Active Interface eno1 )
0000:05:00.1   Ethernet controller: Intel Corporation I350 Gigabit Network
    ➔ Connection (rev 01)
```

In this instance, the following line from the output is for the QAT device:

```
0000:04:00.0   Co-processor: Intel Corporation DH895XCC Series QAT
```

The first value printed on the line is the PCI ID, 0000:04:00.0.

Now, tell TNSR the device at that address is a crypto device:

```
tnsr(config)# dataplane dpdk dev 0000:04:00.0 crypto
```

Activate and check the settings

When viewing the XML configuration with show configuration running, it will contain settings similar to the following example. Note that if other dataplane options are present in the configuration, those will also be visible. Here is how it looks once configured:

```
<dataplane-config>
  <dpdk>
    <dev>
      <id>0000:04:00.0</id>
      <device-type>crypto</device-type>
    </dev>
    <uio-driver>igb_uio</uio-driver>
  </dpdk>
</dataplane-config>
```

After configuring the crypto device and uio driver, TNSR will commit the settings to the dataplane configuration. To activate the new settings, restart the dataplane.

6.4. Setup QAT Compatible Hardware
Lastly, using the `shell` command, verify that VPP can see the crypto device:

```
0000:04:00.0_qat_sym crypto_qat up
numa_node 0, max_queues 2
free_resources 0, used_resources 1
SYMMETRIC_CRYPTO, SYM_OPERATION_CHAINING, HW_ACCELERATED, INPLACE_SGL,
OOP_SGL_IN_SGL_OUT, OOP_LB_IN_SGL_OUT, OOP_LB_IN_LB_OUT
Cipher:  none, aes-cbc-128, aes-cbc-192, aes-cbc-256, aes-ctr-128,
aes-ctr-192, aes-ctr-256, aes-gcm-128, aes-gcm-192, aes-gcm-256
```

### 6.4.2 Troubleshooting

If the QAT device does not appear in the `show dpdk crypto devices` output, or it only shows an AES-NI device, then VPP can not see the crypto device. To correct this, first verify the QAT drivers are loaded, VFs exist for the QAT device, and grub `BOOT_IMAGE` is passing the necessary iommu parameters.

**Verify IOMMU parameters:**

```
$ dmesg | grep iommu

The following parameters should appear somewhere on the `BOOT_IMAGE` line in the `dmesg` output:

```
intel_iommu=on iommu=pt
```

**Verify that the QAT drivers are loaded in the operating system:**

```
$ lsmod | grep qat

```

```
```

**Verify Virtual Functions (VFs) exist for the QAT device:**

```
$ lspci | grep QAT | wc -l
```

The number of listings are dependent on how many threads VPP uses to process packets. At minimum there will be at least three entries, but there may be many more. The lines will look similar to this example:

```
04:00.0 Co-processor: Intel Corporation DH895XCC Series QAT
04:01.0 Co-processor: Intel Corporation DH895XCC Series QAT Virtual Function
04:01.1 Co-processor: Intel Corporation DH895XCC Series QAT Virtual Function
```

TNSR stores the device Physical Function (PF), 04:00.0 for example, in its configuration because the VFs do not yet exist at boot time. They are created by `clixon-backend` when it processes the crypto device. Then, the allocated VFs on the PF have their addresses written to `startup.conf`.

The VFs are bound to `igb_uio` because `igb_uio` is a driver which allows a userspace process to do RDMA on buffers that are used by a PCI device.

### 6.4. Setup QAT Compatible Hardware
If the drivers are loaded and the VFs show under `lspci`, then verify `/etc/vpp/startup.conf` has the appropriate dpdk settings. The `igb_uio` driver must be present and the PCI IDs of TNSR interfaces along with one of the VFs for the QAT device:

```plaintext
dpdk {
    uio-driver igb_uio
    dev 0000:04:01.0
    dev 0000:05:00.1
    dev 0000:03:00.0
    dev 0000:03:00.1
}
```

If that looks correct, verify `igb_uio` is being used by the QAT VF and interfaces:

```bash
$ sudo vppctl show pci all | grep igb_uio
0000:03:00.0 0 8086:15ac 2.5 GT/s x1 igb_uio
0000:03:00.1 0 8086:15ac 2.5 GT/s x1 igb_uio
0000:04:01.0 0 8086:0443 unknown igb_uio
0000:05:00.1 0 8086:1521 5.0 GT/s x4 igb_uio
```

Physical TNSR interfaces will display there in addition to the QAT VF ID, which matches the QAT VF ID configured for dpdk in `/etc/vpp/startup.conf`.

If any of those tests do not provide the expected output, then reboot the system and check again. Ensure the TNSR services and VPP are running, and then check the VPP QAT status again.

```bash
$ sudo vppctl show dpdk crypto devices
```

If there is still no output, verify the PCI ID for the crypto device specified in TNSR is accurate. It must be the first PCI ID displayed by `lspci | grep qat`. Then verify the PCI ID of the next listing in that output (first VF device) is specified in `/etc/vpp/startup.conf` properly and also the same PCI ID seen by VPP when running:

```bash
$ sudo vppctl show pci all | grep igb_uio
```

### 6.5 Remove TNSR NIC for Host Use

If TNSR is controlling a network interface that should be used by the host OS, it can be returned to host OS control in a few steps.

#### 6.5.1 Locate the Interface

First, identify the interface in question. The PCI ID and Linux interface name are required to proceed, and `Host Interface Name to Dataplane ID Mapping` explains the relationship between these interface names and IDs.

In this example, the TNSR interface `GigabitEthernet0/14/3` will be returned to the host OS. Based on the name, the PCI ID is `0000:00:14.3`, and converting from hexadecimal to decimal yields the Linux interface name `enp0s20f3`. This is determined based on PCI bus 0, Bus slot 20 (decimal), function 3.

#### 6.5.2 Remove the Interface from TNSR

First, remove any configuration items using the interface. The interface could be present in several places, so inspect the entire running configuration for references to this interface and then remove them.

Next, remove the interface configuration itself:
tnsr# configure
tnsr(config)# no interface GigabitEthernet0/14/3

If the interface was manually specified in the dataplane by PCI ID as mentioned in Configuring Interfaces for TNSR, that must be also be removed. This will be present in the running configuration inside the <dataplane> section, if one exists. To remove the configuration, follow this example using the correct PCI ID:

```plaintext
tnsr(config)# no dataplane dpdk dev 0000:00:14.3
```

Save the configuration after making these changes, as the next steps will involve actions that may result in the startup configuration being used by TNSR:

```plaintext
tnsr(config)# configuration copy running startup
```

Exit the TNSR CLI.

### 6.5.3 Edit the Host Interface Configuration

The network manager interface configuration scripts are located in `/etc/sysconfig/network-scripts/`. This directory will contain an interface configuration script for the Linux interface name determined above, in the form of `ifcfg-<name>`. In this example, this is `ifcfg-enp0s20f3`.

From a shell on the host OS, edit the file for this interface using `sudo`, for example:

```
$ sudo vi /etc/sysconfig/network-scripts/ifcfg-enp0s20f3
```

Inside that file change `ONBOOT` to `yes`:

```
ONBOOT=yes
```

Remove the `NM_CONTROLLED` line. if one is present.

### 6.5.4 Reactivate the Host Interface

At this point, the interface is ready to return to host OS control. There are two methods to complete the process: Reboot the host, or manually reactivate the interface.

**Reboot**

The fastest and easiest option is to **reboot the host**. This will allow the host to naturally locate and resume control of the device.

**Warning:** All traffic processing by TNSR will stop while the host is rebooting!

Reboot the host from the shell as follows:

```
$ sudo shutdown -r
```
Manually Reactivate

**Warning:** The following procedure is advanced and we do not recommend using this method. We strongly advise rebooting the host instead.

There is also a manual method which may be used if a reboot is not feasible.

First, stop the dataplane and related services:

```bash
$ sudo systemctl stop vpp
```

**Warning:** All traffic processing by TNSR will stop while this service is stopped!

Next, start a root shell and unbind the device from the current driver (TNSR):

```bash
$ sudo -s
# echo '0000:00:14.3' > '/sys/bus/pci/devices/0000:00:14.3/driver/unbind'
```

**Warning:** Note the use of the PCI ID in both locations in the command, and the use of quotes around parameters.

That leaves the device unbound. Now it must be returned to a host kernel driver. The name of this driver depends on the hardware. For most Netgate TNSR devices this will be `igb`, as in the following example.

Still using the root shell from the previous command, bind the interface to the driver as follows:

```bash
# echo '0000:00:14.3' > '/sys/bus/pci/drivers/igb/bind'
```

Lastly, start the dataplane and related services:

```bash
$ sudo systemctl start clixon-backend
```

6.5.5 Configure the Host Interface

At this point the interface is now under host OS control and will be listed in the output of `ip` and similar commands.

```bash
$ ip addr show dev enp0s20f3
5: enp0s20f3: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
  link/ether 00:08:a2:09:95:b4 brd ff:ff:ff:ff:ff:ff
```

The interface configuration in the host OS can be used to change the interface behavior as needed. The default behavior is to act as a DHCP client. This can be changed by editing the interface configuration file noted in *Edit the Host Interface Configuration*. Consult the CentOS documentation for additional details.
CHAPTER
SEVEN

UPDATES AND PACKAGES

TNSR software updates are available to download over the Internet using Linux package management tools (RPM, yum). The settings required to communicate with the software repository containing TNSR updates are preconfigured on TNSR. Connections to the Netgate TNSR repository must be authenticated using a valid signed client certificate.

Warning: Trial versions of TNSR cannot be updated. Reinstall with a full version of TNSR or install a new trial version.

Note: All versions of TNSR, including trial versions, can update the operating system packages even without the update certificate in place. Only TNSR-related packages require authentication to update.

This guide explains how to obtain and install the required client certificate on a TNSR instance.

Warning: Portions of this process are not final and may change.

Commands must be executed on the TNSR instance to generate an X.509 certificate signing request. The request must then be submitted to Netgate for signing. Once the request has been signed and a certificate has been generated, the certificate must be downloaded and installed in TNSR.

Note: While it is possible to create the certificate outside of TNSR and import it afterward, this guide only demonstrates using TNSR directly. See Public Key Infrastructure for more details about creating and importing certificates.

At a high level, the steps involved in the process can be summarized as:

7.1 Generate a Key Pair

This guide uses the TNSR CLI `pki` commands documented in Public Key Infrastructure to generate cryptographic keys that can be used for secure communications and authentication.

Warning: When creating keys and certificates for updates, the name of each component must be `tnsr-updates`, which is the name required by the software repository configuration.

The first step is to generate a set of cryptographic keys:
Note: This command can be run only once successfully. Subsequent attempts will result in an error unless the existing key is deleted.

This new `tnsr-updates` key object contains the private key, which is secret, and a public key, which is included in the certificate.

The same key pair can be used as the basis for multiple certificate signing requests. If a certificate expires, is accidentally deleted, or needs to be replaced for any other reason other than the keys being compromised, generate a new signing request using the existing key pair.

### 7.2 Generate a Certificate Signing Request

The Certificate Signing Request (CSR) contains a public key derived from the key pair generated in the previous step, plus attributes that uniquely identify the requester. A CSR is signed by a Certificate Authority to generate a certificate.

To generate a CSR, first set values which identify this TNSR instance:

```bash
tnr# pki signing-request set common-name tnsr-example.netgate.com
tnr# pki signing-request set country US
tnr# pki signing-request set state Texas
tnr# pki signing-request set city Austin
tnr# pki signing-request set org Netgate
tnr# pki signing-request set org-unit Engineering Testing 1 2 3
```

For the **Common Name**, enter the fully qualified domain name or Public IP address of the TNSR instance. For the other fields, enter information about the name and location of the organization controlling this TNSR instance.

**A Digest Algorithm** is also required to sign the request:

```bash
tnr# pki signing-request set digest sha256
```

View the values that have been set before generating the request:

```bash
tnr# pki signing-request settings show
Certificate signing request fields:
    common-name: tnsr-example.netgate.com
    country: US
    state: Texas
    city: Austin
    org: Netgate
    org-unit: Engineering Testing 1 2 3
    digest: sha256
```

Any typos can be corrected by re-running the appropriate `set` commands.

When all values are correct, generate the request:
**Warning:** As with the key pair, the request must have the name `tnsr-updates`.

```bash
tnsr# pki signing-request tnsr-updates generate
-----BEGIN CERTIFICATE REQUEST-----
MIICzTCCAbUCAQAwgYcxITAfBqNVBAAMGHuc3ItZXhhbXBsa25uZXRmYXRlLmVs
bTElMAkGA1UEBhMCVVMxJAMBgNVBAsMBVQxIjAgBgNVBAMMDVRleGFzQWh0
EDAOBgNVBAoMDVRleGFzQWh0IjAgBgNVBAsMBVRleGFzQWh0IjAwDQYDVQQH
T7xIIVkV5Es6PMXZbwQ7d2fjw8g+/h68Z7d2fjw8g+/h68Z7d2fjw8g+/h68Z
-----END CERTIFICATE REQUEST-----
```

TNSR will print the CSR data to the terminal, as shown above. Copy the text, including the lines containing **BEGIN CERTIFICATE REQUEST** and **END CERTIFICATE REQUEST**, and save it to a file.

### 7.3 Submit the Certificate Signing Request

To generate a signed certificate, the signing request must be submitted to Netgate. Netgate will sign the request with a Certificate Authority key trusted by the TNSR update repository servers.

#### 7.3.1 Required Customer Information

The certificate signing request must be accompanied by information Netgate can use to identify the customer and validate the request. This information varies by platform.

**TNSR Device or ISO Install**

For customers using a device preloaded with TNSR or installing TNSR from an ISO image, the certificate signing support request must be accompanied by information that Netgate can use to validate the request. Netgate must be able to determine that the request is being sent from an authorized user on an account that has an appropriate TNSR purchase.

For example, send the support request from the same e-mail address which was used when making the TNSR purchase and include an order number and other relevant information in the support request when submitting the CSR.

**TNSR in AWS**

For AWS customers, two additional pieces of information are necessary to validate the status of customer accounts before Netgate can sign a certificate:

- The AWS Customer ID

---

**7.3. Submit the Certificate Signing Request**

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• The AWS Instance ID

Note: When registering a TNSR instance to obtain a client certificate, Netgate must be able to prove that this instance of TNSR is a valid instance of the currently published AWS image. To do this, Netgate utilizes the AWS API that indicates which TNSR image the specified instance ID is an instance of. This is the only use of the customer instance ID, which is not stored or retained in any way.

The AWS Customer ID can be found using the instructions at https://docs.aws.amazon.com/general/latest/gr/acct-identifiers.html

The AWS Instance ID can be retrieved from the EC2 Web Console:

1. Navigate to https://console.aws.amazon.com/ec2/
2. Click Instances
3. Click the box next to the TNSR instance to select it
4. The AWS Instance ID is displayed at the bottom of the page under the Description tab

7.3.2 Create a Support Request for the CSR

Using the CSR and customer information, submit a request on the Netgate Support Portal.

Warning: The following steps are still under design and development and may change at any time.

1. Navigate to https://go.netgate.com/support/login
2. Log in with an existing account using an email address and password, or register a new account using the Sign Up button and following the prompts
3. Create a new support request with the following properties:
   - **Department** Select Netgate Global Support
   - **Software Product** Select the matching purchased TNSR product, either TNSR Business or TNSR Enterprise
   - **Platform** Choose the value that matches where TNSR is running, for example TNSR in AWS, Netgate XG-1541 1U, or Whitebox / Other
   - **General Problem Description** Select TNSR Certificate Authorization
   - **Support Level** Choose the support level that matches the purchased TNSR product, TNSR Business, TNSR Business Plus, or TNSR Enterprise
   - **AWS Instance ID** For TNSR on AWS customers only, the ID for this TNSR instance located previously
   - **AWS Customer ID** For TNSR on AWS customers only, the AWS Customer ID located previously
   - **Order Number** For device and ISO customers, the order number of the TNSR purchase for this device
4. Include any other necessary identifying information in the Description field
5. Click Attach file and attach the file containing the CSR text
6. Submit the support request

7.3. Submit the Certificate Signing Request
### 7.4 Retrieve the signed certificate

**Warning:** The following steps are still under design and development and may change at any time.

Once the certificate signing request has been signed by Netgate, the status of the support request will be updated to reflect that the certificate is ready.

When this occurs, download the signed certificate:

1. Navigate to [https://go.netgate.com/support/login](https://go.netgate.com/support/login)
2. Locate the support request
3. Download the attached signed certificate file

### 7.5 Install the certificate

With the signed certificate in hand, it can now be installed on the TNSR instance:

**Warning:** As with the key and CSR, the name of the certificate must be `tnsr-updates`.

```
tnsr# pki certificate tnsr-updates enter
Type or paste a PEM-encoded certificate.
Include the lines containing 'BEGIN CERTIFICATE' and 'END CERTIFICATE'

-----BEGIN CERTIFICATE-----
MIIE7DCCAtSgAwIBAgIJANbZBxsCVDpvMA0GCSqGSIb3DQEBCwUAMAHQxCzAJBgNV
BAYTA1VTMQ4wDAYDVQQIDAVUZXhhczEPMA0GA1UdEwQzMCQxMTAgMCEGCCsGAQUFBwI
MBgGA1UdIwQxMCMGA1UdDgQWAgEAMCQxMCMGA1UdDgQ2MCAwHwYDVR0PBAQDAgYGEI
BCsWggZjBAgh32tZdD+oCQA1MA0GCSqGSIb3DQEBCwUGCCqGSIb3DQEJMA0GCSqGSIb
3DQEBCwUAA4ICAQEAa5n5WU7W5v5Wu5N5Wu5N5Wu5N5Wu5N5Wu5N5Wu5N5Wu5N5Wu5N
-----END CERTIFICATE-----
```

(continues on next page)
After successfully installing the certificate, TNSR can now download software updates from the repository.

7.6 Package Management

The package management commands allow the operator to install new software packages as well as discover and perform updates for installed packages.

7.7 Package Information Commands

There are three commands which query the package database.

A <pkg-glob> is a simple regular expression. It consists of a string of alphanumeric characters which is optionally prefixed or suffixed with a * character. The * character indicates zero or more characters.

For example:

<table>
<thead>
<tr>
<th>abc</th>
<th>matches only the package abc and would not match abcd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>*abc</td>
<td>matches abc or zabc and would not match abcz.</td>
</tr>
<tr>
<td>abcd</td>
<td>matches abcd or abc and would not match zabc.</td>
</tr>
<tr>
<td>*abc</td>
<td>matches any package with abc contained anywhere in its name.</td>
</tr>
<tr>
<td>*</td>
<td>matches any package.</td>
</tr>
</tbody>
</table>

Tip: Do not escape or quote the glob as would typically be required by a Unix shell. The glob abc\* is not the same as abc*.

The first two commands have qualifiers that limit the scope of the packages to all, installed, or updatable packages. These limitations are optional, and if not specified then it defaults to all packages in the database.

To display detailed information on packages:

```
tnsr# package info [ available | installed | updates ] <pkg-glob>
```

Warning: package information is limited to the first 25 packages found. If a query returns more items, a more specific pkg-glob must be used to narrow the search.

To display a simple listing of package names and versions for all matching packages:

```
tnsr# package list [ available | installed | updates ] <pkg-glob>
```

The search command searches for a string in either the package name or description. The output includes the package name and description of the package. The search term is literal, it is not a regular expression or glob:

```
tnsr# package search <term>
```

7.6. Package Management 48
7.8 Package Installation

**Warning:** Recommended procedure is to reboot the router after any package install, remove, or upgrade operation.

To install a package and its required dependencies:

```bash
package install <pkg-glob>
```

To remove a package:

```bash
package remove <pkg-glob>
```

To upgrade a package:

```bash
package upgrade [ <pkg-glob> ]
```

7.9 Updating TNSR

**Warning:** Trial versions of TNSR packages cannot be updated. Reinstall with a full version of TNSR or install a new trial version. The operating system may be updated, but not TNSR.

With a signed client certificate from Netgate in place, TNSR has access to the Netgate software repositories which contain important updates to TNSR. These updates can be retrieved using the `package` command in the TNSR CLI, or `yum` in the host OS shell.

**Note:** Updating TNSR will also update the operating system. Even when there are no TNSR updates available, it is a good practice to periodically perform an update to obtain important operating system updates such as security vulnerability mitigations.

7.9.1 Pre-Upgrade Tasks

Before updating TNSR, perform the following tasks:

- Make sure the signed certificate is in place (*Install the certificate*)
- Make sure the TNSR instance has working Internet connectivity through the host OS management interface
- Take a backup of the running and startup configurations (*Configuration Backups*)

7.9.2 Updating via the TNSR CLI

The easiest way to update TNSR is from within the TNSR CLI itself.

```bash
tnsr# package upgrade
```
That command will download and apply all available updates. Afterward, exit the CLI and start it again.

**Note:** There will be no output from this command until the process completely finishes, which may take a few minutes for larger updates.

### 7.9.3 Updating via the shell

TNSR can also be updated from the command line using the host OS package management commands, in this case, `yum`:

```bash
$ sudo yum clean all
$ sudo yum clean expire-cache
$ sudo yum -y upgrade
```

**Update Script**

The following shell script may be used to keep TNSR and CentOS updated. In addition to the updates it also makes a local backup before performing the update.

Listing 1: Download: `updatetnsr.sh`

```bash
#!/bin/sh

# Stop existing services
sudo systemctl stop strongswan-swanctl frr vpp clixon-restconf

# Time to make the backups
mkdir -p ~/tnsr-config-backup
sudo cp -p /var/tnsr/running_db ~/tnsr-config-backup/running_db-`date +%Y%m%d%H%M%S`.xml
sudo cp -p /var/tnsr/startup_db ~/tnsr-config-backup/startup_db-`date +%Y%m%d%H%M%S`.xml

# Update all RPMs
sudo yum clean all
sudo yum clean expire-cache
sudo yum -y upgrade

# Ensure services are stopped, in case some automatically started after update.
sudo systemctl stop strongswan-swanctl frr vpp clixon-restconf

# Start services
sudo systemctl start clixon-backend clixon-restconf
```

### 7.9.4 Update Troubleshooting

If the TNSR CLI method does not work, use the shell method instead.

If either method prints an error referring to a broken package database, recover it as follows:

```bash
$ mkdir -p ~/tmp/
$ sudo mv /var/lib/rpm/__db* ~/tmp/
```

(continues on next page)
7.9. Updating TNSR

(continued from previous page)

$ sudo rpm --rebuilddb
$ sudo yum clean all
An interface must exist in TNSR before it is available for configuration. For hardware interfaces this is handled by the procedure in Setup Interfaces. To create additional types of interfaces, see Types of Interfaces later in this chapter. Once interfaces are present in TNSR, they can be configured to perform routing and other related tasks.

### 8.1 Locate Interfaces

The next step is to decide the purpose for which TNSR will use each interface.

First, look at the list of interfaces:

```
tnsr# show interface
Interface: GigabitEthernet0/14/1
[...]
Interface: GigabitEthernet0/14/2
[...]
Interface: local0
[...]
```

In the above shortened output, there are two viable interfaces, `GigabitEthernet0/14/1` and `GigabitEthernet0/14/2`. These can be used for any purpose, so map them as needed for the design of the network for which TNSR will be routing.

The example configuration for this network is:

<table>
<thead>
<tr>
<th>Interface</th>
<th>Function</th>
<th>IP Address</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet0/14/1</td>
<td>WAN</td>
<td>203.0.113.2/24</td>
<td>203.0.113.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2001:db8:0:2::2/64</td>
<td>2001:db8:0:2::1</td>
</tr>
<tr>
<td>GigabitEthernet0/14/2</td>
<td>LAN</td>
<td>10.2.0.1/24</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2001:db8:1::1/64</td>
<td></td>
</tr>
</tbody>
</table>

Connect the interfaces on the router hardware to the appropriate networks at layer 1 and layer 2, for example by plugging the WAN into an Internet circuit and the LAN into a local switch. If TNSR is plugged into a managed switch, ensure that its ports are configured for the appropriate VLANs.
Tip: These interface names can be set to custom values. See Customizing Interface Names for details.

8.2 Configure Interfaces

With the configuration data in hand, it is now possible to configure TNSR interfaces for basic IP level connectivity.

From within the TNSR CLI (Entering the TNSR CLI), enter configuration mode and setup the interfaces using this example as a guide:

```
tnsr# configure terminal
tnsr(config)# interface GigabitEthernet0/14/1
tnsr(config-interface)# description WAN
tnsr(config-interface)# ip address 203.0.113.2/24
tnsr(config-interface)# ipv6 address 2001:db8:0:2::2/64
tnsr(config-interface)# enable
tnsr(config-interface)# exit
tnsr(config)# interface GigabitEthernet0/14/2
tnsr(config-interface)# description LAN
tnsr(config-interface)# ip address 10.2.0.1/24
tnsr(config-interface)# ipv6 address 2001:db8:1::1/64
tnsr(config-interface)# enable
tnsr(config-interface)# exit
tnsr(config)# exit
```

In this sample session, both interfaces were configured with an appropriate description for reference purposes, an IP address/subnet mask, and then placed into an enabled state.

If other hosts are present and active on the connected interfaces, it will now be possible to ping to/from TNSR to these networks.

Tip: After making changes, don’t forget to save them to ensure they persist for the next startup by issuing the configuration copy running startup command from within config mode. See Saving the Configuration for more information.

8.2.1 Interface Command

The interface command can configure existing interfaces and create new interfaces.

Configure an existing interface:

```
tnsr(config)# interface <name>
tnsr(config-interface)#
```

This command enters config-interface mode

Note: The maximum interface name length is 63 characters.

Create a new interface:
The mode entered by this command depends upon the type of interface it creates. For more information on interface types and how to configure them, see *Types of Interfaces*.

Print a list of available interfaces and types:

```
%tnsr(config)# interface ?
```

## 8.2.2 Interface Configuration Options

The following commands are available when configuring an interface (`config-interface` mode):

- **access-list (input|output) acl <acl-name>** Access Control Lists which apply to packets on this interface in the given direction (*Standard ACLs*).
- **access-list macip <macip-name>** MACIP Access Control Lists which apply to packets on this interface (*MACIP ACLs*).
- **bond <id>** Set this interface as a part of the given bonding group (*Bonding Interfaces*).
- **bridge domain <id>** Set this interface as a member of the given bridge domain (*Bridge Interfaces*).
- **description** Set the interface description.
- **dhcp client [ipv4]** Configures this interface to obtain its IPv4 address using Dynamic Host Configuration Protocol.
- **dhcp client ipv4 hostname <host-name>** Sets the hostname sent with DHCP client requests.
- **disable** Disable interface administratively.
- **enable** Enable interface administratively.
- **ip address <ip-address>** Sets the IPv4 address for this interface.
- **ip nat (inside|outside)** Configures this interface to be an inside or outside NAT interface (*Network Address Translation*).
- **ip route-table <route-table-name>** Configures a specific IPv4 route table to be used for traffic exiting this interface.
- **ipv6 address <ip6-address>** Sets the IPv6 address for this interface.
- **ipv6 route-table <route-table-name>** Configures a specific IPv6 route table to be used for traffic exiting this interface.
- **lldp** LLDP options for this interface (*Link Layer Discovery Protocol*).
- **mac-address** Configures an alternative MAC address for this interface.
- **map** MAP-E/T options for this interface (*MAP (Mapping of Address and Port)*).
- **mtu <size>** Sets the interface L2 Maximum Transmission Unit (MTU) size, in bytes.
- **vlan tag-rewrite disable** Disable tag rewriting for this interface
- **vlan tag-rewrite pop-1** Remove one level of VLAN tags from packets on this interface.
- **vlan tag-rewrite pop-2** Remove two levels of VLAN tags from packets on this interface.
- **vlan tag-rewrite push-1 (dot1ad|dot1q) <tag>** Add a new layer of VLAN tagging to frames on this interface using the provided VLAN tag.
**8.2.3 DHCP Client Example**

The previous example was for a static IP address deployment. To configure a TNSR interface to obtain its IP address via DHCP as a client, follow this example instead:

```
  tnsr# configure terminal
  tnsr(config)# interface GigabitEthernet3/0/0
  tnsr(config)# interface GigabitEthernet3/0/0 dhcp client ipv4
  tnsr(config)# interface GigabitEthernet3/0/0 enable
  tnsr(config)# interface GigabitEthernet3/0/0 exit
```

**8.3 Monitoring Interfaces**

Each interface has associated counters, which enable traffic volume and error monitoring.

**Note:** To limit the amount of administrative traffic, VPP only updates these counters every 10 seconds.

There are four commands used to monitor interfaces, `show interface`, `show counters`, `interface clear counters`, and `show packet-counters`.

**8.3.1 show interface**

The `show interface` command prints important traffic volume and error counters specific to each interface. For example:

```
  tnsr# show interface

  Interface: TenGigabitEthernet6/0/0
  Admin status: up
  Link up, link-speed 1000 Mbps, full duplex
  Link MTU: 1500 bytes
  MAC address: 00:90:0b:7a:8a:67
  IPv4 Route Table: ipv4-VRF:0
  IPv4 addresses:
    203.0.113.2/24
```

(continues on next page)
The `show interface` command also supports filtering of its output using one or more special keywords. When the list is filtered, its name, description, and administrative status are printed along with the chosen output.

- **acl** Prints the access control lists configured on an interface
- **counters** Prints the interface traffic counters for an interface
- **ipv4** Prints the IPv4 addresses present on the interface and the IPv4 route table used by the interface.
- **ipv6** Prints the IPv6 addresses present on the interface and the IPv6 route table used by the interface.
- **link** Prints the link status (e.g. up or down), media type and duplex, and MTU
- **mac** Prints the hardware MAC address, if present
- **nat** Prints the NAT role for an interface (e.g. inside or outside)

These keywords may be used with the entire list of interfaces, for example:

```
  tnsr# show interface ipv4
```

The filtering may also be applied to a single interface:

```
  tnsr# show interface TenGigabitEthernet6/0/0 link
```

Multiple keywords may also be used:

```
  tnsr# show interface ipv4 link
```

### 8.3.2 show counters

The `show counters` command displays detailed information on all available interface counters.

Example output:

```
  tnsr# show counters
  Interface: TenGigabitEthernet6/0/0
            admin up, link up
            receiver       value      transmit      value
            rx-bytes:      4020452    tx-bytes:      17072
            rx-packets:    15446      tx-packets:    62
            rx-error:      0          tx-error:      7
            rx-ip4:        952        tx-ip4:        9
            rx-ip6:        0          tx-ip6:        0
            rx-miss:       0          tx-miss:       0
            rx-no-buffer:  0
```

(continues on next page)
Counter values take a minimum of 10 seconds to be populated with valid data.

### 8.3.3 clear interface counters

The `interface clear counters <name>` command clears all counters on a given interface. This command is available in config mode. If no specific interface is given, all interfaces will have their counters cleared:

```
TNSR# configure
TNSR(config)# interface clear counters
Counters cleared
TNSR(config)#
```

### 8.3.4 Available Counters

Table 2: Counter Descriptions

<table>
<thead>
<tr>
<th>Counter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rx-bytes</td>
<td>bytes received</td>
</tr>
<tr>
<td>rx-packets</td>
<td>packets received</td>
</tr>
<tr>
<td>rx-error</td>
<td>receiver errors</td>
</tr>
<tr>
<td>rx-ip4</td>
<td>IPv4 packets received</td>
</tr>
<tr>
<td>rx-ip6</td>
<td>IPv6 packets received</td>
</tr>
<tr>
<td>rx-miss</td>
<td>receiver miss</td>
</tr>
<tr>
<td>rx-no-buffer</td>
<td>no buffers on receiver</td>
</tr>
<tr>
<td>tx-bytes</td>
<td>bytes transmitted</td>
</tr>
<tr>
<td>tx-packets</td>
<td>packets transmitted</td>
</tr>
<tr>
<td>tx-error</td>
<td>transmitter errors</td>
</tr>
<tr>
<td>drop</td>
<td>packets dropped</td>
</tr>
<tr>
<td>punt</td>
<td>packets punted</td>
</tr>
</tbody>
</table>

### 8.3.5 show packet-counters

The `show packet-counters` command prints packet statistics and error counters taken from the dataplane. These counters show counts of packets that have passed through various aspects of processing, such as encryption, along with various types of packet send/receive errors.

Example output:

```
TNSR# show packet-counters
<table>
<thead>
<tr>
<th>Count</th>
<th>Node</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>624</td>
<td>dpdk-crypto-input</td>
<td>Crypto ops dequeued</td>
</tr>
<tr>
<td>624</td>
<td>dpdk-esp-decrypt-post</td>
<td>ESP post pkts</td>
</tr>
<tr>
<td>624</td>
<td>dpdk-esp-decrypt</td>
<td>ESP pkts received</td>
</tr>
<tr>
<td>622</td>
<td>esp-encrypt</td>
<td>ESP pkts received</td>
</tr>
<tr>
<td>624</td>
<td>ipsec-if-input</td>
<td>good packets received</td>
</tr>
<tr>
<td>304</td>
<td>ip4-input</td>
<td>Multicast RPF check failed</td>
</tr>
<tr>
<td>9</td>
<td>ip4-arp</td>
<td>ARP requests sent</td>
</tr>
</tbody>
</table>
```

(continues on next page)
22 lldp-input lldp packets received on disabled interfaces

8 ethernet-input no error
2 ethernet-input unknown ethernet type
5821 ethernet-input unknown vlan
16 arp-input ARP request IP4 source address learned

28 GigabitEthernet0/14/0-output interface is down
8 GigabitEthernet3/0/0-output interface is down

8.4 Types of Interfaces

Regular Interfaces Typically these are hardware interfaces on the host, or virtualized by the hypervisor in a virtual machine environment. These are made available to TNSR through VPP, as described in Setup Interfaces.

VLAN Subinterfaces VLAN interfaces are configured on top of regular interfaces. They send and receive traffic tagged with 802.1q VLAN identifiers, allowing multiple discrete networks to be used when connected to a managed switch performing VLAN trunking or tagging.

memif Shared memory packet interfaces (memif) are virtual interfaces which connect between TNSR and other applications on the same host.

tap Virtual network TAP interfaces which are available for use by host applications.
ipsec Interfaces created and used by IPsec tunnels.

Loopback Local loopback interfaces used for a variety of reasons, including management and routing so that the address on the interface is always available, no matter the status of a physical interface.

GRE Generic Routing Encapsulation, an unencrypted tunneling interface which can be used to route traffic to remote hosts over a virtual point-to-point interface connection.

SPAN Switch Port Analyzer, copies packets from one interface to another for traffic analysis.

Bond Bonded interfaces, aggregate links to switches or other devices employing a load balancing or failover protocol such as LACP.

Bridge Bridges connect interfaces together bidirectionally, linking the networks on bridge members together into a single bridge domain. The net effect is similar to the members being connected to the same layer 2 or switch.

VXLAN Interfaces Virtual Extensible LAN (VXLAN) is a similar concept to VLANs, but it encapsulates Layer 2 traffic in UDP, which can be transported across other IP networks. This enables L2 connectivity between physically separated networks in a scalable fashion.

8.4.1 VLAN Subinterfaces

VLANs enable a device to carry multiple discrete broadcast domains, allowing a single switch to function as if it were multiple switches. VLANs are commonly used for network segmentation in the same way that multiple switches can be used: To place hosts on a specific segment, isolated from other segments. Where trunking is employed between switches, devices on the same segment need not reside on the same switch. Devices that support trunking can also communicate on multiple VLANs through a single physical port.

TNSR supports VLANs through primarily through subinterfaces, though a variety of VLAN tag rewriting options are available directly on interfaces (Configure Interfaces). Using subinterfaces, TNSR can send and receive VLAN tagged
traffic on one or more interfaces. The device to which TNSR is connected must also tag traffic in the same way as TNSR.

TNSR also supports multiple levels of VLAN tagged subinterfaces, commonly known as QinQ or 802.1ad. This is used to transport multiple VLANs inside another VLAN-tagged outer frame. Intermediate equipment only sees the outer tag, and the receiving end can pop off the outer tag and use the multiple networks inside independently as if it had a direct layer 2 connection to those networks. In this way, providers can isolate multiple tenants on the same equipment, allowing each tenant to use whichever VLAN tags they require, or achieve other goals such as using greater than the default limit of 4096 VLANs.

**Note:** TNSR can forward packets it receives on a QinQ interface or route packets out a QinQ interface, but the router-plugin does not currently support QinQ so features such as ping will not work against the subinterface directly.

**VLAN Subinterface Configuration**

A few pieces of information are necessary to create a VLAN subinterface (“subif”):

- The parent interface which will carry the tagged traffic, e.g. `GigabitEthernet3/0/0`
- The subinterface ID number, which is a positive integer that uniquely identifies this subif on the parent interface. It is commonly set to the same value as the VLAN tag
- The VLAN tag used by the subif to tag outgoing traffic, and to use for identifying incoming traffic bound for this subif. This is an integer in the range 1-4095, inclusive. This VLAN must also be tagged on the corresponding switch configuration for the port used by the parent interface.

**Creating a VLAN Subinterface**

The `interface subif <parent> <subinterface id>` command creates a new subif object with the given identifier. This command enters `config-subif` mode. That mode contains the following commands:

- **default** Default subinterface, will match any traffic that does not match another subinterface on the same parent interface.
- **untagged** This subinterface will match frames without any VLAN tags.
- **exact-match** Specifies whether to exactly match the VLAN ID and the number of defined VLAN IDs. When this is not set, frames with more VLAN tags will also be matched. Layer 3/routed interfaces must use `exact-match`, it is optional for unrouted/L2 interfaces.
- **dot1q (<vlan-id>|any)** The VLAN tag to match for this subinterface.
- **inner-dot1q (<vlan-id>|any)** An inner 802.1q VLAN tag for use with QinQ
- **outer-dot1ad (<vlan-id>|any)** An outer 802.1ad VLAN tag for use with QinQ
- **outer-dot1q (<vlan-id>|any)** An outer 802.1q VLAN tag for use with QinQ
- **vlan <vlan-id>** VLAN ID for tag rewriting

**Note:** Where multiple similar options are present, generally this is for compatibility with other equipment that requires using those specific options. Consult the documentation for the peer device to find out which options it prefers.

After creating the interface, it will be available in TNSR. The name of this interface is composed of the parent interface name and the subif id, joined by a . For example, `TenGigabitEthernet6/0/0.70`
VLAN Subinterface Examples

VLAN Example

First, create a new subif object. In this example, both the subif id and the 802.1q VLAN tag are the same, 70:

```
tnsr(config)# interface subif TenGigabitEthernet6/0/0 70
tnsr(config-subif)# dot1q 70
tnsr(config-subif)# exact-match
tnsr(config-subif)# exit
```

Upon commit, this creates a corresponding subif interface which appears with the parent interface name and the subif id, joined by a .:

```
tnsr(config)# interface TenGigabitEthernet6/0/0.70
tnsr(config-interface)#
```

At this point, it behaves identically to regular interface in that it may have an IP address, routing, and so on.

QinQ Example

This example creates a QinQ subinterface with an inner tag of 100 and an outer tag of 200. The subinterface ID number can be any arbitrary unsigned 32-bit integer, but in this case it makes the purpose more clear to have it match the outer and inner VLAN tags of the subinterface:

```
tnsr(config)# subif GigabitEthernet0/b/0 200100
tnsr(config-subif)# inner-dot1q 100
tnsr(config-subif)# outer-dot1q 200
tnsr(config-subif)# exit
```

8.4.2 Shared Memory Packet Interfaces (memif)

A Shared Memory Packet Interface (memif) has two components: A socket and an interface. A memif also requires a role, either master or slave. In most TNSR applications, it will be the master and the other endpoint will be a slave. A single socket may only be associated with one role type.

Memif Configuration

Creating a memif Socket

The `interface memif socket` command requires an identifier number and a filename, both of which must be unique to this socket. The full form of the command is: `interface memif socket id <id> filename <socket-filename>`

In this command, the available parameters are:

- **id** A required identifier unique to this memif instance. This is an integer in the range 1..4294967294.
- **socket-filename** The full path to a socket file used for establishing memif connections. A socket can be used for either master or slave interfaces, but not both. A socket can have more than one master, or it can have more than one slave.

8.4. Types of Interfaces
Creating a memif interface

Next, the `interface memif interface <id>` command creates a memif object. This command requires its own interface identifier, and it must be tied to the socket using the same ID from the previous command.

This command enters `config-memif` mode, where the following commands are available:

- **socket-id <id>**  
  The socket ID for the associated memif socket created previously. This value is required.

- **buffer-size <size>**  
  The size of the buffer allocated for each ring entry. Default 2048.

- **mac-address <mac>**  
  MAC address for the memif interface.

- **mode <mode>**  
  Sets the mode for the memif interface. Mode must be one of:

  - **ethernet**  
    Ethernet (L2) mode.

  - **ip**  
    IP (L3) mode.

  - **punt/inject**  
    Reserved for future use. Not yet implemented.

  - **ring-size <size>**  
    Number of entries in receive and transmit rings. Value is 8..32 and is used as a power of 2. Default value is 10 for $2^{10}$ entries.

  - **role <role> [options]**  
    Sets the role of the memif interface. The default role is `master` and this is the most common role for TNSR. The following modes and options are available:

    - **master**  
      Master role. The master does not expose its memory to the slave peer.

    - **slave**  
      Slave role. Allocates and shares memory with the master to transfer data. When operating in slave mode, the number of receive or transmit queues may be set as an option:

        - **rx-queues <n-rx-qs>**  
          Number of receive queues. May be between 1..255.

        - **tx-queues <n-tx-qs>**  
          Number of transmit queues. May be between 1..255.

    - **secret <sec-str>**  
      A quoted secret string, up to 24 characters.

After creating the interface, it will be available in TNSR. The name of this interface is composed of the socket ID and the interface ID: `interface memif<socket id>/<interface id>`.

### Memif Example

First, create a socket with an ID of 23, using a socket file of `/tmp/memif23.sock`:

```bash
tnsr(config)# interface memif socket id 23 filename /tmp/memif23.sock
```

Next, run commands to create a memif interface with an interface ID of 100 taking on the role `master` on the socket created previously:

```bash
tnsr(config)# interface memif interface 100
ten# (config-memif)# socket-id 23
ten# (config-memif)# role master
ten# (config-memif)# exit
```
Now the interface will be available to TNSR. In this example with a socket ID of 23 and an interface ID of 100, the full interface name is memif23/100.

**Memif status**

For a list of all current memif entries, along with their names and configuration, use the `show interface memif` command:

```
  tnsr# show interface memif

  Socket Id  Filename
  ------------------------------
    0          /run/vpp/memif.sock
   23         /tmp/memif23.sock

  memif id: 100
    Memif name: memif23/100
    Interface: memif23/100
    Role: master
    Mode: ethernet
    MAC address: 02:fe:8c:e5:ce:06
    Socket id: 23
    Ring size: 0
    Buffer size: 0
    Admin up: false
    Link up: false
```

**8.4.3 Tap Interfaces**

Virtual network tap interfaces give daemons and clients in the host operating system access to send and receive network traffic through TNSR to other networks. A tap interface can carry layer 2 and layer 3 frames between the host OS and TNSR, and be a bridge member.

**Tap Configuration**

The `interface tap <name>` command creates a tap object with the given name. This name is also used to create the tap interface in the host OS. For example, if a tap object was created with `interface tap mytap`, then the interface in the host OS is named `mytap`.

This command enters config-tap mode, which contains the following commands:

- **instance <instance>** Required instance identifier for the tap interface. A tap interface appears in TNSR using the `tap` prefix followed by the chosen identifier number. For example, with an identifier number of 1, the TNSR interface will be `tap1`.
- **mac-address <mac>** The MAC address for the TNSR side of the tap interface.
- **(rx-ring-size|tx-ring-size) <size>** Configures the receive (rx) or transmit (tx) ring buffer size.

**Note:** Default ring size is 256. The value must be a power of 2 and must be less than or equal to 32768.

- **host bridge <bridge-name>** Configure the tap as part of a host bridge.
Note: A tap object cannot have both an IP address and a bridge name set.

**host (ipv4|ipv6) gateway <ip-addr>** Configure a gateway for the host tap interface.

**host (ipv4|ipv6) prefix <ip-addr>** Configures the host IPv4 or IPv6 address for the tap interface.

**host mac-address <mac>** The MAC address for the host side of the tap interface.

**host namespace <ns>** Configure a namespace inside which the tap will be created on the host.

**TAP Examples**

**Example tap Interface**

The following commands create a tap object named mytap with an instance id of 1:

```
  tnsr(config)# interface tap mytap
  tnsr(config-tap)# instance 1
```

At this point, the TNSR and host OS interfaces exist but contain no configuration:

In TNSR:

```
  tnsr# show int tap1
  Interface: tap1
    Admin status: down
    Link up, unknown, unknown duplex
    Link MTU: 9216 bytes
    MAC address: 02:fe:77:d9:be:1e
    IPv4 Route Table: ipv4-VRF:0
    IPv6 Route Table: ipv6-VRF:0
```

In the host OS:

```
  $ ip address show mytap
  300: mytap: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UNKNOWN
    group default qlen 1000
    link/ether 42:5a:f0:6f:d9:77 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::405a:f0ff:fe6f:d977/64 scope link
      valid_lft forever preferred_lft forever
```

**Example Tap Interface Addresses**

Configuring addresses for tap interfaces depends on the location of the interface.

For the interface visible in TNSR, configure it in the same manner as other TNSR interfaces:

```
  tnsr# configure
  tnsr(config)# int tap1
  tnsr(config-interface)# ip address 10.2.99.2/24
  tnsr(config-interface)# enable
  tnsr(config-interface)# exit
  tnsr(config)# exit
  tnsr#
```

**8.4. Types of Interfaces**
The MAC address of the tap interface may also be set on the tap object:

```
tnsr# configure
tnsr(config)# interface tap mytap
tnsr(config-tap)# mac-address 02:fe:77:d9:be:ae
tnsr(config-tap)# exit
tnsr(config)# exit
tnsr#
```

The address for the host OS interface is configured by the host command under the tap object instance:

```
tnsr# configure
tnsr(config)# interface tap mytap
tnsr(config-tap)# host ipv4 prefix 10.2.99.1/24
tnsr(config-tap)# exit
tnsr(config)# exit
tnsr#
```

At this point, the interfaces will show the configured addresses:

In TNSR:

```
tnsr# show int tap1
Interface: tap1
  Admin status: up
  Link up, unknown, unknown duplex
  Link MTU: 9216 bytes
  MAC address: 02:fe:77:d9:be:ae
  IPv4 Route Table: ipv4-VRF:0
  IPv4 addresses:
    10.2.99.2/24
  IPv6 Route Table: ipv6-VRF:0
```

In the host OS:

```
$ ip address show mytap
308: mytap: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UNKNOWN
    group default qlen 1000
    link/ether 02:fe:77:d9:be:ae brd ff:ff:ff:ff:ff:ff
    inet 10.2.99.1/24 scope global mytap
      valid_lft forever preferred_lft forever
    inet6 fe80::02fe:77d9:beae/64 scope link
      valid_lft forever preferred_lft forever
```

The host <family> prefix <address> syntax works similarly for IPv6 with an appropriate address.

### 8.4.4 Loopback Interfaces

Loopback interfaces are internal interfaces available for use in TNSR for routing and other internal traffic handling purposes such as acting as a bridged virtual interface (Bridge Interfaces).

#### Loopback Configuration

Before a loopback interface can be configured, a loopback instance must be created by the `interface loopback <name>` command. This command enters config-loopback mode. The loopback must be given a unique name and a positive numeric instance identifier.
The following commands are available in config-loopback mode:

- `instance` A required instance identifier. This value is used to generate the loopback interface name in TNSR in the form of `loop<id>`. For example, with an id of 1, the loopback interface name is `loop1`.

- `description` A brief text description of this loopback instance.

- `mac-address` An optional MAC address to use for the loopback interface. If omitted, TNSR will generate a MAC in the form of `de:ad:00:00:00:<id>`.

**Loopback Example**

This example creates a new loopback object named `mgmtloop` with an instance identifier of 1:

```
tnsr(config)# interface loopback mgmtloop
tnsr(config-loopback)# instance 1
tnsr(config-loopback)# exit
```

Upon commit, the new interface will be available for use by TNSR. The interface will be designated `loop<instance id>`, in this case, `loop1`. It can then be configured in the same manner as other interfaces:

```
tnsr(config)# interface loop1
tnsr(config-interface)# ip address 10.25.254.1/24
tnsr(config-interface)# exit
```

**8.4.5 GRE Interfaces**

A Generic Routing Encapsulation (GRE) interface enables direct routing to a peer that does not need to be directly connected, similar to a VPN tunnel, but without encryption. GRE is frequently combined with an encrypted transport to enable routing or other features not possible with the encrypted transport on its own. GRE interfaces can be combined with dynamic routing protocols such as BGP, or use static routing.

**GRE Configuration**

To create a GRE object, TNSR requires an object name, positive integer instance ID, source IP address, and destination IP address. The first step is to run the `gre <object-name>` command, which enters config-gre mode. Inside config-gre mode, the following commands are available:

- `instance <id>` Required instance identifier. This value is used to generate the GRE interface name in TNSR in the form of `gre<id>`. For example, with an id of 1, the GRE interface name is `grel`.

- `source <ip-address>` Required IP address on TNSR to use as a source for GRE traffic associated with this instance. Can be an IPv4 or IPv6 address.

- `destination <ip-address>` Required IP address of the remote GRE peer, which is the destination for GRE traffic associated with this instance. Can be an IPv4 or IPv6 address, but the address family must match that of the source IP address.

- `encapsulation route-table <route-table>` This option controls which route table is used by the GRE object, for traffic utilizing the GRE interface. The default behavior is to use the default routing table.

- `tunnel-type <type>` TNSR supports multiple GRE tunnel types, where <type> is one of the following:
  - `l3` Layer 3 encapsulation, the default type of GRE tunnel, which can carry layer 3 IP traffic and above.
erspan session-id <id>  Encapsulated Remote Switched Port Analyzer (ERSPAN). This requires a session ID number, which is an integer in the range 0..1023. When combined with Switch Port Analyzer (SPAN) Interfaces, ERSPAN can deliver copies of local packets to a remote host for inspection. Explained in detail in GRE ERSPAN Example Use Case.

teb  Transparent Ethernet Bridging (TEB)

GRE Examples

This example creates a new GRE object named test1, with an instance id of 1, and the source and destination addresses shown:

```
tnsr(config)# gre test1
ntsr(config-gre)# instance 1
ntsr(config-gre)# source 203.0.113.2
ntsr(config-gre)# destination 203.0.113.25
ntsr(config-gre)# exit
```

Upon commit, the new GRE interface will be available for use by TNSR. The name of the GRE interface is gre<instance id>, which in this case results in gre1. The GRE interface can then be configured similar to other interfaces (Configure Interfaces):

```
tnsr(config)# interface gre1
ntsr(config-interface)# ip address 10.2.123.1/30
ntsr(config-interface)# enable
ntsr(config-interface)# exit
ntsr(config)# exit
```

See also:

For an example ERSPAN configuration, see GRE ERSPAN Example Use Case

**GRE Status**

To view a list of current GRE objects, use show gre:

```
tnsr# show gre
Name   Instance Type Source IP  Dest IP     Encap Rt   Session Id
------- -------- ------- -------- -------- ------- ------- -------
test1  1        L3       203.0.113.2 203.0.113.25 ipv4-VRF:0 0
```

This command prints a list of all GRE objects and a summary of their configuration.

**8.4.6 Switch Port Analyzer (SPAN) Interfaces**

A SPAN interface ties two interfaces together such that packets from one interface (the source) are directly copied to another (the destination). This feature is also known as a “mirror port” on some platforms. SPAN ports are commonly used with IDS/IPS, monitoring systems, and traffic logging/statistical systems. The target interface is typically monitored by a traffic analyzer, such as snort, that receives and processes the packets.

A SPAN port mirrors traffic to another interface which is typically a local receiver. To send SPAN packets to a remote destination, see GRE ERSPAN Example Use Case which can carry mirrored packets across GRE.
**SPAN Configuration**

SPAN instances are configured from config mode using the `span <source-interface>` command. That command enters config-span mode. Inside config-span mode, the following commands are available:

- **onto <destination-interface> <layer> <state>** Specifies a destination for SPAN traffic. May be repeated for multiple destinations. This interface may not be the same as the <source-interface> given to create the span instance.

The available parameters include:

- **destination-interface** The interface which will receive copies of packets from the source interface. The destination interface can be any interface available to TNSR except for the <source-interface> given to create the span instance.

- **layer** Sets the layer above which packet information is forwarded to the destination. Can be one of the following choices:
  - **hw** Mirror hardware layer packets.
  - **l2** Mirror Layer 2 packets.

- **state** Can be one of the following choices:
  - **rx** Enables receive packets
  - **tx** Enables transmit packets
  - **both** Enables both transmit and receive
  - **disabled** Disables both transmit and receive

**Note:** When removing a span instance, the state does not need to be present on the command, and will be ignored.

**SPAN Example**

This example creates a new span that copies all packets sent and received on GigabitEthernet0/14/0 to memif1/1. The packet copies include hardware level information and above.

```
tnsr(config)# span GigabitEthernet0/14/0
tnsr(config-span)# onto memif1/1 hw both
tnsr(config-span)# exit
```

See also:

For an example ERSPAN configuration that combines GRE in ERSPAN mode with a span instance, see [GRE ERSPAN Example Use Case](#).

### 8.4.7 Bonding Interfaces

TNSR supports bonding multiple interfaces together for link aggregation and/or redundancy. Several bonding methods are supported, including Link Aggregation Control Protocol (LACP, 802.3ad). These types of interfaces may also be called LAG or LAGG on other platforms and switches.
**Bond Configuration**

A bond instance has two main components on TNSR: The bond itself, and the interfaces which are a member of the bond. Beyond that, the device to which the bonded interfaces connect, typically a switch, must also support the same bonding protocol and it must also have ports with an appropriately matching configuration.

**Creating a bond**

The `interface bond <instance>` command in config mode enters config-bond mode. An instance number, such as 0, must be manually specified to create a new bond interface.

`config-bond` mode contains the following commands:

- **load-balance (l2|l23|l34)** Configures the load balancing hash for the bonded interface. This setting determines how traffic will be balanced between ports. Traffic matching a single source and destination pair for the configured hash value will flow over a single link. Using higher level hashing will balance loads more evenly in the majority of cases, depending on the environment, but requires additional resources to handle.

  This load-balance configuration is only available in `lacp` and `xor` modes.

  This should be set to match the switch configuration for the ports.

  - **l2** Layer 2 (MAC address) hashing only. Any traffic to/from a specific pair of MAC addresses will flow over a single link. This method is the most common, and may be the only method supported by the other end of the bonded link.

  **Note:** If the bonded interface only transmits traffic to a single peer, such as an upstream gateway, then all traffic will flow over a single link. The bond still has redundancy, but does not take advantage of load balancing.

  - **l23** Layer 2 (MAC address) and Layer 3 (IP address) hashing. For non-IP traffic, acts the same as l2.

  - **l34** Layer 3 (IP address) and Layer 4 (Port, when available) hashing. If no port information is present (or for fragments), acts the same as l23, and for non-IP traffic, acts the same as l2.

- **mode (round-robin|active-backup|xor|broadcast|lacp)**

  - **round-robin** Load balances packets across all bonded interfaces by sending a packet out each interface sequentially. This does not require any cooperation from the peer, but can potentially lead to packets arriving at the peer out of order. This can only influence outgoing traffic, the behavior of return traffic is up to the peer.

  - **active-backup** Provides only redundancy. Uses a single interface of the bond, and will switch to another if the first interface fails. The switch can only see the MAC address of the active port.

  - **xor** Provides hashed load balancing of packet transmission. The transmit behavior is controlled by the `load-balance` option discussed previously. This mode is a step up from `round-robin`, but the behavior of return traffic is still up to the peer.

  - **broadcast** Provides only link redundancy by transmitting all packets on all links.

  - **lacp** Provides dynamic load balancing and redundancy using Link Aggregation Control Protocol (LACP, 802.3ad). In this mode, TNSR will negotiate an LACP link with an appropriately-configured switch, and monitors the links. This method is the most...
flexible and reliable, but requires active cooperation from a switch or suitable peer. The load balancing behavior can be controlled with the `load-balance` command discussed previously.

**mac-address <mac-address>** Optionally specifies a manually-configured MAC address to be used by all members of the bond, except in `active-backup` mode in which case it is only used by the active link.

**Bond Interface Settings**

Additionally, from within `config-interface` on an Ethernet interface, the following commands are available:

```plaintext
bond <instance> [long-timeout] [passive]
```

- **instance** The instance ID of the bond to which this interface will belong.
- **long-timeout** Uses a 90-second timeout instead of the default timeout of 3 seconds when monitoring bonding peers, such as with LACP.
- **passive** This interface will be a member of the bond but will not initiate LACP negotiations.

**Bond Example**

This example sets up a basic LACP bond between two interfaces. The first step is to create the bond instance:

```plaintext
tnsr(config)# interface bond 0
tnsr(config-bond)# load-balance l2
tnsr(config-bond)# mode lacp
tnsr(config-bond)# mac-address 00:08:a2:09:95:99
tnsr(config-bond)# exit
```

Next, decide which TNSR interfaces will be members of the bond, and configure them to be a part of the bond instance. In this case, the example uses `GigabitEthernet0/14/2` and `GigabitEthernet0/14/3`:

```plaintext
tnsr(config)# int GigabitEthernet0/14/2
tnsr(config-interface)# bond 0
tnsr(config-interface)# enable
tnsr(config-interface)# exit
tnsr(config)# int GigabitEthernet0/14/3
tnsr(config-interface)# bond 0
tnsr(config-interface)# enable
tnsr(config-interface)# exit
tnsr(config)# exit
```

With that complete, TNSR will now have a new interface, `BondEthernet0`:

```plaintext
Interface: BondEthernet0
  Admin status: down
  Link up, unknown, unknown duplex
  Link MTU: 9216 bytes
  MAC address: 00:08:a2:09:95:99
  IPv4 Route Table: ipv4-VRF:0
  IPv6 Route Table: ipv6-VRF:0
  Slave interfaces:
    GigabitEthernet0/14/2
```

(continues on next page)
Looking at the interfaces that are members of the bond, the BondEthernet0 membership is also reflected there:

Interface: GigabitEthernet0/14/2
Admin status: up
Link up, unknown, full duplex
Link MTU: 9206 bytes
MAC address: 00:08:a2:09:95:99
IPv4 Route Table: ipv4-VRF:0
IPv6 Route Table: ipv6-VRF:0
Bond interface: BondEthernet0
  counters:
    received: 52575 bytes, 163 packets, 0 errors
    transmitted: 992 bytes, 8 packets, 19 errors
    31 drops, 0 punts, 0 rx miss, 0 rx no buffer

Interface: GigabitEthernet0/14/3
Admin status: up
Link up, unknown, full duplex
Link MTU: 9206 bytes
MAC address: 00:08:a2:09:95:99
IPv4 Route Table: ipv4-VRF:0
IPv6 Route Table: ipv6-VRF:0
Bond interface: BondEthernet0
  counters:
    received: 4006 bytes, 37 packets, 0 errors
    transmitted: 620 bytes, 5 packets, 13 errors
    20 drops, 0 punts, 0 rx miss, 0 rx no buffer

A configuration can now be applied to BondEthernet0:

```
tnsr(config)# interface BondEthernet0
tnsr(config-interface)# ip address 10.2.3.1/24
tnsr(config-interface)# enable
tnsr(config-interface)# exit
tnsr(config)# exit
```

Finally, look at the completed interface configuration:

```
tnsr# show interface BondEthernet0
Interface: BondEthernet0
  Admin status: up
  Link up, unknown, unknown duplex
  Link MTU: 9216 bytes
  MAC address: 00:08:a2:09:95:99
  IPv4 Route Table: ipv4-VRF:0
  IPv4 addresses:
    10.2.3.1/24
  IPv6 Route Table: ipv6-VRF:0
  Slave interfaces:
    GigabitEthernet0/14/2
```

(continues on next page)
GigabitEthernet0/14/3

counters:
- received: 0 bytes, 0 packets, 0 errors
- transmitted: 806 bytes, 9 packets, 0 errors
- 2366 drops, 0 punts, 0 rx miss, 9 rx no buffer

For information on the LACP state, use `show interface lacp`:

```
tnsr# show interface lacp
Interface name: GigabitEthernet0/14/2
  Bond name: BondEthernet0
  RX-state: CURRENT
  TX-state: TRANSMIT
  MUX-state: COLLECTING_DISTRIBUTING
  PTX-state: PERIODIC_TX

Interface name: GigabitEthernet0/14/3
  Bond name: BondEthernet0
  RX-state: CURRENT
  TX-state: TRANSMIT
  MUX-state: COLLECTING_DISTRIBUTING
  PTX-state: PERIODIC_TX
```

**Bond Status**

To view the bond configuration, use `show interface bond`. This will show the configured bond parameters and other information that does not appear on the interface output:

```
tnsr# show interface bond
Interface name: BondEthernet0
  Mode: lacp
  Load balance: l2
  Active slaves: 2
  Slaves: 2
  Slave interfaces:
    GigabitEthernet0/14/2
    GigabitEthernet0/14/3
```

To view the bonding status of all interfaces, use `show interface bonding`:

```
tnsr# show interface bonding

Interface: BondEthernet0
  Admin status: up
  Slave interfaces:
    GigabitEthernet0/14/2
    GigabitEthernet0/14/3

Interface: GigabitEthernet0/14/0
  Description: Uplink
  Admin status: up

Interface: GigabitEthernet0/14/1
  Admin status: down
```

(continues on next page)
To view the LACP status, use `show interface lacp [interface name]`:

```
tnsr# show interface lacp
Interface name: GigabitEthernet0/14/2
   Bond name: BondEthernet0
   RX-state: CURRENT
   TX-state: TRANSMIT
   MUX-state: COLLECTING_DISTRIBUTING
   PTX-state: PERIODIC_TX

Interface name: GigabitEthernet0/14/3
   Bond name: BondEthernet0
   RX-state: CURRENT
   TX-state: TRANSMIT
   MUX-state: COLLECTING_DISTRIBUTING
   PTX-state: PERIODIC_TX
```

### 8.4.8 Bridge Interfaces

Bridges connect multiple interfaces together bidirectionally, linking the networks on bridge members together into a single bridge domain. The net effect is similar to the members being connected to the same layer 2 or switch.

This is commonly used to connect interfaces across different types of links, such as Ethernet to VXLAN. Another common use is to enable filtering between two segments of the same network. It could also be used to allow individual ports on TNSR to act in a manner similar to a switch, but unless filtering is required between the ports, this use case is not generally desirable.

**Warning:** Bridges connect together multiple layer 2 networks into a single larger network, thus it is easy to unintentionally create a layer 2 loop if two bridge members are already connected to the same layer 2. For example, the same switch and VLAN.

There are two components to a bridge: The bridge itself, and the interfaces which are members of the bridge.

**Bridge Configuration**

**Creating a Bridge**

A bridge is created by the `interface bridge domain <bdi>` command, available in `config` mode. This command enters `config-bridge` mode where the following options are available:
arp entry ip <ip-addr> mac <mac-addr> Configures a static ARP entry on the bridge. Entries present will be used directly, rather than having TNSR perform an ARP request flooded on all bridge ports to locate the target. Additionally, when a bridge is not set to learn MACs, these entries must be created manually to allow devices to communicate across the bridge.

arp term Boolean value that when present enables ARP termination on this bridge. When enabled, TNSR will terminate and respond to ARP requests on the bridge. Disabled by default.

flood Boolean value that when present enables Layer 2 flooding. Enabled by default. When TNSR cannot locate the interface where a request should be directed on the bridge, it is flooded to all ports.

forward Boolean value that when present enables Layer 2 unicast forwarding. Enabled by default. Allows unicast traffic to be forwarded across the bridge.

learn When present, enables Layer 2 learning on the bridge. Enabled by default.

mac-age <minutes> When set, enables MAC aging on the bridge using the specified aging time.

uu-flood When present, enables Layer 2 unknown unicast flooding. Enabled by default.

### Bridge Interface Settings

To add an interface to a bridge as a member, the following settings are available from within config-interface mode:

```
interface bridge domain <domain-id> [bvi] [shg <n>]
```

domain id Bridge Domain ID, corresponding to the ID given when creating the bridge interface previously.

bvi Boolean value that when present indicates that this is a Bridged Virtual Interface (BVI). A bridge connects multiple interfaces together but it does not connect them to TNSR. A BVI interface, typically a loopback, allows TNSR to participate in the bridge for routing and other purposes.

An L3 packet routed to the BVI will have L2 encapsulation added and then is handed off to the bridge domain. Once on the bridge domain, the packet may be flooded to all bridge member ports or sent directly if the destination is known or static. A packet arriving from the bridge domain to a BVI will be routed as usual.

**Note:** A bridge domain may only contain one BVI member.

**shg <n>** A Split Horizon Group identifier, used with VXLAN interfaces. This number must be non-zero and the same number must be used on each VXLAN tunnel added to a bridge domain. This prevents packets from looping back across VXLAN interfaces which are meshed between peers.

### Bridge Example

This example will setup a bridge between GigabitEthernet3/0/0 and GigabitEthernet0/14/1, joining them into one network. Further, a loopback interface is used to allow TNSR to act as a gateway for clients on these bridged interfaces.

First, create the bridge with the desired set of options:

```bash
tnsr(config)# interface bridge domain 10
tnsr(config-bridge)# flood
tnsr(config-bridge)# uu-flood
```

(continues on next page)
Next, add both interfaces to the bridge:

```
  tnsr(config)# int GigabitEthernet3/0/0
  tnsr(config-interface)# bridge domain 10
  tnsr(config-interface)# enable
  tnsr(config-interface)# exit
  tnsr(config)# int GigabitEthernet0/14/1
  tnsr(config-interface)# bridge domain 10
  tnsr(config-interface)# enable
  tnsr(config-interface)# exit
  tnsr(config)# interface loopback bridgeloop
  tnsr(config-loopback)# instance 1
  tnsr(config-loopback)# exit
  tnsr(config)# interface loop1
  tnsr(config-interface)# ip address 10.25.254.1/24
  tnsr(config-interface)# bridge domain 10 bvi
  tnsr(config-interface)# enable
  tnsr(config-interface)# exit
```

**Bridge Status**

To view the status of bridges, use the `show interface bridge domain [<id>]` command:

```
  tnsr(config)# show interface bridge domain 10
  Bridge Domain Id: 10
       flood: true
       uu-flood: true
       forward: true
       learn: true
       arp-term: false
       mac-age: 0
       BVI IF: loop1
       Domain Interface Members
          IF: GigabitEthernet0/14/1   SHG: 0
          IF: GigabitEthernet3/0/0   SHG: 0
          IF: local0                 SHG: 0
          IF: loop1                  SHG: 0
  ARP Table Entries
```

If the `id` value is omitted, TNSR will print the status of all bridges.

**8.4.9 VXLAN Interfaces**

Virtual Extensible LAN, or VXLAN, interfaces can be used to encapsulate Layer 2 frames inside UDP, carrying traffic for multiple L2 networks across Layer 3 connections such as between routed areas of a datacenter, leased lines, or VPNs.

VXLAN tunnels are commonly used to bypass limitations of traditional VLANs on multi-tenant networks and other areas that require large scale L2 connectivity without direct connections.
There are two main components to a VXLAN tunnel: The VXLAN tunnel itself, and the bridge domain used to terminate the tunneled traffic to another local interface.

**VXLAN Configuration**

A new VXLAN tunnel is created with the `vxlan <tunnel-name>` command in `config` mode, which then enters `config-vxlan` mode.

In `config-vxlan` mode, the following commands are available:

- `instance <id>` Required instance identifier configured on the VXLAN tunnel. Based on this, a new interface will be available in TNSR named `vxlan_tunnel<id>`. For example, with `instance 0` the interface is named `vxlan_tunnel0`.

- `vni <u24>` Required VXLAN Network Identifier

- `source <ip-addr>` Required source IP address on TNSR used to send VXLAN tunnel traffic.

- `destination <ip-addr>` Required destination IP address for the far side of the tunnel. This can be a multicast address, but if it is, then the `multicast interface` must also be defined.

- `encapsulation route-table <rt-table-name>` Routing table used for VXLAN encapsulation.

- `multicast interface <if-name>` Interface used for multicast. Required if the `destination` address is a multicast address. If defined, the `destination` address must be multicast.

**Note:** The `source` IP address, `destination` IP address and `encapsulation` route table must all be of the same address family, either IPv4 or IPv6.

**VXLAN-Related Settings**

In addition to the VXLAN settings, there are related settings in bridges and interfaces which are used with VXLAN tunnels.

In `config-bridge` mode, the `arp term` command to enable ARP termination is needed for bridges used with VXLAN tunnels.

In `config-interface` mode, when adding an interface to a bridge, the `shg` (Split Horizon Group) parameter is required for VXLAN tunnels. This number must be non-zero and the same number must be used on each VXLAN tunnel added to a bridge domain. This prevents packets from looping back across VXLAN interfaces which are meshed between peers.

**VXLAN Example**

First, create the bridge with the desired set of options:

```
tnsr(config)# interface bridge domain 10
tnsr(config-bridge)# arp term
tnsr(config-bridge)# flood
tnsr(config-bridge)# uu-flood
tnsr(config-bridge)# forward
tnsr(config-bridge)# learn
tnsr(config-bridge)# exit
```

Add host interface to bridge domain:
tnsr(config)# int GigabitEthernet3/0/0
tnsr(config-interface)# bridge domain 10 shg 1
tnsr(config-interface)# exit

Create the VXLAN tunnel:

```bash
tnsr(config)# vxlan xmpl
tnsr(config-vxlan)# instance 0
tnsr(config-vxlan)# vni 10
tnsr(config-vxlan)# source 203.0.110.2
tnsr(config-vxlan)# destination 203.0.110.25
tnsr(config-vxlan)# exit
```

Add the VXLAN tunnel to bridge domain:

```bash
tnsr(config)# int vxlan_tunnel0
tnsr(config-interface)# bridge domain 10 shg 1
tnsr(config-interface)# exit
```

**VXLAN Status**

To view the status of VXLAN tunnels, use the `show vxlan` command:

```bash
tnsr# show vxlan
Name Instance Source IP Dest IP Encap Rt Decap Node IF Name Mcast IF VNI
xmpl 0 203.0.110.2 203.0.110.25 ipv4-VRF:0 1 vxlan_tunnel0 10
```

8.4. Types of Interfaces
A route is how TNSR decides where to deliver a packet. Each route is comprised of several components, including:

- **Route Table** A discrete collection of routes to be consulted by TNSR or its services.
- **Destination** The network/prefix to which clients or TNSR services will send packets.
- **Next Hop Address** The neighboring router which can accept traffic for the destination network.
- **Next Hop Interface** The interface through which TNSR can reach the neighboring router.

### 9.1 Route Tables

TNSR is able to use multiple discrete route tables but these tables do not offer complete VRF-style isolation. When routing packets, TNSR consults the route tables present on the interface the packet enters (ingress) which match the address family of the packet (IPv4 or IPv6).

If an interface is not configured for a specific route table, TNSR uses the default table. For IPv4, the default routing table is `ipv4-VRF:0`. For IPv6, the default is `ipv6-VRF:0`. Custom routing tables may be given arbitrary names.

**Warning:** VRF is in the name of the default route tables, but TNSR does not offer full virtual routing and forwarding (VRF) features at this time.

Identical routes can have different destination paths in separate route tables, but identical networks cannot be directly connected to multiple interfaces.

### 9.2 Neighbors

For directly connected networks, TNSR will attempt to locate neighboring hosts via Address Resolution Protocol (ARP) for IPv4 or Neighbor Discover Protocol (NDP) for IPv6. In this way, TNSR can discover the hardware MAC address to which a packet will be delivered in these networks.

#### 9.2.1 Static Neighbors

Static neighbor entries can override this dynamic behavior so that a specified IPv4 or IPv6 address is always associated with the same MAC address.

The command to specify a static neighbor takes the following form:
tnsr(config)# neighbor <interface> <ip-address> <mac-address>
[no-adj-route-table-entry]

The parameters for this command are:

- **<interface>** The interface on which this static entry will be placed.
- **<ip-address>** The IPv4 or IPv6 address for the static neighbor entry.
- **<mac-address>** The MAC address to associate with the given IP address.

**no-adj-route-table-entry** Do not create an adjacency route table entry.

For example, to add a static entry to map 1.2.3.4 to a MAC address of 00:11:22:33:44:55 on the interface GigabitEthernet3/0/0, run this command from config mode:

```
tnsr(config)# neighbor GigabitEthernet3/0/0 1.2.3.4 00:11:22:33:44:55
```

### 9.2.2 View Neighbors

To see the current table of known IPv4 and IPv6 neighbors, use the `show neighbor [interface <if-name>]` command.

**Note:** In other products, this information may be referred to as the ARP table or NDP table.

```
tnsr# show neighbor

<table>
<thead>
<tr>
<th>Interface</th>
<th>S/D</th>
<th>IP Address</th>
<th>MAC Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>GigabitEthernet0/14/0</td>
<td>D</td>
<td>203.0.113.1</td>
<td>00:90:0b:37:a3:24</td>
</tr>
<tr>
<td>GigabitEthernet0/14/0</td>
<td>D</td>
<td>203.0.113.14</td>
<td>00:0d:b9:33:0f:71</td>
</tr>
<tr>
<td>GigabitEthernet3/0/0</td>
<td>S</td>
<td>1.2.3.4</td>
<td>00:11:22:33:44:55</td>
</tr>
<tr>
<td>GigabitEthernet3/0/0</td>
<td>D</td>
<td>10.2.0.129</td>
<td>00:0c:29:4c:b3:9b</td>
</tr>
</tbody>
</table>
```

This output can optionally be filtered by interface name.

The **S/D** column shows if the entry is static (**S**) or dynamic (**D**).

### 9.3 Viewing Routes

To view the contents of all route tables:

```
tnsr# show route
```

To view the contents of a single route table:

```
tnsr# show route table <table name>
```

For example, to view the default IPv4 route table only, use:

```
tnsr# show route table ipv4-VRF:0
```
9.3.1 Route Flags

In the route display, the flags: row may contain the following:

- **no flags**: If the flags line is empty, this is a normal route with no special actions.
- **local**: This network is local to TNSR and packets to this destination will not leave the TNSR host.
- **drop**: Packets matching this route will be dropped by TNSR. Commonly seen with null routes for subnets or for traffic which must not leave a subnet.
- **unreachable**: Packets matching this route will be dropped by TNSR, and TNSR will send an ICMP “Destination unreachable” message back to the source address.
- **prohibit**: Packets matching this route will be dropped by TNSR, and TNSR will send an ICMP “Destination administratively prohibited” message back to the source address.

9.3.2 Common Routes

Routing tables on TNSR may include unexpected entries by default or even after adding and configuring interfaces and other services. The following list covers several of these types of routes that may be present and what they mean:

- **0.0.0.0/32 (drop)**: Null route to drop traffic with an empty address.
- **0.0.0.0/0**: Default route for packets that do not match any other route, such as for Internet hosts or other remote destinations.
- **224.0.0.0/4 (drop)**: Multicast that must not be routed.
- **224.0.0.0/24**: Local subnet multicast.
- **240.0.0.0/4 (drop)**: Reserved network that must not be routed.
- **255.255.255.255/32 (local)**: Special broadcast address for networks local to TNSR.
- **x.x.x.<first>/32 (drop)**: Null route for subnet configured on an interface. Last octet will vary depending on subnet size and network address. For example, this is 0 in a /24 subnet.
- **x.x.x.<last>/32 (drop)**: Broadcast address for subnet configured on an interface. Last octet will vary depending on subnet size and network address. For example, this is 255 in a /24 subnet.
- **x.x.x.x/32 (local, next hop x.x.x.x/32)**: Internal route for an address present on a TNSR interface.

Routes can also be added to the table dynamically by other processes such as via BGP or if an interface is configured as a DHCP client. Check the status or other associated logs for configured features to find the origins of these routes.

9.4 Managing Routes

Routes are entered into TNSR using the `route (ipv4|ipv6) table <name>` command in configuration mode. When using the `route` command for this purpose, the address family and table name must be specified in order to establish the routing context. This command enters `config-route-table` mode. From there, individual routes can be managed.

Inside `config-route-table` mode, the following commands are available:

- **description**: Sets a description for the route table.
- **route <destination-prefix>**: Configures a route to the specified destination network. This enters `config-rttbl-next-hop` mode where the remaining parameters for the route are set.
Tip: For a single address, use a /32 mask for IPv4 or /128 for IPv6.

Inside `config-rttbl-next-hop` mode, the following commands are available:

- **description** Sets a description for this route.

- **next-hop <hop-id> via <action|gateway>** Configures how TNSR will handle traffic to this destination. This may be repeated multiple times with unique `hop-id` values to specify multiple destinations. The following parameters are available to control the route behavior:
  - **hop-id** The ID of the next hop. Must be unique between entries in the same route.
  - **via <ip-address>** Sets the next hop for this route as an IP address. Additional modifiers are possible for any `via` form using an IP address destination, see `Route modifiers`.
  - **via <ip-address> <interface>** Configures both the IP address and interface for the next hop. This is the most commonly used form for routes. May use modifiers, see `Route modifiers`.
  - **via <ip-address> next-hop-table <route-table-name>** Configures a recursive route lookup using a different route table. May use modifiers, see `Route modifiers`.
  - **via classify <classify-name>** Reserved for future use.
  - **via drop** Drops traffic to this destination (null route).
  - **via local** The destination is local to TNSR, such as an interface address or loopback.
  - **via null-send-prohibit** Packets matching this route will be dropped by TNSR, and TNSR will send an ICMP “Destination administratively prohibited” message back to the source address.
  - **via null-send-unreach** Packets matching this route will be dropped by TNSR, and TNSR will send an ICMP “Destination unreachable” message back to the source address.

### 9.4.1 Route modifiers

For routes set with a next hop using `via <ip-address>`, additional modifiers control how TNSR resolves the route destination.

- **preference** Sets the administrative distance preference. Helps to choose between multiple possible destinations when routing protocols are used. This is only a local value, and a lower value is taken as being more reliable (closer).

- **weight** The weight of routes to the same destination. Acts as a ratio of packets to deliver to each next hop.

  Tip: Equal weights will deliver the same amount of traffic to all next hops for this destination prefix, uneven weights will deliver more traffic via the higher weighted connection. If one path has a weight of 1, and the other has a weight of 3, then the first path will receive 25% (1/(1+3)) of the traffic and the other will receive 75% (3/(1+3)).

- **resolve-via-attached** Sets a constraint on recursive route resolution via attached network. The next hop is unknown, but destinations in this prefix may be located via ARP.

- **resolve-via-host** Sets a constraint on recursive route resolution via host. The next hop is known, but the interface is not.
Tip: Multiple modifiers may be used together, but when doing so, weight and preference must be set first.

Example

IPv4 example:

```
> tnsr(config)# route ipv4 table ipv4-VRF:0
> tnsr(config-route-table-v4)# route 10.2.10.0/24
> tnsr(config-rttbl4-next-hop)# next-hop 0 via 10.2.0.2 GigabitEthernet0/14/2
```

IPv6 Example:

```
> tnsr(config)# route ipv6 table ipv6-VRF:0
> tnsr(config-route-table-v6)# route fe07:b337:c4f3::/48
> tnsr(config-rttbl6-next-hop)# next-hop 0 via 2001:db8:1::2 GigabitEthernet0/14/2
```

Breaking down the examples above, first the route table is specified. Within that context a destination network route is given. The destination network establishes a sub-context for a specific route. From there, the next hop configuration is entered.

Note: When entering a next hop for a route in this way, both the IP address of the destination router and the interface must be given.

To specify more than one route, exit out of the next-hop context so that TNSR is in the correct context for the route table itself, then enter an additional destination and next-hop.

9.5 Default Route

In TNSR, the default route, sometimes called a default gateway, is the gateway of last resort. Meaning, traffic that is not local and does not have any other route specified will be sent using that route. There is no default keyword in TNSR; The special network 0.0.0.0/0 is used instead.

In this example, the gateway from Example Configuration is added using the WAN interface:

**IPv4 Default Route Example:**

```
> tnsr(config)# route ipv4 table ipv4-VRF:0
> tnsr(config-route-table-v4)# route 0.0.0.0/0
> tnsr(config-rttbl4-next-hop)# next-hop 0 via 203.0.113.1 GigabitEthernet0/14/1
> tnsr(config-rttbl4-next-hop)# exit
```

**IPv6 Default Route Example:**

```
> tnsr(config)# route ipv6 table ipv6-VRF:0
> tnsr(config-route-table-v6)# route ::/0
> tnsr(config-rttbl6-next-hop)# next-hop 0 via 2001:db8:0:2::1 GigabitEthernet0/14/1
> tnsr(config-rttbl6-next-hop)# exit
```

9.5. Default Route
Access Lists can be used to control ingress or egress traffic or to match hosts, networks and other contexts. An ACL contains a set of rules that defines source and destination hosts or networks to match, along with other aspects of traffic such as protocol and port number. Access Lists have an implicit final deny action. Any traffic not matched with an explicit permit rule will be dropped. Access Lists assume “any” for a value unless otherwise specified.

Access Lists can be stateful (reflect), or work without state tracking (permit).

Access Lists must be defined first and then applied to an interface along with a specific direction.

Host ACLs operate differently, as they govern traffic for interfaces in the host operating system rather than inside TNSR.

10.1 Standard ACLs

A standard ACL works with IPv4 or IPv6 traffic at layer 3. The name of an ACL is arbitrary so it may be named in a way that makes its purpose obvious.

ACLs consist of one or more rules, defined by a sequence number that determines the order in which the rules are applied. A common practice is to start numbering at a value higher than 0 or 1, and to leave gaps in the sequence so that rules may be added later. For example, the first rule could be 10, followed by 20.

Each rule must have an action and a defined ip-version. Rules can also define a source, destination, protocol, and other attributes for matching packets.

**description <text>** Text describing the purpose of this ACL.

**action (deny|permit|reflect)** Determines what happens to packets matched by the rule. This is required.

- **deny** Drop a packet matching this rule.
- **permit** Pass a single packet matching the rule. Since this action is per-packet and stateless, a separate ACL may also be required to pass traffic in the opposite direction.
- **reflect** Permit a packet matching this rule and use a stateful packet processing path. Track the session and automatically permit return traffic in the opposite direction.

**ip-version (ipv4|ipv6)** Controls whether IPv4 or IPv6 packets will be matched by the rule. This is required, and also governs validation of the source and destination when applicable.

**source destination** Define matching criteria for a rule based on where a packet came from or where it is going.

- **source address <ip-address>** Match the source address of a packet. The given address must match the type set for ip-version.
source port any  Match any TCP or UDP source port number (0 through 65535). Only valid when protocol is set to TCP or UDP. This is the default behavior when the rule does not contain a source port value.

source port <port-first> [- <port-last>]  Match the specified TCP or UDP source port or range of source ports. When supplying a range, the first port must be lower than the last port. Only valid when protocol is set to tcp or udp.

destination address <ip-address>  Match the destination address of a packet. The given address must match the type set for ip-version.

destination port any  Match any TCP or UDP destination port number (0 through 65535). Only valid when protocol is set to TCP or UDP. This is the default behavior when the rule does not contain a destination port value.

destination port <port-first> [- <port-last>]  Match the specified TCP or UDP destination port or range of destination ports. When supplying a range, the first port must be lower than the last port. Only valid when protocol is set to tcp or udp.

Note:  Matching a source or destination port is only possible when the protocol is explicitly set to tcp or udp.

protocol (icmp|tcp|udp)  Restricts the rule to match one specific protocol. This may be one of: icmp, tcp, udp. If no protocol is specified, then the rule will match any protocol (0). When matching icmp, IPv4 will match ICMP and IPv6 will match ICMPv6.

tcp flags value <v> mask <m>  For rules matching TCP packets, tcp flags further restrict the match. This statement requires both a value and mask, which may be given in either order. The value and mask together define the flags matched out of a possible set of flags. These flags are specified numerically using the standard values for the flags: URG=32, ACK=16, PSH=8, RST=4, SYN=2, FIN=1. Add the values together to reach the desired value.

For example, with stateful filtering a common way to detect the start of a TCP session is to look for the TCP SYN flag with a mask of SYN+ACK. That way it will match only when SYN is set and ACK is not set. Using the values from the previous paragraph yields: tcp flags value 2 mask 18

icmp (codetype) <first> [- <last>]  For rules matching ICMP protocol packets, icmp type and icmp code restrict matches to a specific value or range. The type and code are entered numerically in the range of 0-255. For a list of possible type and code combinations, see the IANA ICMP Parameters list.

icmp (codetype) any  Match any ICMP code or type. This is the default behavior.

10.1.1 Standard ACL Example

The following example ACL will block only SSH (tcp port 22) to 203.0.113.2 and permit all IPv4 other traffic:

```
tnsr(config)# acl blockssh
tnsr(config-acl)# rule 10
tnsr(config-acl-rule)# action deny
tnsr(config-acl-rule)# ip-version ipv4
tnsr(config-acl-rule)# destination address 203.0.113.2/32
tnsr(config-acl-rule)# destination port 22
tnsr(config-acl-rule)# protocol tcp
tnsr(config-acl-rule)# exit
```

(continues on next page)
Deconstructing the above example, the ACL behaves as follows:

- The name of the ACL is `blockssh`.
- The first rule is `10`. This leaves some room before it in case other rules should be matched before this rule in the future.
- Rule 10 will **deny** traffic matching:
  - A destination of a single IPv4 address, `203.0.113.2`
  - A destination of a single TCP port, `22` (ssh)
  - A source of any is implied since it is not specified
- The second rule is `20`. The gap between 10 and 20 leaves room for future expansion of rules between the two existing rules.
- Rule 20 will **permit** all other IPv4 traffic, since there is no source or destination given.

The ACL is then applied to `GigabitEthernet0/14/1` in the inbound direction.

### 10.2 MACIP ACLs

MACIP ACLs and layer 3 ACLs (*Standard ACLs*) work similarly, but MACIP ACLs match traffic at layer 2 using MAC addresses.

Since MACIP ACLs work with layer 2 information, they can only effectively function on interfaces which support operating at layer 2, such as Ethernet. Additionally, MACIP ACLs can only match layer 2 interface packets from neighboring hosts on directly connected networks.

**Warning:** The MAC address of a remote host that reaches TNSR via routing though another gateway cannot be determined, thus cannot be matched by a MACIP ACL.

For example, traffic arriving at TNSR from the Internet via Ethernet will typically have a source MAC address of the default gateway or routing peer, and *not* the actual source of the traffic.

MACIP ACLs may only be applied in the input direction, and only match source addresses.

- **description <text>** Text describing the purpose of this ACL.
- **action <name>** Determines how the rule governs packets that match.
  - **deny** Drops a packet which matches this rule.
  - **permit** Passes a single packet matching the rule.
ip-version (ipv4|ipv6) Controls whether IPv4 or IPv6 packets will be matched by the rule. This is required when an address is present for the rule, and governs validation of the address value when applicable.

address <ip-prefix> Match the source IPv4 or IPv6 address of a packet.

mac address <mac-address> Optionally specifies a MAC address to block, in six groups of two colon-separated hexadecimal values, such as 00:11:22:33:44:55. When unset, the default value is 00:00:00:00:00:00 and uses the same value for a mask, which will match any MAC address.

mac mask <mac-mask> Optionally specifies a mask which defines portions of a MAC address to match, similar to an IP Prefix value. Given in six groups of two colon-separated hexadecimal values, such as ff:ff:ff:ff:ff:ff, which matches the first half of a given MAC address. A mask of ff:ff:ff:ff:ff:ff matches an entire MAC address exactly. A mask of 00:00:00:00:00:00 matches any MAC address, and is the default behavior when no mask is set.

10.2.1 MACIP ACL Example

```
tnsr(config)# macip blockamac
tnsr(config-macip)# rule 10
tnsr(config-macip-rule)# action deny
tnsr(config-macip-rule)# mac address 00:11:22:33:44:55
tnsr(config-macip-rule)# mac mask ff:ff:ff:ff:ff:ff
tnsr(config-macip-rule)# exit
tnsr(config-macip)# exit
tnsr(config)# int GigabitEthernet0/14/2
tnsr(config-interface)# access-list macip blockamac
tnsr(config-interface)# exit
tnsr(config)#
```

10.3 Viewing ACL and MACIP Information

The `show acl [<name>]` command prints a list of defined ACLs and their actions. If `<name>` is given, then output is limited to the specified ACL.

```
tnsr# show acl

Access Control List: blockssh
 IPv Seq Action Source Dest Proto SP/T DP/C Flag Mask
---- --- ------ ---------- -------------- ----- -------- ----- ---- ----
ipv4 10 deny 0.0.0.0/0 203.0.113.2/32 tcp 0-65535 22-22 0x00 0x00
ipv4 20 permit 0.0.0.0/0 0.0.0.0/0 0.0.0.0/0 0
```

The `show macip [<name>]` command works the same way for MACIP entries:

```
tnsr(config)# show macip

MACIP ACL: blockamac
 AF Seq Action IP Prefix MAC Address
---- --- ------ -------------- ----------------- --------------
ipv4 10 deny 0.0.0.0/0 00:11:22:33:44:55 ff:ff:ff:ff:ff:ff
```
10.4 ACL and NAT Interaction

When NAT is active, ACL rules are always processed before NAT on interfaces where NAT is applied, in any direction. The remainder of the section refers to the following example static NAT rule:

```plaintext
nat static mapping tcp local 10.2.0.129 22 external 203.0.113.2 222
```

In this example, that rule is applied on the external-facing interface containing 203.0.113.2.

10.4.1 Inbound ACL Rules

ACL Rules set to be processed in the **inbound** direction on an interface (access-list input acl <name> sequence <seq>) will match on the external address and/or port in a static NAT rule. In the above example, this means an inbound ACL would match on a destination IP address of 203.0.113.2 and/or a destination port of 222.

10.4.2 Outbound ACL Rules

ACL Rules set to be processed in the **outbound** direction on an interface (access-list output acl <name> sequence <seq>) will match on the local address and/or port in a static NAT rule. In the above example, this means an outbound ACL would match on a source IP address of 10.2.0.129 and/or a source port of 22.

10.5 Host ACLs

TNSR can also create host ACLs to control traffic on host interfaces, such as the management interface. These ACLs are implemented using Netfilter.

As mentioned in Default Allowed Traffic, TNSR includes a default set of host ACLs which protect host OS interfaces. Host ACLs created by administrators can override or augment the default blocking behavior.

ACLs are ordered by sequence number, and evaluated from the start to the end, stopping when a match is found. Each ACL contains one or more rules which define matching criteria and actions taken.

To create a new ACL, from config mode, use the command `host acl <acl-name>`, with the name to use for the new ACL. This command enters config-host-acl mode, where the following commands are available:

- **description <text>** A text description of the host ACL.
- **sequence <acl-seq>** The sequence number of this ACL. This sequence number controls the order of the ACLs when TNSR generates the host OS ruleset.
- **rule <rule-seq>** Creates a new rule in this ACL with the given sequence number and enters config-host-acl-rule mode. The sequence number of the rule controls the order of the individual rules inside this ACL.

Inside config-host-acl-rule mode, the following commands are available:

- **action (deny|permit)** Controls whether packets matching this rule will be passed (permit) or dropped (deny).
- **description <text>** A text description of this rule.
- **match input-interface <host-interface>** When set, this rule will only match traffic on the given host interface name. This is an interface name as seen by the host operating system, and not a TNSR interface.
match ip address (source|destination) <ip-addr>  Matches based on a given source or destination IP address.

match ip icmp type <type> [code <code>]  Matches a specific IPv4 ICMP type and optionally matches the ICMP code as well. To match ICMP, the IP protocol must be set to icmp. Allowed types include: address-mask-reply, address-mask-request, destination-unreachable, echo-reply, echo-request, info-reply, info-request, parameter-problem, redirect, router-advertisement, router-solicitation, source-quench, time-exceeded, timestamp-reply, and timestamp-request.

match ip icmpv6 type <type> [code <code>]  Matches a specific IPv6 ICMP type and optionally matches the ICMP code as well. To match ICMP, the IP protocol must be set to icmp. Allowed types include: destination-unreachable, echo-reply, echo-request, mld-listener-query, mld-listener-reduction, mld-listener-report, nd-neighbor-advert, nd-neighbor-solicit, nd-redirect, nd-router-advert, nd-router-solicit, packet-too-big, parameter-problem, router-renumbering, and time-exceeded.

match ip port (source|destination) <port-num>  Matches the given source or destination port number. To match a port, the protocol must be tcp or udp.

match ip port (source|destination) range start <low-port-num> [end <high-port-num>]  Matches the given source or destination port range, given as a lower start port number and a higher ending port number. To match a port, the protocol must be tcp or udp.

match ip protocol (icmp|tcp|udp)  Matches the specified IP protocol. When unset, any protocol will match the rule. However, it must be set to enable protocol-specific matching such as ports (TCP or UDP) or ICMP types/codes.

match ip tcp flag (ack|cwr|ece|fin|psh|rst|syn|urg)  Matches a specific TCP flag. May only be used when protocol is set to tcp.

match ip version (4|6)  Matches based on whether a packet is IPv4 (4), or IPv6 (6).

match mac address (source|destination) <mac>  Matches based on the source or destination MAC address. This is only valid for neighboring hosts on interfaces which provide layer 2 information, such as Ethernet.

10.5.1 Host ACL Example

This example configures a rule to allow traffic from the remote system 203.0.113.54 to reach a local host OS daemon on port 12345, used by the TNSR IDS daemon:

```
tnsr(config)# host acl tnsrids
tnsr(config-host-acl)# sequence 10
tnsr(config-host-acl)# description TNSR IDS
tnsr(config-host-acl)# rule 100
tnsr(config-host-acl-rule)# description Pass to tnsrids
tnsr(config-host-acl-rule)# action permit
tnsr(config-host-acl-rule)# match ip address source 203.0.113.54
tnsr(config-host-acl-rule)# match ip protocol tcp
tnsr(config-host-acl-rule)# match ip port destination 12345
```

10.5.2 Host ACL Status

To see the list of current host ACLs, use the following command:
tnsr# show host ruleset

```plaintext
table inet tnsr_filter {
  
  chain tnsr_input_mgmt_local {
    jump tnsrids
  }

  chain tnsr_input_mgmt_default {
    tcp dport ssh accept
    tcp dport http accept
    tcp dport https accept
    ip protocol icmp accept
    ip6 nexthdr ipv6-icmp accept
    tcp dport bgp accept
    ip protocol ospf accept
    udp dport isakmp accept
    tcp dport ntp accept
    udp dport ntp accept
    tcp dport domain accept
    udp dport domain accept
    udp dport snmp accept
    udp dport bootps accept
    ip ttl 1 udp dport 33434-33524 counter packets 0 bytes 0 accept
  }

  chain tnsr_input {
    type filter hook input priority 0; policy accept;
    iifname "lo" accept
    ct state established,related accept
    jump tnsr_input_mgmt_mgmt_local
    jump tnsr_input_mgmt_mgmt_default
    drop
  }

  chain tnsr_forward {
    type filter hook forward priority 0; policy drop;
  }

  chain tnsrsids {
    tcp dport 12345 counter packets 0 bytes 0 accept
  }
}
```

10.5. Host ACLs
Border Gateway Protocol (BGP) is a dynamic routing protocol used between network hosts. BGP routes between autonomous systems, connecting to defined neighbors to exchange routing information.

BGP can be used for exterior routing (ebgp) or interior routing (ibgp), routing across Internet circuits, private links, or segments of local networks.

The BGP service in TNSR is handled by FRR.

### 11.1 Required Information

Before starting, take the time to gather all of the information required to form a BGP adjacency to a neighbor. At a minimum, TNSR will need to know these items:

- **Local AS Number**  The autonomous system (AS) number for TNSR. This is typically assigned by an upstream source, an RIR, or mutually agreed upon by internal neighbors.

- **Local Router ID**  Typically the highest numbered local address on the firewall. This is also frequently set as the internal or LAN side IP address of a router. It does not matter what this ID is, so long as it is given in IPv4 address notation and does not conflict with any neighbors.

- **Local Network(s)**  The list of networks that are advertised over BGP as belonging to the Local AS. For external BGP, this is typically the IP address block allocated by the RIR. For internal BGP, this may be a list of local networks or a summarized block.

- **Neighbor AS Number**  The autonomous system number of the neighbor.

- **Neighbor IP Address**  The IP address of the neighboring router.

The example in this section uses the following values:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local AS Number</td>
<td>65002</td>
</tr>
<tr>
<td>Local Router ID</td>
<td>10.2.0.1</td>
</tr>
<tr>
<td>Local Network(s)</td>
<td>10.2.0.0/16</td>
</tr>
<tr>
<td>Neighbor AS Number</td>
<td>65005</td>
</tr>
<tr>
<td>Neighbor IP Address</td>
<td>203.0.113.14</td>
</tr>
</tbody>
</table>

**Warning:** If NAT is active on the same interface acting as a BGP peer, then NAT forwarding must also be enabled. See [NAT Forwarding](#).
11.2 Enabling BGP

The BGP service has a master enable/disable toggle that must be set before BGP will operate. Enable BGP using the `enable` command in `config-frr-bgp` mode:

```
 tnsr(config)# route dynamic bgp
 tnsr(config-frr-bgp)# bgp enable
```

The BGP service is managed as described in Service Control.

**Warning:** After starting or restarting TNSR, restart the BGP service from within the TNSR configuration mode CLI to ensure that the routes from BGP neighbors are fully populated throughout TNSR:

```
 tnsr(config)# service bgp restart
```

11.3 Example BGP Configuration

The following example configures a BGP adjacency to a neighbor using the settings from Example BGP Configuration:

```
 tnsr(config)# route dynamic bgp
 tnsr(config-frr-bgp)# server 65002
 tnsr(config-bgp)# router-id 10.2.0.1
 tnsr(config-bgp)# neighbor 203.0.113.14
 tnsr(config-bgp-neighbor)# remote-as 65005
 tnsr(config-bgp-neighbor)# enable
 tnsr(config-bgp-neighbor)# exit
 tnsr(config-bgp)# address-family ipv4 unicast
 tnsr(config-bgp-ip4uni)# network 10.2.0.0/16
 tnsr(config-bgp-ip4uni)# exit
 tnsr(config-bgp)# exit
 tnsr(config-frr-bgp)# enable
 tnsr(config-frr-bgp)# exit
 tnsr(config)# service bgp restart
```

The next few sections break down and explain each part of this example.

11.3.1 Router Statement

```
 tnsr(config)# route dynamic bgp
 tnsr(config-frr-bgp)# server 65002
```

This statement enters BGP Server mode and sets the autonomous system number for this router to 65002.

```
 tnsr(config-bgp)# router-id 10.2.0.1
```

BGP mode offers a new subset of commands, including setting the `router-id` as shown here. In this example the internal IP address of TNSR, 10.2.0.1, is set as the router ID.

BGP mode also can define the neighbors and configure the behavior of BGP for different address families, among other possibilities.
11.3.2 Neighbor Configuration

```
tnsr(config-bgp)# neighbor 203.0.113.14
tnsr(config-bgp-neighbor)# remote-as 65005
tnsr(config-bgp-neighbor)# enable
tnsr(config-bgp-neighbor)# exit
```

The `neighbor` statement can take either an IP address to setup a single neighbor, as the example shows for `203.0.113.14`, or it can take a name which configures a peer group. The command changes to BGP neighbor mode, indicated by the `config-bgp-neighbor` prefix in the prompt.

Peer groups work nearly identical to neighbors, and they define options that are common to multiple neighbors. To configure a neighbor as a member of a peer group, append `peer-group <group name>` to the `neighbor` statement.

Within BGP neighbor mode, the most important directive is `remote-as` to set the AS number of the neighbor. In this case, the AS number of the neighbor is `65005`. The majority of other neighbor configuration is handled by the neighbor definition for a specific address family.

The default state of a neighbor is disabled down. To enable the neighbor, enter the `enable` command in BGP neighbor mode.

11.3.3 Address Family Configuration

```
tnsr(config-bgp)# address-family ipv4 unicast
tnsr(config-bgp-ip4uni)# network 10.2.0.0/16
tnsr(config-bgp-ip4uni)# exit
```

The TNSR BGP implementation is capable of handling routing information for IPv4 and IPv6 independently, among other network layer protocols. The `address-family` command defines BGP behavior for each specific supported case. The most common address families are `ipv4 unicast` and `ipv6 unicast`. The command changes to BGP address family mode, `bgp-af`, which contains settings specific to each address family.

In this example for the `ipv4 unicast` address family, BGP is instructed to announce a route for the `10.2.0.0/16` network prefix. Neighbors will receive this route once they form an adjacency to this router.

11.3.4 BGP Example with Loopback

BGP on TNSR can also be used with loopback interfaces for more advanced routing scenarios. Using a loopback for a BGP update source allows the path to the routing peer to be handled in some other way. It may be static, or it may involve multiple paths to the peer, for example.

This scenario is based on the previous example, but uses a loopback interface for the update source.

Configure Loopback

```
tnsr(config)# interface loopback bgploop
tnsr(config-loo foak)# instance 1
tnsr(config-loopback)# exit
tnsr(config)# interface loop1
tnsr(config-interface)# ip address 10.5.222.1/32
tnsr(config-interface)# exit
```
Since the loopback is not on an interface, the 10.5.222.1 address must be routed to TNSR somehow. This could be an address in a routed block, or there could be another method of handling routes between the peers.

**Route to Peer**

Likewise, TNSR must know how to reach the remote peer, 10.5.222.2, which in this case the example also assumes is a loopback address configured in a similar manner. In this example, the peer is reachable at 203.0.113.14 which is in a network directly connected to TenGigabitEthernet6/0/0. For simplicity, this will only be a static route:

```
    tnsr(config)# route ipv4 table ipv4-VRF:0
    tnsr(config-route-table-v4)# route 10.5.222.2/32
    tnsr(config-rttbl4-next-hop)# next-hop 0 via 203.0.113.14 TenGigabitEthernet6/0/0
```

**Setup BGP with Loopback Address**

Now setup the BGP service, using the new neighbor address and with the loopback address as an update source:

```
    tnsr(config)# route dynamic bgp
    tnsr(config-frr-bgp)# server 65002
    tnsr(config-bgp)# router-id 10.2.0.1
    tnsr(config-bgp)# neighbor 10.5.222.2
    tnsr(config-bgp-neighbor)# remote-as 65005
    tnsr(config-bgp-neighbor)# update-source 10.5.222.1
    tnsr(config-bgp-neighbor)# enable
    tnsr(config-bgp-neighbor)# exit
    tnsr(config-bgp)# address-family ipv4 unicast
    tnsr(config-bgp-ip4uni)# network 10.2.0.0/16
    tnsr(config-bgp-ip4uni)# exit
    tnsr(config-bgp)# exit
    tnsr(config-frr-bgp)# enable
    tnsr(config-frr-bgp)# exit
    tnsr(config)# service bgp restart
```

**11.4 Advanced Configuration**

The BGP functionality in TNSR is capable of advanced configurations far beyond those detailed in this section. There are numerous commands to fine-tune BGP behavior, to handle routes, route maps, prefix lists, timer adjustments, etc. As TNSR uses FRR, most FRR configuration commands for BGP are mirrored in TNSR.

For a full command reference, see *Commands*.

**11.5 BGP Information**

TNSR supports several commands to display information about the BGP daemon configuration and its status.

**11.5.1 Configuration Information**

To view the BGP configuration:
To view the routing daemon manager (Zebra) configuration:

```
tnsr# show route dynamic manager
```

To view other individual sections of the configuration:

```
tnsr# show route dynamic access-list [<access-list-name>]
tnsr# show route dynamic bgp as-path [<as-path-name>]
tnsr# show route dynamic bgp community-list [<community-list-name>]
tnsr# show route dynamic prefix-list [<prefix-list-name>]
tnsr# show route dynamic route-map [<route-map-name>]
```

### 11.5.2 Status Information

For a brief summary of BGP status information:

```
tnsr# show route dynamic bgp summary
```

For lists configured BGP Neighbors and their status details:

```
tnsr# show route dynamic bgp neighbors [ [<peer>] [advertised-routes|dampened-routes|flap-statistics|prefix-counts|received|received-routes|routes] ]
```

For information about a specific BGP peer group:

```
tnsr# show route dynamic bgp peer-group <peer-group-name>
```

For a list of valid BGP next hops:

```
tnsr# show route dynamic bgp nexthop [detail]
```

For details about an address or prefix in the BGP routing table:

```
tnsr# show route dynamic bgp network <IP Address|Prefix>
```

### 11.5.3 BGP Active Session Control

The `clear` command can be used to reset active BGP sessions. This command is available from within `config-frr-bgp` mode. The general form of the command is:

```
tnsr(config)# route dynamic bgp
tnsr(config-frr-bgp)# clear (*|<peer>|<asn>) [soft]
```

The first parameter controls what will be cleared, and values may be completed automatically with `tab`:

- `*` Clears all open BGP sessions
- `<peer>` Clears all sessions to a specific peer IP address or peer group name
- `<asn>` Clears all sessions to a specific AS number

The second parameter, `soft`, is optional and controls whether or not the command will trigger a soft reconfiguration.
11.5.4 Additional Information

Additional BGP status information can be obtained by using the `vtysh` program outside of TNSR. The `vtysh` program must be run as root:

```
sudo vtysh
```

The `vtysh` interface offers numerous commands. Of particular interest for BGP status are the following:

- `show bgp summary` A brief summary of BGP status information.
- `show bgp neighbors` Lists configured BGP Neighbors and their status details.
- `show ip bgp` A list of routes and paths for networks involved in BGP.
- `show ip route` The IP routing table managed by the FRR Zebra daemon, which marks the origin of routes to see which entries were obtained via BGP.

11.6 Working with Large BGP Tables

When working with a large set of routes, roughly exceeding 30,000 route table entries, TNSR may require additional memory to be allocated for the VPP dataplane Forwarding Information Bases (FIB). Smaller routing tables do not require special configuration.

This memory allocation can be performed in configuration mode using one of the following commands:

For IPv4 *(Memory)*:

```
tnsr# configure
tnsr(config)# dataplane ip heap-size <size>
```

For IPv6 *(Memory)*:

```
tnsr# configure
tnsr(config)# dataplane ip6 heap-size <size>
```

The format of the size is `<number>[KMG]`, for example: `512M` or `1G` for 512 Megabytes or 1 Gigabyte, respectively. Additionally, the statistics segment heap size may also need to be increased *(Statistics Segment)*:

```
tnsr# configure
tnsr(config)# dataplane statseg heap-size <size>
```

**Note:** The default size for `dataplane statseg heap-size` is 96MB, which is sufficient for approximately one million routes.

The VPP dataplane service requires a restart to enable these configuration changes. Restart VPP from the TNSR configuration mode CLI using the following command:

```
tnsr# configure
tnsr(config)# service dataplane restart
```
IPsec provides a standards-based VPN implementation compatible with other IPsec implementations. The IPsec sub-system in TNSR is handled by strongSwan.

Currently, TNSR supports routed IPsec, allowing BGP or static routes to send traffic through IPsec.

12.1 Required Information

Before attempting to configure an IPsec tunnel, several pieces of information are required in order for both sides to build a tunnel. Typically the administrators of both tunnel endpoints will negotiate and agree upon the values to use for an IPsec tunnel.

At a minimum, these pieces of information should be known to both endpoints before attempting to configure a tunnel:

- **Local Address** The IP address on TNSR which will be used to send and accept IPsec traffic from the peer.
- **Local IKE Identity** The IKE identifier for TNSR, typically an IP address and the same as **Local Address**.
- **Local Network(s)** A list of local networks which will communicate through the IPsec tunnel to hosts on **Remote Network(s)**. This is not entered into the configuration on TNSR for routed IPsec, but will be needed by the peer.
- **Remote Address** The IP address of the IPsec peer.
- **Remote IKE Identity** The identifier for the IPsec peer, typically the same as **Remote Address**.
- **Remote Network(s)** A list of networks at the peer location with which hosts in the **Local Network(s)** will communicate. If using static routing, routes must be manually added for these networks using the **Remote IPsec Address** and ipsecX interface. If BGP is used with IPsec, this will be handled automatically.
- **IKE Version** Either 1 for IKEv1 or 2 for IKEv2. IKEv2 is stronger and more capable, but not all IPsec equipment can properly handle IKEv2.
- **IKE Lifetime** The maximum amount of time that an IKE session can stay alive until it is renegotiated.
- **IKE Encryption** The encryption algorithm used to encrypt IKE messages.
- **IKE Integrity** The integrity algorithm used to authenticate IKE messages
- **IKE DH/MODP Group** Diffie-Hellman group for key establishment, given in bits.
- **IKE Authentication** The type of authentication used to verify the identity of the peer.
- **Pre-Shared Key** When using Pre-Shared Key for IKE Authentication, this key is used on both sides to authenticate the peer.
SA Lifetime  The amount of time that a child security association can be active before it is rekeyed.
SA Encryption  The encryption algorithm used to encrypt tunneled traffic.
SA Integrity  The integrity algorithm used to authenticate tunneled traffic.
SA DH/MODP Group  Diffie-Hellman group for security associations, in bits.
Local IPsec Address  The local IP address for the ipsecX interface, used for routing traffic to/from IPsec peers.
Remote IPsec Address  The remote IP address for the peer on ipsecX, used as a gateway for routing, or a BGP neighbor.

Warning: If NAT is active on the same interface acting as an IPsec endpoint, then NAT forwarding must also be enabled. See NAT Forwarding.

12.2 IPsec Example

12.2.1 Required Information

This table contains the Required Information used to form the IPsec tunnel used in this example.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Address</td>
<td>203.0.113.2</td>
</tr>
<tr>
<td>Local IKE Identity</td>
<td>203.0.113.2</td>
</tr>
<tr>
<td>Local Network(s)</td>
<td>10.2.0.0/16</td>
</tr>
<tr>
<td>Remote Address</td>
<td>203.0.113.25</td>
</tr>
<tr>
<td>Remote IKE Identity</td>
<td>203.0.113.25</td>
</tr>
<tr>
<td>Remote Network(s)</td>
<td>10.25.0.0/16</td>
</tr>
<tr>
<td>IKE Version</td>
<td>1</td>
</tr>
<tr>
<td>IKE Lifetime</td>
<td>28800</td>
</tr>
<tr>
<td>IKE Encryption</td>
<td>AES-128</td>
</tr>
<tr>
<td>IKE Integrity</td>
<td>SHA1</td>
</tr>
<tr>
<td>IKE DH/MODP Group</td>
<td>2048 (14)</td>
</tr>
<tr>
<td>IKE Authentication</td>
<td>Pre-Shared Key</td>
</tr>
<tr>
<td>Pre-Shared Key</td>
<td>mysupersecretkey</td>
</tr>
<tr>
<td>SA Lifetime</td>
<td>3600</td>
</tr>
<tr>
<td>SA Encryption</td>
<td>AES-128</td>
</tr>
<tr>
<td>SA Integrity</td>
<td>SHA1</td>
</tr>
<tr>
<td>SA DH/MODP Group</td>
<td>2048 (14)</td>
</tr>
<tr>
<td>Local IPsec Address</td>
<td>172.32.0.1/30</td>
</tr>
<tr>
<td>Remote IPsec Address</td>
<td>172.32.0.2</td>
</tr>
</tbody>
</table>

12.2.2 Example Configuration

This configuration session implements the tunnel described by the settings in Example IPsec Configuration:
This example is used as a reference through the remainder of the chapter.
12.3 IPsec Configuration

The `ipsec tunnel <n>` command, issued from `config` mode, changes to IPsec tunnel mode. This is denoted by `config-ipsec-tun` in the prompt.

The identifier number for tunnel entries starts at 0 and increments by one. To determine the next tunnel number for a new entry, run `ipsec tunnel ?` and TNSR will print the existing tunnel ID numbers.

This command creates an IPsec tunnel with an identifier of 0:

```
 tnsr(config)# ipsec tunnel 0
 tnsr(config-ipsec-tun)#
```

The remainder of the configuration is covered in the following sections.

12.3.1 IPsec Endpoints

Next, the IPsec tunnel needs endpoints, defined using the following commands from within `config-ipsec-tun` mode:

- **local-address** Defines the IP address used by TNSR for this IPsec tunnel. This address must exist on a TNSR interface.
- **remote-address** Defines the IP address or hostname of the remote peer.

**IPsec Endpoint Example**

```
 tnsr(config-ipsec-tun)# local-address 203.0.113.2
 tnsr(config-ipsec-tun)# remote-address 203.0.113.25
```

12.3.2 IPsec Keys

Inside `config-ipsec-tun` mode, the following commands are available for IPsec key management.

- **crypto config-type (ike|manual)** Configures the type of key management TNSR will use for this tunnel.
  - **ike** Internet Key Exchange (IKE). The most common method of key management. IPsec tunnels utilize IKE to dynamically handle key exchange when both parties are negotiating a security association.
  - **manual** Static key management.

- **crypto ike** Enters `config-ipsec-crypto-ike` mode to configure IPsec IKE behavior, which is the bulk of the remaining work for most IPsec tunnels.

**IKE Configuration**

Inside `config-ipsec-crypto-ike` mode, the following commands are available to configure basic IKE behavior:

- **version <x>** Instructs TNSR to use either IKEv1 or IKEv2. Use 2 for IKEv2, which is more secure, or 1 for IKEv1 which is more common and more widely supported.
lifetime <xx> Sets the maximum time for this IKE session to be valid, in seconds within the range 120.214783647. Default value is 14400 seconds (4 hours). Commonly set to 28800 seconds (8 hours). This value should be longer than the IKE child lifetime, discussed later.

dpd-interval <xx> Optional time to wait between sending Dead Peer Detection (DPD) polls, given in seconds within the range 0–65535.

key-renewal (reauth/rekey) Controls the method used to update keys on an established IKE security association (SA) before the lifetime expires.

reauth TNSR performs a full teardown and re-establishment of IKE and child SAs.
rekey Inline rekeying while SAs stay active. Only available in IKEv2.

proposal <name> Configures a new IKE proposal and enters config-ike-proposal mode.

identity (local/remote) Configures IKE identity validation and enters config-ike-identity mode.

authentication (local/remote) Configures IKE authentication and enters config-ike-auth mode.

Additional config-ipsec-crypto-ike mode commands are available to configure other aspects of the IPsec tunnel, such as proposals, identity, and authentication. These are covered next.

IKE Example

This example tells TNSR to use IKE for key management, and then sets the tunnel to IKEv2 and a lifetime of 8 hours.

```
tnsr(config-ipsec-tun)# crypto config-type ike
ntsr(config-ipsec-tun)# crypto ike
ntsr(config-ipsec-ike)# version 2
ntsr(config-ipsec-crypto-ike)# lifetime 28800
```  

Additional IKE Configuration

The remainder of the IKE configuration is covered in the following sections.

IKE Proposal

IKE Proposals instruct TNSR how the key exchange will be encrypted and authenticated. TNSR supports a variety of encryption algorithms, integrity/authentication hash algorithms, pseudo-random functions (PRF), and Diffie-Hellman (DH) group specifications. These choices must be coordinated between both endpoints.

**Tip:** Some vendor IPsec implementations refer to IKE/ISAKMP as “Phase 1”, which may help when attempting to map values supplied by a peer to their corresponding values in TNSR.

From within config-ipsec-crypto-ike mode, use the proposal <name> command to start a new proposal and enter config-ike-proposal mode. In config-ike-proposal mode, the following commands are available:

- **encryption <ea-name>** Configures the encryption algorithm to use for the proposal.
- **integrity <ia-name>** Configures the integrity algorithm to use for the proposal.
- **prf <prf-name>** Configures the pseudo-random function (PRF) to use for the proposal.
- **group <group-name>** Configures the Diffie-Hellman group (DH Group) to use for the proposal.
Tip: To see a list of supported choices for each option, follow the initial command with a ?, such as `encryption ?`.

Each of these is described in more detail in the following sections.

**Encryption Algorithms**

TNSR supports many common, secure encryption algorithms. Some older and insecure algorithms are not supported. Algorithms based on AES are common and secure, and are widely supported by other VPN implementations.

AES-GCM, or AES Galois/Counter Mode is an efficient and fast authenticated encryption algorithm, which means it provides data privacy as well as integrity validation, without the need for a separate integrity algorithm.

Additionally, AES-based algorithms can often be accelerated by AES-NI.

**Warning:** TNSR includes the Triple-DES (3DES) algorithm for compatibility with legacy systems, but it is not considered secure. Specifically, 3DES is considered broken by attacks such as Sweet32. Use stronger encryption algorithms where possible.

A full list of encryption algorithms supported by TNSR:

```
 tnsr(config-ike-proposal)# encryption ?
 <cr>
 3des   Triple-DES
 aes128 128 bit AES-CBC
 aes128ccm12 128 bit AES-CCM with 12 byte ICV
 aes128ccm16 128 bit AES-CCM with 16 byte ICV
 aes128ccm8 128 bit AES-CCM with 8 byte ICV
 aes128ctr 128 bit AES-Counter
 aes128gcm12 128 bit AES-GCM with 12 byte ICV
 aes128gcm16 128 bit AES-GCM with 16 byte ICV
 aes128gcm8 128 bit AES-GCM with 8 byte ICV
 aes192 192 bit AES-CBC
 aes192ccm12 192 bit AES-CCM with 12 byte ICV
 aes192ccm16 192 bit AES-CCM with 16 byte ICV
 aes192ccm8 192 bit AES-CCM with 8 byte ICV
 aes192ctr 192 bit AES-Counter
 aes192gcm12 192 bit AES-GCM with 12 byte ICV
 aes192gcm16 192 bit AES-GCM with 16 byte ICV
 aes192gcm8 192 bit AES-GCM with 8 byte ICV
 aes256 256 bit AES-CBC
 aes256ccm12 256 bit AES-CCM with 12 byte ICV
 aes256ccm16 256 bit AES-CCM with 16 byte ICV
 aes256ccm8 256 bit AES-CCM with 8 byte ICV
 aes256ctr 256 bit AES-Counter
 aes256gcm12 256 bit AES-GCM with 12 byte ICV
 aes256gcm16 256 bit AES-GCM with 16 byte ICV
 aes256gcm8 256 bit AES-GCM with 8 byte ICV
 camellia128 128 bit Camellia
 camellia128ccm12 128 bit Camellia-CCM with 12 byte ICV
 camellia128ccm16 128 bit Camellia-CCM with 16 byte ICV
 camellia128ccm8 128 bit Camellia-CCM with 8 byte ICV
 camellia128ctr 128 bit Camellia-Counter
```
Integrity Algorithms

Integrity algorithms provide authentication of messages and randomness, ensuring that packets are authentic and were not altered by a third party before arriving, and also for constructing keying material for encryption.

Note: When using an authenticated encryption algorithm like AES-GCM with a child Security Association (SA) as opposed to IKE/ISAKMP, an integrity option should not be configured, as it is redundant and reduces performance.

When an authenticated encryption algorithm is used with IKE, configure a Pseudo-Random Function (PRF) instead of an Integrity Algorithm. If an integrity algorithm is defined in this case, TNSR will attempt to map the chosen algorithm to an equivalent PRF.

A full list of integrity algorithms supported by TNSR:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>camellia192</td>
<td>192 bit Camellia</td>
<td></td>
</tr>
<tr>
<td>camellia192ccm12</td>
<td>192 bit Camellia-CCM with 12 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia192ccm16</td>
<td>192 bit Camellia-CCM with 16 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia192ccm8</td>
<td>192 bit Camellia-CCM with 8 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia192ctr</td>
<td>192 bit Camellia-Counter</td>
<td></td>
</tr>
<tr>
<td>camellia256</td>
<td>256 bit Camellia</td>
<td></td>
</tr>
<tr>
<td>camellia256ccm12</td>
<td>256 bit Camellia-CCM with 12 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia256ccm16</td>
<td>256 bit Camellia-CCM with 16 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia256ccm8</td>
<td>256 bit Camellia-CCM with 8 byte ICV</td>
<td></td>
</tr>
<tr>
<td>camellia256ctr</td>
<td>256 bit Camellia-Counter</td>
<td></td>
</tr>
<tr>
<td>chacha20poly1305</td>
<td>256 bit ChaCha20/Poly1305 with 16 byte ICV</td>
<td></td>
</tr>
</tbody>
</table>

Pseudo-Random Functions

A Pseudo-Random Function (PRF) is similar to an integrity algorithm, but instead of being used to authenticate messages, it is only used to provide randomness for purposes such as keying material. PRFs are primarily used with an authenticated encryption algorithm type such as AES-GCM, but they can be explicitly defined for use with other integrity algorithms.

If a PRF is not explicitly defined, TNSR will attempt to derive the PRF to use based on the integrity algorithm for a given proposal.

Note: In the case of AES-NI, prf aes xcbc is likely the most appropriate choice as it can be accelerated by AES-NI, and it is more widely supported than its improved successor prf aes cmac.

A full list of pseudo-random function supported by TNSR:
Diffie-Hellman Groups

Diffie-Hellman (DH) exchanges allow two parties to establish a shared secret across an untrusted connection. DH choices can be referenced in several different ways depending on vendor implementations. Some reference a DH group by number, others by size. When referencing by group number, generally speaking higher group numbers are more secure.

**Tip:** In most cases, modp2048 (Group 14) is the lowest choice considered to provide sufficient security in a modern computing environment.

A full list of DH Groups supported by TNSR:

```plaintext
tnsr(config-ike-proposal)# group ?
<cr>
ecp256        Group 19 (256 bit ECP)
ecp384        Group 20 (384 bit ECP)
ecp521        Group 21 (521 bit ECP)
modp1024       Group 2 (1024 bit modulus)
modp1024s160   Group 22 (1024 bit modulus, 160 bit POS)
modp1536       Group 5 (1536 bit modulus)
modp2048       Group 14 (2048 bit modulus)
modp2048s224   Group 23 (2048 bit modulus, 224 bit POS)
modp2048s256   Group 24 (2048 bit modulus, 256 bit POS)
modp3072       Group 15 (3072 bit modulus)
modp4096       Group 16 (4096 bit modulus)
modp6144       Group 17 (6144 bit modulus)
modp768        Group 1 (768 bit modulus)
modp8192       Group 18 (8192 bit modulus)
```

**Warning:** TNSR supports modp768 (Group 1) and modp1024 (Group 2) for compatibility purposes but they are considered broken by the Logjam Attack and should be avoided.

TNSR also supports modp1024s160 (Group 22), modp2048s224 (Group 23), and modp2048s256 (Group 24) for compatibility but they should also be avoided as they have a questionable source of primes.

IKE Proposal Example

This example configures one proposal. This proposal uses AES-128 encryption, SHA-1 for integrity hashing, and DH group 14 (2048 bit modulus).
IKE Identity

In IKE, each party must ensure it is communicating with the correct peer. One aspect of this validation is the identity information included in IKE. Each router tells the other its own local identity and they each validate it against the stored remote identity. If they do not match, the peer is rejected.

From within `config-ipsec-crypto-ike` mode, use the `identity local` and `identity remote` commands to configure local and remote identity information. In either case, the `identity` command enters `config-ike-identity` mode.

IKE requires both local and remote identities. The local identity is sent to the remote peer during the exchange. The remote identity is used to validate the identity received from the peer during the exchange.

In `config-ike-identity`, the following commands are available:

- **type <name>** Sets the type of identity value. The following types are available:
  - `address` IPv4 or IPv6 address in the standard notation for either (e.g. 192.0.2.3 or 2001:db8:1:2::3)
    - This is the most common type, with the value set to the address on TNSR used as the local-address for the IPsec tunnel.
  - `dn` An X.509 distinguished name (e.g. certificate subject)
  - `email` Email address (e.g. user@example.com).
  - `fqdn` A fully qualified domain name (e.g. host.example.com)
  - `key-id` An arbitrary string used as an identity
  - `none` Automatically interpret the type based on the value
- **value <text>** The identity value, in a format corresponding to the chosen type.

**Note:** The local identity type and value must both be supplied to the administrator of the remote peer so that it can properly identify this endpoint.

Identity Example

First configure the local identity of this firewall. The identity is an IP address, using the same value as the local address of the IPsec tunnel.

```
tnsr(config-ipsec-crypto-ike)# identity local
tnsr(config-ike-identity)# type address
tnsr(config-ike-identity)# value 203.0.113.2
tnsr(config-ike-identity)# exit
```

Next, configure the remote identity. The remote peer has also chosen to use an IP address, the value of which is the remote address used for the IPsec tunnel.

```
```
IKE Authentication

After verifying the identity, TNSR will attempt to authenticate the peer using the secret from its configuration in one or two round passes. In most common configurations there is only a single authentication round, however in IKEv2 a tunnel may have two rounds of unique authentication.

From within config-ipsec-crypto-ike mode, use the authentication local and authentication remote commands to configure local and remote authentication information. In either case, the authentication command enters config-ike-auth mode.

TNSR will use the parameters under authentication local to authenticate outbound traffic and the authentication remote parameters are used to authenticate inbound traffic.

Note: With pre-shared key mode, most real-world configurations use identical values for both local and remote authentication.

From config-ike-auth mode, the round <n> command configures parameters for round 1 or 2. As mentioned previously, most configurations will only use round 1. The round command then enters config-ike-auth-round mode.

In config-ike-auth-round mode, the following commands are available:

- **type <name>** The type of authentication to perform.
  
  Currently the only authentication type supported by TNSR is psk (pre-shared key).
  
- **psk <text>** For psk type authentication, this command defines the pre-shared key value.

IKE Authentication Example

This example only has one single round of authentication, a pre-shared key of mysupersecretkey. Thus, the type is set to psk and then the psk is set to the secret value.

**Warning:** Do not transmit the pre-shared key over an insecure channel such as plain text e-mail!

First, add the local authentication parameters:

```bash
tnsr(config-ipsec-crypto-ike)# authentication local
tnsr(config-ike-auth)# round 1
tnsr(config-ike-auth-round)# type psk
tnsr(config-ike-auth-round)# psk mysupersecretkey
tnsr(config-ike-auth-round)# exit
tnsr(config-ike-auth)# exit
```

Next, configure the remote authentication parameters. As in most practical uses, this is set identically to the local authentication value.
12.3.3 Security Associations

After establishing a secure channel, the two endpoints can negotiate an IPsec security association (IPsec SA) as a “child” entry. TNSR supports adding multiple children as needed, though with routed IPsec only one is necessary.

**Tip:** Some vendor IPsec implementations refer to IPsec security association child entries as “Phase 2”, which may help when attempting to map values supplied by a peer to their corresponding values in TNSR.

From within config-ipsec-crypto-ike mode, the child <n> command configures the child noted by the given number. The child command enters ike-child mode.

Within ike-child mode, the following commands are available:

- **lifetime <xx>** Sets the maximum time for this child IPsec SA to be valid before it must be rekeyed. The value is given in seconds within the range 120..214783647. Default value is 3600 seconds (one hour). This value must be shorter than the IKE lifetime, discussed earlier.

- **replay-window (0|64)** Number of packets in replay window. The replay window is used to protect the tunnel against attacks where the sequence number is re-used or has been processed recently. Some allowance is helpful in dealing with network link issues that cause packets to arrive late or out-of-order. A value of 0 disables the replay window. A value of 64 enables a 64 packet replay window.

- **proposal <name>** Each child may have one or more proposal entries which define acceptable encryption, integrity, and DH Group (Perfect Forward Security, PFS) parameters to encrypt and validate the IPsec SA traffic.

Child SA proposals work similarly to IKE/ISAKMP proposals as described in IKE Proposal. This command enters config-ike-child-proposal mode to configure these proposals. in config-ike-child-proposal mode, the following commands are available:

- **encryption <ea-name>** Configures the encryption algorithm to use for the proposal.

- **integrity <ia-name>** Configures the integrity algorithm to use for the proposal.

- **group <group-name>** Configures the Diffie-Hellman group (DH Group) to use for the proposal.

- **sequence-number (esn/noesn)** Controls whether or not TNSR will attempt to negotiate extended sequence number (ESN) support with the peer. ESN uses 64-bit sequence numbers instead of the 32-bit sequence numbers. The default is noesn which disables ESN negotiation.

**Child SA Example**

This example only has a single child, thus child 1. The child has a lifetime of 3600.
Next, create a child SA proposal. This example uses AES-128 for encryption, SHA-1 for an authentication hash, and PFS group 14 (2048 bit modulus).

```bash
tsnr(config-ike-child)# proposal 1
tnsr(config-ike-child-proposal)# encryption aes128
tnsr(config-ike-child-proposal)# integrity sha1
tnsr(config-ike-child-proposal)# group modp2048
```

This completes the configuration for the IPsec tunnel, at this point after exiting back to basic mode the tunnel will attempt to establish a connection to the peer.

```bash
tsnr(config-ike-child-proposal)# exit
tsnr(config-ike-child)# exit
tsnr(config-ipsec-crypto-ike)# exit
tsnr(config-ipsec-tun)# exit
```

### 12.3.4 Configuring the IPsec Interface

TNSR supports routed IPsec via the ipsecX interface. The number of the ipsec interface corresponds to the index number of the tunnel set previously. For example `ipsec tunnel 0` is `ipsec0`, and `ipsec tunnel 2` is `ipsec2`.

These IPsec interfaces are used to configure routed IPsec connectivity and they behave like most other interfaces. For example, they can have access lists defined to filter traffic.

The ipsecX interface should be configured with an IP address and the peer will have its own IP address in the same subnet. This allows the two endpoints to communicate directly over the IPsec interface and also gives the peer an address through which traffic for other subnets may be routed. When configured in this way, it acts like a directly connected point-to-point link to the peer.

#### IPsec Interface Example

In this example, the `ipsec0` interface is given an address of `172.32.0.1/30`. The remote peer will be `172.32.0.2/30`.

```bash
tsnr(config)# interface ipsec0
tenr(config-interface)# ip address 172.32.0.1/30
tenr(config-interface)# exit
```

### 12.3.5 IPsec Routes

The IPsec interface allows the peers to talk directly, but in most cases with IPsec there is more interesting traffic to handle. For example, a larger subnet on the LAN side of each peer that must communicate securely.

To allow these networks to reach one another, routes are required. These may be managed manually using static routes, or a dynamic routing protocol such as BGP can manage the routes automatically.

#### IPsec Static Route Example

This example adds a static route to the main IPv4 routing table for a subnet located behind the peer. Any traffic trying to reach a host inside the `10.25.0.0/16` subnet will be routed through the `ipsec0` interface using the peer address in that subnet (`172.32.0.2`) as the next hop.
See also:
For a larger example involving BGP for dynamic route management, see *TNSR IPsec Hub for pfSense*.

### 12.4 IPsec Status Information

To view status information about active IPsec tunnels, use the `show ipsec tunnel` command. This command prints status output for all IPsec tunnels, and it also supports printing tunnel information individually by providing the tunnel ID. This command supports several additional parameters to increase or decrease the amount of information it displays.

The following forms of `show ipsec tunnel` are available:

- **show ipsec tunnel** Display a short summary of all IPsec tunnels.
- **show ipsec tunnel [n]** Display a short summary of a specific IPsec tunnel `n`.
- **show ipsec tunnel [n] verbose** Display a verbose list of all IPsec tunnels, optionally limited to a single tunnel `n`. The output shows detailed information such as active encryption, hashing, DH groups, identifiers, and more.
- **show ipsec tunnel [n] ike [verbose]** Display only IKE parameters of all tunnels. Optionally limited to a single tunnel `n` and/or expanded details with `verbose`.
- **show ipsec tunnel [n] child [verbose]** Display only IPsec child Security Association parameters of all tunnels. Optionally limited to a single tunnel `n` and/or expanded details with `verbose`.

#### 12.4.1 IPsec Status Examples

Show the status of tunnel 0:

```bash
tnsr# show ipsec tunnel 0
IPsec Tunnel: 0
  IKE SA: ipsec0  ID: 13  Version: IKEv1
    Local: 203.0.113.2  Remote: 203.0.113.25
    Status: ESTABLISHED  Up: 372s  Reauth: 25275s
  Child SA: child0  ID: 7
    Status: INSTALLED  Up: 372s  Rekey: 2523s  Expire: 3228s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
  Child SA: child0  ID: 8
    Status: INSTALLED  Up: 372s  Rekey: 2813s  Expire: 3228s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
  Child SA: child0  ID: 9
    Status: INSTALLED  Up: 372s  Rekey: 2583s  Expire: 3228s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
```
Adding the `verbose` keyword also shows detailed information about the encryption parameters:

```bash
tnsr# show ipsec tunnel 0 verbose
IPsec Tunnel: 0
  IKE SA: ipsec0  ID: 13  Version: IKEv1
    Local: 203.0.113.2  Remote: 203.0.113.25
    Status: ESTABLISHED  Up: 479s  Reauth: 25168s
    Local ID: 203.0.113.2  Remote ID: 203.0.113.25
    Cipher: AES_CBC_128  MAC: HMAC_SHA1_96
    PRF: PRF_HMAC_SHA1  DH: MODP_2048
    SPI Init: 188099798256787091  Resp: 143790875259838715
    Initiator: yes
  Child SA: child0  ID: 7
    Status: INSTALLED  Up: 479s  Rekey: 2416s  Expire: 3121s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
    Cipher: AES_CBC_128  MAC: HMAC_SHA1_96  PFS: MODP_2048
    SPI in: 3540263882  out: 974161796
  Child SA: child0  ID: 8
    Status: INSTALLED  Up: 479s  Rekey: 2706s  Expire: 3121s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
    Cipher: AES_CBC_128  MAC: HMAC_SHA1_96  PFS: MODP_2048
    SPI in: 2432966668  out: 1361993947
  Child SA: child0  ID: 9
    Status: INSTALLED  Up: 479s  Rekey: 2476s  Expire: 3121s
    Received: 0 bytes, 0 packets
    Transmitted: 0 bytes, 0 packets
    Cipher: AES_CBC_128  MAC: HMAC_SHA1_96  PFS: MODP_2048
    SPI in: 2318058408  out: 1979056986
```

Specifying the `ike` or `child` parameter filters the output, and these also support `verbose` output:

```bash
tnsr# show ipsec tunnel 0 ike
IPsec Tunnel: 0
  IKE SA: ipsec0  ID: 13  Version: IKEv1
    Local: 203.0.113.2  Remote: 203.0.113.25
    Status: ESTABLISHED  Up: 372s  Reauth: 25275s
```

```bash
tnsr# show ipsec tunnel 0 ike verbose
IPsec Tunnel: 0
  IKE SA: ipsec0  ID: 13  Version: IKEv1
    Local: 203.0.113.2  Remote: 203.0.113.25
    Status: ESTABLISHED  Up: 479s  Reauth: 25168s
    Local ID: 203.0.113.2  Remote ID: 203.0.113.25
    Cipher: AES_CBC_128  MAC: HMAC_SHA1_96
    PRF: PRF_HMAC_SHA1  DH: MODP_2048
    SPI Init: 188099798256787091  Resp: 143790875259838715
    Initiator: yes
```

### 12.5 IPsec Cryptographic Acceleration

TNSR will automatically configure software cryptographic acceleration for VPP if an IPsec tunnel is defined in the configuration. To enable this configuration, the VPP service must be restarted manually so it can enable the feature and allocate additional memory.
Note: The cryptographic accelerator setting applies to all tunnels, so the restart is only required after the first IPsec tunnel configured by TNSR. The restart is not required for additional tunnels or when changing IPsec settings.

Restart the VPP dataplane from the TNSR basic mode CLI using the following command:

```
tnsr# config
tnsr(config)# service dataplane restart
```

If the TNSR configuration contains no IPsec tunnels, TNSR will not require the memory resources associated with cryptographic acceleration and TNSR will not require a restart of the VPP dataplane service.

See also:

See *DPDK Configuration* for information on further configuration of cryptographic acceleration in the dataplane.
CHAPTER

THIRTEEN

NETWORK ADDRESS TRANSLATION

Network Address Translation, or NAT, involves changing properties of a packet as it passes through a router. Typically this is done to mask or alter the source or destination to manipulate how such packets are processed by other hosts.

The most common examples are:

- Source NAT, also known as Outbound NAT, which translates the source address and port of a packet to mask its origin.
- Destination NAT, commonly referred to as Static NAT or Port Forwards which translate the destination address and port of a packet to redirect the packet to a different target host behind the router.

TNSR applies NAT based on the configured mode and the presence of directives that set inside (internal/local) and outside (external/remote) interfaces.

An inside interface is a local interface where traffic enters and it will have its source hidden by NAT. An outside interface is an interface where that translation will occur as a packet exits TNSR. An example of this is shown in Outbound NAT.

Note: NAT is processed after ACL rules. For more information, see ACL and NAT Interaction.

13.1 Dataplane NAT Modes

The dataplane has several NAT modes that may be used. This mode is configured via the `dataplane nat mode <mode>` command from config mode.

The following modes are available:

- **simple** Simple NAT mode. Holds less information for each session, but only works with outbound NAT and static mappings.
- **endpoint-dependent** Endpoint-dependent NAT mode. The default mode. Uses more information to track each session, which also enables additional features such as `out-to-in-only` and `twice-nat`.
- **deterministic** Deterministic NAT (CGN) mode. Used for large-scale deployments with a focus on performance at a cost of using much more memory.

After changing the NAT mode, the dataplane must be restarted with `service dataplane restart`.

Note: There must be at least one inside and outside interface for NAT to function, see Network Address Translation and Outbound NAT for more details.
13.1.1 Simple NAT

Simple NAT is the most basic NAT mode. It tracks sessions in a hash table using four items:

- Source IP address
- Source port
- Protocol
- FIB table index

Simple NAT has a couple basic options that may be adjusted using the `dataplane nat mode-options simple <option>` command:

- `out2in-dpo` Enables out-to-in DPO
- `static-mapping-only` Static mapping only, disables dynamic translation of connections.

13.1.2 Endpoint-dependent NAT

Endpoint-dependent NAT mode is the default NAT mode on TNSR. Endpoint-dependent NAT mode tracks more information about each connection. As suggested by the name, the key difference is in tracking the destination of the connection:

- Source IP address
- Source port
- Target IP address
- Target port
- Protocol
- FIB table index

Some NAT features require this extra information, notably `out-to-in-only` and `twice-nat`.

13.1.3 Deterministic NAT

Deterministic NAT mode, also known as Carrier-Grade NAT (CGN) mode, is geared for maximum performance at a large scale. This performance comes at a price, however, in that it consumes greater amounts of memory to achieve its goals.

For more information on Deterministic NAT, see Deterministic NAT.

13.2 NAT Options

The NAT options described here control TNSR NAT behavior independent of the chosen mode.

13.2.1 NAT Forwarding

When NAT is active, it will affect traffic to and from services on TNSR, such as IPsec and BGP. When NAT is enabled, by default TNSR will drop traffic that doesn’t match an existing NAT session or static NAT rule. To change this behavior, enable NAT forwarding mode:
If NAT is active and there are no services present on TNSR which need to communicate using an interface involved with NAT, then it is more secure and efficient to disable forwarding:

```
tnsr(config)# nat global-options nat44 forwarding false
```

### 13.3 NAT Pool Addresses

Before TNSR can perform any type of NAT, an **inside** and **outside** interface must be set and the **outside/external** addresses (e.g. WAN-side) must be listed in a NAT pool. These pools are added from configure mode (Configuration Mode) in the TNSR CLI (Entering the TNSR CLI).

For a single external address, define a NAT pool like so:

```
tnsr(config)# nat pool addresses 203.0.113.2
```

For multiple addresses, use a range:

```
tnsr(config)# nat pool addresses 203.0.113.2 - 203.0.113.5
```

TNSR also supports using an interface to automatically determine the pool addresses:

```
tnsr(config)# nat pool interface GigabitEthernet0/14/1
```

For **Outbound NAT** this is typically the interface set as **ip nat outside**.

### 13.4 Outbound NAT

Outbound NAT, sometimes referred to as Source NAT, Overload NAT or Port Address Translation (PAT), changes the source address and port of packets exiting a given interface. This is most commonly performed in order to hide the origin of a packet, allowing multiple IPv4 hosts inside a network to share one, or a limited number of, external or outside addresses on a router.

In TNSR, this type of NAT is configured by marking the LAN or internal interface as **inside** and the WAN or external interface as **outside**, for example:

```
tnsr(config)# nat pool addresses 203.0.113.2
tnsr(config)# interface GigabitEthernet0/14/1
tnsr(config-interface)# ip nat outside
tnsr(config-interface)# exit
tnsr(config)# interface GigabitEthernet0/14/2
tnsr(config-interface)# ip nat inside
tnsr(config-interface)# exit
tnsr(config)# nat global-options nat44 forwarding true
tnsr(config)#
```

Traffic originating on the inside interface and exiting the outside interface will have its source address changed to match that of the outside interface.
Warning: The address of the outside interface must exist as a part of a NAT pool (NAT Pool Addresses) or connectivity from the inside interface will not function with NAT configured. Use either an address pool as shown above, or nat pool interface <name> where <name> is the same interface that contains ip nat outside.

Warning: When activating ip nat outside, services on TNSR may fail to accept or initiate traffic on that interface depending on the NAT mode. For services on TNSR to function in combination with ip nat outside, endpoint-dependent NAT mode must be enabled. In TNSR 18.11 and later, this is the default mode.

The following commands set TNSR to endpoint-dependent NAT mode:

```
tnsr(config)# dataplane nat mode endpoint-dependent
tnsr(config)# service dataplane restart
```

Additionally, NAT forwarding must be enabled for this traffic to be accepted by TNSR. See NAT Forwarding for details.

### 13.5 Static NAT

Static NAT entries alter traffic, redirecting it to a static host on an internal network, or mapping it to a static address on the way out:

```
tnsr(config)# nat pool addresses <external address>
tnsr(config)# nat static mapping (icmp|tcp|udp) local <local address> [local port] → external (external address|external interface) [external port] [twice-nat] [out-to-in-only] [route-table <rt-tbl-name>]
```

There are two common use cases for static NAT in practice: Port Forwarding and 1:1 NAT.

Warning: Remember to add the address of the outside interface as a part of a NAT pool (NAT Pool Addresses) or the static NAT entry will fail to commit.

Warning: The out-to-in-only and twice-nat features require endpoint-dependent NAT mode. In TNSR 18.11 and later, this is the default mode.

The following commands set TNSR to endpoint-dependent NAT mode:

```
tnsr(config)# dataplane nat mode endpoint-dependent
tnsr(config)# service dataplane restart
```

### 13.5.1 Port Forwards

Port forwards redirect a port on an external NAT pool address to a port on a local host. A port forward is accomplished by specifying ports in the static NAT command:

```
tnsr(config)# nat pool addresses 203.0.113.2
tnsr(config)# nat static mapping tcp local 10.2.0.5 22 external 203.0.113.2 222
```

13.5. Static NAT
In the above example, a TCP connection to port 222 on 203.0.113.2 will be forwarded to port 22 on 10.2.0.5. The source address remains the same.

### 13.5.2 1:1 NAT

1:1 NAT, also called One-to-One NAT or in some cases “Network Address Translation”, maps all ports of an external address for a given protocol to an an internal address. This mapping works for inbound and outbound packets. To create a 1:1 mapping, make a static NAT entry which does not specify any ports:

```
tnsr(config)# nat pool addresses 203.0.113.3
tnsr(config)# nat static mapping tcp local 10.2.0.5 external 203.0.113.3
```

### 13.5.3 Twice NAT

Twice NAT changes both the source and destination address of inbound connection packets. This works similar to a static NAT port forward, but requires an additional NAT address specification.

First, add the internal address for source translation:

```
tnsr(config)# nat pool addresses 10.2.0.2 twice-nat
```

Next, add the external address to which the client originally connects:

```
tnsr(config)# nat pool addresses 203.0.113.2
```

Finally, add the static mapping which sets up the destination translation:

```
tnsr(config)# nat static mapping tcp local 10.2.0.5 22 external 203.0.113.2 222 twice-nat
```

In the above example, a TCP connection to port 222 on 203.0.113.2 will be forwarded to port 22 on 10.2.0.5. When the packet leaves TNSR, the source is translated so the connection appears to originate from 10.2.0.2 using a random source port.

**Warning:** This feature requires endpoint-dependent NAT mode. In TNSR 18.11 and later, this is the default mode.

The following commands set TNSR to endpoint-dependent NAT mode:

```
tnsr(config)# dataplane nat mode endpoint-dependent
tnsr(config)# service dataplane restart
```

### 13.6 NAT Reassembly

If a packet is fragmented before it arrives on a TNSR interface, only the initial fragment packet contains header information needed to properly apply NAT. Later fragments lack these details, which prevents TNSR NAT from seeing port data. This can lead to fragments being mishandled because TNSR has no way to determine what it should do to these fragments. NAT reassembly works around this problem by holding fragments and reassembling entire packets for inspection, allowing TNSR to properly act upon the full packet.
### 13.6.1 Configuration

The `nat reassembly (ipv4|ipv6)` command, available from `config` mode, enters `config-nat-reassembly` mode to configure how NAT fragment reassembly behaves for either IPv4 or IPv6.

The following commands are available within `config-nat-reassembly` mode:

- **concurrent-reassemblies <max-reassemblies>** Configures the maximum number of packets held for reassembly at any time. Default 1024.
- **disable** Disables NAT reassembly
- **enable** Enables NAT reassembly
- **fragments <max-fragments>** Maximum number of fragments to reassemble. Default 5.
- **timeout <seconds>** Number of seconds to wait for additional fragments to arrive for reassembly. Default 2 seconds.

### 13.6.2 View Configuration

To view the current values in the configuration for NAT reassembly, use `show nat reassembly`:

```
tnsr# show nat reassembly
NAT Reassembly Parameters
-------------------------
Family: ipv4
   Enabled : true
   Timeout : 2 seconds
   Max Fragments : 5
   Max concurrent reassemblies: 1024
Family: ipv6
   Enabled : true
   Timeout : 2 seconds
   Max Fragments : 5
   Max concurrent reassemblies: 1024
```

### 13.7 Dual-Stack Lite

Dual-Stack Lite, also knows as DS-Lite, is mechanism which facilitates large scale IPv4 NAT by encapsulating IPv4 packets inside IPv6 packets for delivery to a Carrier-Grade NAT (CGN) endpoint. This allows providers to provision end users with only a routed IPv6 address, and any IPv4 traffic is carried through IPv6 to a CGN device. Once the IPv6 packet reaches the CGN device, the IPv4 packet is extracted, has NAT applied, and is forwarded. The CGN device will apply NAT using one of its routable IPv4 addresses, shared between DS-Lite users.

By using encapsulation, DS-Lite avoids multiple layers of NAT between the customer and the Internet. An end-user network which connects to a DS-Lite provider should not perform any IPv4-IPv4 NAT on the traffic before it reaches a router configured for DS-Lite.

DS-Lite is considered an IPv6 transition mechanism as it allows providers to reduce their dependence on scarce IPv4 routable addresses, while still giving clients full access to IPv4 and IPv6 resources. It also removes the need to use potentially conflicting IPv4 private address space for IPv4 routing inside a provider network.

There are two endpoints to DS-Lite connections:
• DS-Lite Basic Bridging BroadBand (B4) element on the customer end
• DS-Lite Address Family Transition Router (AFTR) element at the provider end

From a customer perspective, their side is before (B4) DS-Lite and the ISP side is after (AFTR) DS-Lite.

TNSR can operate in either capacity: As a CPE DS-Lite B4 client endpoint, or as an AFTR endpoint providing DS-Lite connectivity and IPv4 NAT to clients.

13.7.1 Acting as a B4 Endpoint

For a customer premise equipment (CPE) role which connects to an ISP offering DS-Lite service, the following steps are required:

First, configure IPv6 connectivity to the ISP.

Next, configure the local IPv6 address TNSR will use for its DS-Lite B4 endpoint. For example, this might be the IPv6 WAN interface address:

```bash
tnsr(config)# dslite b4 endpoint <ip6-address>
```

Finally, configure the remote IPv6 DS-Lite AFTR endpoint address given by the ISP:

```bash
tnsr(config)# dslite aftr endpoint <ip6-address>
```

13.7.2 Acting as an AFTR Endpoint

For a provider role as a DS-Lite AFTR endpoint serving customers, the following steps are required:

First, configure IPv6 and IPv4 connectivity such that this TNSR instance has both IPv6 and IPv4 connectivity to the Internet.

Next, configure the local AFTR IPv6 address TNSR will use to receive DS-Lite encapsulated packets from customer equipment:

```bash
tnsr(config)# dslite aftr endpoint <ip6-address>
```

Next, configure one or more routable (“public”) IPv4 addresses for the DS-Lite NAT pool. These addresses are used by TNSR to apply NAT to outgoing IPv4 traffic which arrived via DS-Lite:

```bash
tnsr(config)# dslite pool address <ipv4-addr-first> [- <ipv4-addr-last>]
```

IPv4 packets arriving through DS-Lite from a customer will be removed from the encapsulation, have NAT applied, and then be forwarded upstream (e.g. to the Internet). Reply packets will come back, and then go back through NAT and DS-Lite to reach customers.

13.7.3 DS-Lite Status

To view active DS-Lite sessions, use the following command:

```bash
tnsr# show dslite
```
13.8 Deterministic NAT

Deterministic NAT mode, also known as Carrier-Grade NAT (CGN) mode, is geared for maximum performance at a large scale. This performance comes at a price, however, in that it consumes greater amounts of memory to achieve its goals.

To switch the NAT mode used by TNSR, see Dataplane NAT Modes.

Deterministic NAT pre-allocates 1000 external ports per inside address, which can increase memory requirements significantly. Each single session requires approximately 15 Bytes of memory.

Deterministic NAT enforces maximum numbers of NAT sessions per user, and only works for TCP, UDP, and ICMP protocols.

Deterministic NAT requires a mapping, configured as follows:

```text
tnsr(config)# nat deterministic mapping inside <inside-prefix> outside <outside-prefix>
```

In this command, the parameters to replace are:

- **inside <inside-prefix>** The internal subnet containing local users, for example, 198.18.0.0/15.
- **outside <outside-prefix>** The external subnet to which these users will be mapped using deterministic NAT. For example, 203.0.113.128/25.

Configured mappings may be viewed as follows:

```text
tnsr(config)# show nat deterministic-mappings
Deterministic Mappings
----------------------------
Inside  Outside  Ratio  Ports  Sessions
---------  --------  ----  ------  ---------
198.14.0.0/15 203.0.113.128/25 1024 63   0
```

13.9 NAT Status

TNSR offers several ways to view the active NAT configuration, rules, and sessions. These start with `nat show`, and are all available in config and master mode.

13.9.1 View NAT Configuration

To view the current NAT configuration parameters (not rules), use `show nat config`:

```text
tnsr# show nat config
NAT Configuration Parameters
----------------------------
translation hash buckets 1024
translation hash memory 134217728
deterministic false
```

(continues on next page)
13.9.2 View Static Mappings

To view currently configured static NAT mappings, use `show nat static-mappings`:

```
tnsr# show nat static-mappings
Static Mappings
Proto  Local IP  Port  External IP  Port  Interface  Twice NAT  Out to In  Route Table
----  --------  ----  -----------  ----  --------  ---------  -----------  -----------
tcp   10.2.0.5  22    203.0.113.2  222  ipv4-VRF:0
```

13.9.3 View Deterministic Mappings

To view currently configured deterministic NAT mappings, use `show nat deterministic-mappings`:

```
tnsr# show nat deterministic-mappings
Deterministic Mappings
----------------------
Inside  Outside  Ratio  Ports  Sessions
--------  --------  -----  ------  -------
198.14.0.0/15 203.0.113.128/25  1024  63     0
```

13.9.4 View Dynamic Configuration

To view the IP addresses or interfaces currently assigned for use by NAT, use `show nat dynamic addresses` or `show nat dynamic interfaces`, depending on the TNSR NAT configuration:

```
tnsr# show nat dynamic addresses
Pool Addresses  Route Table  Twice NAT
----------  --------  --------
203.0.113.2
```

13.9.5 View Interfaces

To view the interfaces which are currently marked as inside and outside for NAT purposes, use `show nat interface-sides`:
13.9.6 View NAT Fragment Reassembly

To view NAT packet fragment reassembly parameters, use `show nat reassembly`:

```plaintext
tnsr# show nat reassembly

NAT Reassembly Parameters
-------------------------
Family: ipv4
   Enabled : true
   Timeout : 2 seconds
   Max Fragments : 5
   Max concurrent reassemblies: 1024
Family: ipv6
   Enabled : true
   Timeout : 2 seconds
   Max Fragments : 5
   Max concurrent reassemblies: 1024
```

13.9.7 View NAT Sessions

To view a summary of outgoing NAT sessions by source address, use `show nat sessions`:

```plaintext
tnsr# show nat sessions

NAT sessions
------------

<table>
<thead>
<tr>
<th>IP address</th>
<th>Static</th>
<th>Dynamic</th>
<th>Route Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2.0.1</td>
<td>0</td>
<td>4</td>
<td>ipv4-VRF:0</td>
</tr>
<tr>
<td>203.0.113.2</td>
<td>0</td>
<td>1</td>
<td>ipv4-VRF:0</td>
</tr>
</tbody>
</table>
```

To see more detail for each specific session, add `verbose` to the previous command, which becomes `show nat sessions verbose`:

```plaintext
tnsr# show nat sessions verbose

NAT sessions detail
-------------------

<table>
<thead>
<tr>
<th>Proto</th>
<th>Inside/Outside/Ext</th>
<th>Type</th>
<th>Route Table</th>
<th>Last used</th>
<th>Bytes/pkts</th>
</tr>
</thead>
<tbody>
<tr>
<td>udp</td>
<td>10.2.0.1:123</td>
<td>dynamic</td>
<td>ipv4-VRF:0</td>
<td>143</td>
<td>498</td>
</tr>
<tr>
<td></td>
<td>203.0.113.2:16253</td>
<td></td>
<td>ipv4-VRF:0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>52.6.160.3:123</td>
<td></td>
<td>ipv4-VRF:0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>udp</td>
<td>10.2.0.1:123</td>
<td>dynamic</td>
<td>ipv4-VRF:0</td>
<td>143</td>
<td>498</td>
</tr>
</tbody>
</table>
```

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13.10 NAT Examples

The examples in this section describe and demonstrate use cases and packet flows for typical scenarios involving NAT.

13.10.1 AWS NAT Examples

When using TNSR with AWS, it is relatively easy to unintentionally create an asymmetric routing situation. AWS knows about your local networks and will happily egress traffic with NAT for them, when other networking setups would otherwise drop or fail to hand off the traffic.

The examples in this section covers what would happen with a TNSR setup in AWS with two instances: An internal LAN instance with a local “client” system making an outbound request, and an external WAN instance that is intended to handle public-facing traffic. TNSR sits between the WAN and LAN instance to route traffic. In AWS, the VPC routing table is configured such that the LAN instance uses TNSR for its default gateway. The expected flow is that traffic flows from clients, through TNSR, to the Internet and back the same path.

This table lists the networks and addresses used by these examples.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Networks</td>
<td>192.0.2.0/24 (LAN), 198.18.5.0/24 (WAN), 203.0.113.0/24 (External)</td>
</tr>
<tr>
<td>AWS Gateways</td>
<td>192.0.2.1 (LAN), 198.18.5.1 (WAN), 203.0.113.1 (External)</td>
</tr>
<tr>
<td>TNSR LAN</td>
<td>192.0.2.2/24</td>
</tr>
<tr>
<td>TNSR WAN</td>
<td>198.18.5.2</td>
</tr>
<tr>
<td>TNSR GW</td>
<td>198.18.5.1 (AWS Gateway)</td>
</tr>
<tr>
<td>LAN Client</td>
<td>192.0.2.5/24</td>
</tr>
<tr>
<td>LAN Client GW</td>
<td>192.0.2.2 (TNSR LAN)</td>
</tr>
<tr>
<td>Server</td>
<td>198.51.100.19/24</td>
</tr>
<tr>
<td>Server GW</td>
<td>198.51.100.1</td>
</tr>
</tbody>
</table>

AWS Example without NAT

In this example, TNSR is not configured to perform NAT. This example steps through each portion of a packet and its reply, and then discusses the problems at the end.

First, the client initiates a connection using a packet which arrives on the TNSR LAN interface

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>192.0.2.5:1025</td>
<td>198.51.100.19:443</td>
<td>192.0.2.2</td>
</tr>
</tbody>
</table>

TNSR performs a FIB lookup. The destination IP address is not within the the subnets configured on the TNSR instance interfaces, so it matches the default route.
Fig. 1: AWS example packet flow without NAT
TNSR forwards the packet out its WAN interface to its default gateway on the WAN. TNSR is not configured for NAT, thus it does not perform any translation.

The packet reaches the AWS internet gateway connected to the VPC. Its source IP address is still the private IP address of the LAN instance.

The AWS internet gateway performs NAT. It recognizes the source IP address as belonging to the LAN instance and rewrites it to the public IP address of the LAN instance.

The AWS internet gateway forwards the packet to the internet.

The destination host sends a reply to the public IP address of the LAN instance. It arrives at the AWS internet gateway.

The AWS internet gateway performs NAT. It recognizes the destination IP address as belonging to LAN instance and rewrites it to the private IP address of the LAN instance.

The AWS internet gateway knows how to reach the private IP address of the LAN instance directly, so it forwards the reply packet directly to the LAN instance, skipping the TNSR instance.

The packet arrives at the client.

The return path skipped TNSR, so TNSR is only seeing half the packets for the connection. At best this means the asymmetric routing will bypass any filtering or inspection of the replies (IDS/IPS), and at worst it could mean subsequent packets would be dropped instead of passing through TNSR.
AWS Example with NAT

In this example, TNSR has NAT configured such that its LAN is defined as an inside interface and its WAN is an outside interface. See *Outbound NAT* for details. Packets leaving the WAN will be translated such that they leave with a source address set to the TNSR WAN interface IP address.

![AWS Example With NAT](image)

Fig. 2: AWS example packet flow with NAT

First, the client initiates a connection using a packet which arrives on the TNSR LAN interface

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>192.0.2.5:1025</td>
<td>198.51.100.19:443</td>
<td>192.0.2.2</td>
</tr>
</tbody>
</table>

TNSR performs a FIB lookup. The destination IP address is not within the the subnets configured on the TNSR instance interfaces, so it matches the default route

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>192.0.2.5:1025</td>
<td>198.51.100.19:443</td>
<td>Default</td>
</tr>
</tbody>
</table>

TNSR applies NAT and forwards the packet out its WAN interface to its default gateway on the WAN subnet.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>198.18.5.2:34567</td>
<td>198.51.100.19:443</td>
<td>198.18.5.1</td>
</tr>
</tbody>
</table>
The packet reaches the AWS internet gateway connected to the VPC. Its source IP address is the private IP address of the TNSR WAN instance.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>198.18.5.2:34567</td>
<td>198.51.100.19:443</td>
<td>198.18.5.1</td>
</tr>
</tbody>
</table>

The AWS internet gateway performs NAT. It recognizes the source IP address as belonging to the WAN instance and rewrites it to the public IP address of the WAN instance.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>203.0.113.50:40250</td>
<td>198.51.100.19:443</td>
<td>Default</td>
</tr>
</tbody>
</table>

The AWS internet gateway forwards the packet to the internet.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>203.0.113.50:40250</td>
<td>198.51.100.19:443</td>
<td>203.0.113.1</td>
</tr>
</tbody>
</table>

The destination host sends a reply to the public IP address of the WAN instance. It arrives at the AWS internet gateway.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>198.51.100.19:443</td>
<td>203.0.113.50:40250</td>
<td>198.51.100.1</td>
</tr>
</tbody>
</table>

The AWS internet gateway performs NAT. It recognizes the destination IP address as belonging to WAN instance and rewrites it to the private IP address of the WAN instance. The AWS internet gateway knows how to reach the private IP address of the WAN instance directly, so it forwards the reply packet directly to the WAN instance.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>198.51.100.19:443</td>
<td>198.18.5.2:34567</td>
<td>Direct L2 WAN</td>
</tr>
</tbody>
</table>

The packet arrives at the TNSR WAN, which performs NAT. It recognizes the source and destination as matching an existing NAT state belonging to the LAN client and rewrites the destination address to the LAN client. TNSR knows how to reach the client LAN IP address directly, so it forwards the reply packet.

<table>
<thead>
<tr>
<th>Proto</th>
<th>Source</th>
<th>Destination</th>
<th>Via</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>198.51.100.19:443</td>
<td>192.0.2.5:1025</td>
<td>Direct L2 LAN</td>
</tr>
</tbody>
</table>

The packet arrives back at the client.

In this case, the NAT performed on TNSR ensured that the AWS gateway delivered the reply back to TNSR instead of handing it off directly. This allowed the packet and its reply to use the same path outbound and inbound.
MAP (MAPPING OF ADDRESS AND PORT)

MAP is short for Mapping of Address and Port. It is a carrier-grade IPv6 transition mechanism capable of efficiently transporting high volumes of IPv4 traffic across IPv6 networks.

There are two MAP implementations in TNSR Enterprise: MAP-T which uses translation and MAP-E which uses encapsulation.

With MAP, IPv4 requests are forwarded from an end user Customer Edge (CE) device through an IPv6 Border Relay (BR) router which processes and forwards the requests to IPv4 destinations. Customer IPv6 requests can proceed directly to IPv6 destinations without going through the BR, which lowers the burden on the BR.

MAP is stateless, thus capable of handling large scale traffic volume without additional overhead for tracking individual connections. Each CE device receives a public IPv4 address but may only use a specific port range on that address. In this way, multiple users may share a public address without an additional layer of NAT. Since this relationship is predetermined, the ports are also available bidirectionally, which is not possible with other solutions such as Carrier-Grade NAT/NAT444.

MAP-T and MAP-E require port information to operate, thus fragments must be reassembled at the BR before forwarding. This is due to the fact that protocol and port information are only present in the first packet. Intelligent caching & forwarding may be employed for handling fragments.

TNSR can currently act as a BR, providing service to CE clients.

14.1 MAP Configuration

MAP configurations consist of MAP domains, MAP rules, and interface configuration.

14.1.1 MAP Domains

A MAP domain encompasses a set of addresses, translation parameters, and MAP rules. Groups of CE devices belong to specific MAP domains.

A MAP domain is created in config mode using the `nat nat64 map <domain name>` command from within `config mode`. That command enters `config-map` mode.

This mode, `config-map`, contains a number of MAP options specific to a MAP domain:

- **description** A short text description noting the name or purpose of this MAP domain.
- **port-set <length|offset>** A port set is, as the name implies, a set of ports. This is typically divided up into multiple sets of ports, the exact size and ranges of which are calculated using the port set length and offset, discussed next. With MAP, users are overloaded onto a single IP address, with different port sets on a single IP address being allocated to multiple users. In this way, users can share individual IP addresses but only have access to specific ranges of ports.
port-set length <psid-length> Determines the number of port sets to allocate inside the available 16-bit port range (1-65536). A larger port set length allows for more users to share an address, but allocates them each a smaller number of ports. For example, a port set length of 8 uses 8 bits to define the port set, leaving the remaining 8 bits for use by each customer, or 256 ports each.

port-set offset <psid-offset> Determines the position of the port set identifier inside the available bits which represent the port. An offset of 0 means the identifier is first, and the ports per user will be contiguous. Placing the offset in the middle of the available space will allow users to utilize multiple ranges that are not contiguous, but each user will have slightly less ports available. For example, with a port set length of 8, but an offset of 2, each user can utilize only 192 ports instead of 256, since it is split into three ranges of 64 ports each. The offset cannot be larger than the port set length subtracted from the total available bits (16).

There are minor security benefits when using multiple non-contiguous port ranges since it is more difficult for an attacker to guess which ports belong to a given customer, but the loss of port capacity may outweigh this benefit in most environments.

embedded-address bit-length <ea-width> The Embedded Address Bits value is the sum of the bits needed for the IPv4 prefix and the port set length. For example, if the IPv4 prefix is a /24, that requires 8 bits to embed and allows 256 addresses for users. A port set length of 8 allows for 256 port sets. With a port set offset of 0, this yields a maximum of 65,536 users sharing 256 IPv4 addresses, each of which can use 256 ports.

Note: To utilize MAP rules, this value must be 0.

ipv4 prefix <ip4-prefix> The IPv4 Prefix is available pool of IPv4 addresses which can be utilized by MAP clients. The size of this prefix must be represented in the Embedded Address Bits. For example, a /24 prefix network requires 8 bits to uniquely identify an address.

ipv6 prefix <ip6-prefix> The IPv6 prefix contains the range of possible addresses assigned to clients. The end-user network must be at least a 64 prefix, leaving 64 bits to represent both this prefix and the embedded address bits. The smallest possible IPv6 prefix will be 128 bits less the sum of the end user network and embedded address bits. For example, with an embedded address length of 16, 48 bits remain for the IPv6 prefix. Shorter prefixes (e.g. 44) allow for additional IPv6 subnets to be assigned to clients.

ipv6 source <ip6-src> The IPv6 source address on the router used as the MAP domain BR address and Tunnel source. This address should exist on the interface used for mapping. For MAP-T, this must have a prefix length of either /64 or /96. For MAP-E, this is a single address (/128) and not a prefix.

mtu <mtu-val> The Maximum Transmission Unit (MTU) is the largest packet which can traverse the link without fragmentation. This must be set appropriately due to the importance of MAP fragment handling, as required information to calculate targets is only in the first packet and not additional fragments.

14.1.2 MAP Rules

MAP rules exist inside a MAP domain and are configured from within config-map mode. MAP rules map specific port sets to specific MAP CE end user addresses. These are 1:1 manual mappings and take the place of automatic calculation, and as such to use MAP rules, the embedded-address bit-length must be 0.

A map rule takes the following form:
The components of a rule are:

- `port-set <psid>`: The port set ID (PSID) to match for this rule.
- `ipv6-destination <ip6-destination>`: The MAP CE IPv6 address to associate with this specific port set ID.

### 14.1.3 MAP Interface Configuration

TNSR must be told which interface is used with MAP, and how that interface will operate. Within `config-interface` mode (*Configure Interfaces*), there are two possible settings for MAP:

- `map <enable|disable>`: Enables or disables MAP for this interface.
- `map translate`: When present and MAP is enabled, the interface operates in translate mode (MAP-T). When not set, encapsulation is used instead (MAP-E).

### 14.1.4 View MAP Configuration

The MAP configuration can be viewed with the `show map` command. Without a given domain name, information is printed for all MAP domains, plus the MAP parameters.

```
tnsr# show map cpoc
    Name         IP4 Prefix         IP6 Prefix       IP6 Src Pref     EA Bits PSID Off PSID Len MTU
              ------------------------- -------------------- ----------------- -------------- -------- -------  --------
    cpoc         192.168.1.0/24    2001:db8::/32     1234:5678:90ab:cdef::/64 16    6     4       1280
```

```
tnsr# show map
MAP Parameters
----------------
Fragment: outer
Fragment ignore-df: false
ICMP source address: 0.0.0.0
ICMP6 unreachable msgs: disabled
Pre-resolve IPv4 next hop: 0.0.0.0
Pre-resolve IPv6 next hop: ::
IPv4 reassembly lifetime: 100
IPv4 reassembly pool size: 1024
IPv4 reassembly buffers: 2048
IPv4 reassembly HT ratio: 1.00
IPv6 reassembly lifetime: 100
IPv6 reassembly pool size: 1024
IPv6 reassembly buffers: 2048
IPv6 reassembly HT ratio: 1.00
Security check enabled: true
Security check fragments enabled: false
Traffic-class copy: enabled
Traffic-class value: 0
```

(continues on next page)
14.2 MAP Parameters

MAP Parameters control the behavior of MAP-T and MAP-E. These parameters are configured by the `nat nat64 map parameters` command from within `config` mode, which enters `config-map-param` mode where the individual values are set.

From within `config-map-param` mode, the following commands are available:

- **fragment ignore-df** Allows TNSR to perform IPv4 fragmentation even when packets contain the do-not-fragment (DF) bit. This improves performance by moving the burden of fragmentation to the endpoint rather than the MAP relay.

- **fragment (inner|outer)** Controls whether TNSR will fragment the inner (encapsulated or translated) packets or the outer (tunnel) packets.

- **icmp source-address <ipv4-address>** Sets the IPv4 address used by TNSR to send relayed ICMP error messages.

- **icmp6 unreachable-msgs (enable|disable)** When enabled, TNSR will generate ICMPv6 unreachable messages when a packet fails to match a MAP domain or fails a security check.

- **pre-resolve (ipv4|ipv6) next-hop <ip46-address>** Manually configures the next hop for IPv4 or IPv6 routing of MAP traffic, which bypasses a routing table lookup. This increases performance, but means that the next hop cannot be determined dynamically or by routing protocol.

- **reassembly (ipv4|ipv6) buffers <bufs>** The maximum number of cached fragment buffers. Setting a limit can improve resilience to DoS/resource exhaustion attacks.

- **reassembly (ipv4|ipv6) ht-ratio <ratio>** The fragment hash table multiplier, expressed as a ratio such as 1:18. This ratio, multiplied by `pool-size`, determines the number of buckets in the hash table.

- **reassembly (ipv4|ipv6) lifetime <lf>** The life time, in milliseconds, of a reassembly attempt. Longer times allow for more accurate reassembly at the expense of consuming more resources and potentially exhausting available fragment resources.

- **reassembly (ipv4|ipv6) pool-size <ps>** The fragment pool size, in bytes. This controls how many sets of fragments can be allocated.

- **security-check (enable|disable)** Enables or disables validation of decapsulated IPv4 addresses against the external IPv6 address on single packets or the first fragment of a packet. Disabling the check increases performance but potentially allows IPv4 address spoofing.

- **security-check fragments (enable|disable)** Extends the previous security check to all fragments instead of only inspecting the first packet.

- **tcp mss <mss-value>** Sets the MSS value for MAP traffic, typically the MTU less 40 bytes.

- **traffic-class tc <tc-val>** Sets the Class/TOS field of outer IPv6 packets to the specified value.
traffic-class copy (enable|disable)  When enabled, copies the class/TOS field from the inner IPv4 packet header to the outer IPv6 header. This is enabled by default, but disabling can slightly improve performance.

14.2.1 View MAP Parameters

The current value of MAP parameters can be displayed by the `show map` command:

```
 tnsr# show map
 MAP Parameters
------------
Fragment: outer
Fragment ignore-df: false
ICMP source address: 0.0.0.0
ICMP6 unreachable msgs: disabled
Pre-resolve IPv4 next hop: 0.0.0.0
Pre-resolve IPv6 next hop: ::
IPv4 reassembly lifetime: 100
IPv4 reassembly pool size: 1024
IPv4 reassembly buffers: 2048
IPv4 reassembly HT ratio: 1.00
IPv6 reassembly lifetime: 100
IPv6 reassembly pool size: 1024
IPv6 reassembly buffers: 2048
IPv6 reassembly HT ratio: 1.00
Security check enabled: true
Security check fragments enabled: false
Traffic-class copy: enabled
Traffic-class value: 0
```

<table>
<thead>
<tr>
<th>Name</th>
<th>IP4 Prefix</th>
<th>IP6 Prefix</th>
<th>IP6 Src Pref</th>
<th>EA Bits</th>
<th>PSID</th>
<th>Off</th>
<th>PSID Len</th>
</tr>
</thead>
<tbody>
<tr>
<td>cpec</td>
<td>192.168.1.0/24</td>
<td>2001:db8::/32</td>
<td>1234:5678:90ab::/64</td>
<td>16</td>
<td>6</td>
<td>4</td>
<td>1280</td>
</tr>
</tbody>
</table>
14.3 MAP Example

14.3.1 Environment

<table>
<thead>
<tr>
<th>MAP Border Relay</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP Domain Name</td>
<td>cpoc</td>
</tr>
<tr>
<td>IPv6 Prefix</td>
<td>2001:db8::/32</td>
</tr>
<tr>
<td>IPv6 Source Prefix</td>
<td>1234:5678:90ab:cdef::/64</td>
</tr>
<tr>
<td>IPv4 Prefix</td>
<td>192.168.1.0/24</td>
</tr>
<tr>
<td>Port Set Length</td>
<td>8</td>
</tr>
<tr>
<td>Port Set Offset</td>
<td>0</td>
</tr>
<tr>
<td>Embedded Address Bits</td>
<td>16</td>
</tr>
<tr>
<td>MTU</td>
<td>1300</td>
</tr>
<tr>
<td>Interface</td>
<td>GigabitEthernet0/14/0</td>
</tr>
<tr>
<td>IPv6 Address</td>
<td>fd01:2::1/64</td>
</tr>
<tr>
<td>IPv4 Address</td>
<td>203.0.113.2/24</td>
</tr>
</tbody>
</table>

14.3.2 TNSR Border Relay Configuration

This shows an example Border Relay (BR) configuration in TNSR to provide service to MAP-T Customer Edge (CE) clients. This example assumes some configuration details are already in place, such as the IPv4 prefix already being routed to the BR from upstream, and default routes configured in TNSR for upstream gateways.

First, configure the interface connected to the upstream network. There could be separate interfaces for reaching the Internet and for reaching the CE network, but this example uses a single interface.

```bash
tenr(config)# interface GigabitEthernet0/14/0
tenr(config-interface)# ip address 203.0.113.2/24
ntenr(config-interface)# ipv6 address fd01:2::1/64
ntenr(config-interface)# exit
```

Next, configure the MAP domain:

```bash
tenr(config)# nat nat64 map cpoc
ntenr(config-map)# ipv4 prefix 192.168.1.0/24
ntenr(config-map)# ipv6 prefix 2001:db8::/32
ntenr(config-map)# ipv6 source 1234:5678:90ab:cdef::/64
ntenr(config-map)# embedded-address bit-length 16
ntenr(config-map)# port-set length 4
ntenr(config-map)# port-set offset 6
ntenr(config-map)# mtu 1280
ntenr(config-map)# exit
```

Then add a static route:

```bash
tenr(config)# route ipv6 table ipv6-VRF:0
tenr(config-route-table-v6)# route 2001:db8::/32
ntenr(config-rttbl6-next-hop)# next-hop 0 via fd01:2::2 GigabitEthernet0/14/0
ntenr(config-rttbl6-next-hop)# exit
ntenr(config-route-table-v6)# exit
```

Lastly, enable MAP and MAP-T translation for the interface:
tnsr(config)# interface GigabitEthernet0/14/0
tnsr(config-interface)# map translate
tnsr(config-interface)# map enable
tnsr(config-interface)# exit

See also:

For information on configuring other operating systems to act as a CE, consult their documentation or check the links in Additional MAP Reading and Tools for additional information.

14.4 MAP Types

14.4.1 MAP-T (Translation)

With MAP-T, translations are made using mapping rules that can calculate addresses and ports based on information embedded in an IPv6 address, along with several known parameters.

MAP-T clients determine where to send translated IPv4 traffic using the Default Mapping Rule (DMR) IPv6 /64 prefix.

14.4.2 MAP-E (Encapsulation)

MAP-E is similar to MAP-T, but instead of translating IPv4 traffic and encoding information in the address, the IPv4 requests are encapsulated in IPv6 between the CE and BR as described in RFC 2473.

MAP-E clients send all IPv4 encapsulated traffic to the BR IPv6 address.

14.4.3 Additional MAP Reading and Tools

MAP is a complex topic and much of it is outside the scope of TNSR documentation. There are a number of additional resources that have information on MAP along with examples for other operating systems and example environments.

We recommend the following links as starting points for MAP information.

- CableLabs MAP Technical Report CL-TR-MAP-V01-160630
- Charter MAP-T deployment presentation MAP-T NANOG Video / MAP-T NANOG Slides
- Cisco MAP Simulation Tool
- MAP-E RFC 7597
- MAP-T RFC 7599
The Dynamic Host Configuration Protocol (DHCP) service on TNSR provides automatic addressing to clients on an interface. Typically, this service uses a local, internal interface such as one connected to a LAN or DMZ.

### 15.1 DHCP Configuration

The main IPv4 DHCP configuration mode, entered with `dhcp4 server`, defines global options for IPv4 DHCP that affect the general behavior of DHCP as well as options that cover all subnets and pools.

To enter IPv4 DHCP configuration mode, enter:

```
tnsr# configure
tnsr(config)# dhcp4 server
```

From this mode, there are a variety of possibilities, including:

- **subnet** Subnet configuration, see *Subnet Configuration*.
- **description** Description of the DHCP server
- **option** A DHCP Option declaration, see *DHCP Options*.
- **decline-probation-period <n>** Decline lease probation period, in seconds.
- **echo-client-id <boolean>** Controls whether or not the DHCP server sends the client-id back to the client in its responses.
- **interface listen <if-name>** The interface upon which the DHCP daemon will listen. **This is required.**
- **interface socket {raw|udp}** Controls whether the DHCP daemon uses raw or UDP sockets.
- **lease filename <path>** Lease database file
- **lease lfc-interval <n>** Lease file cleanup frequency, in seconds.
- **lease persist <boolean>** Whether or not the lease database will persist.
- **logging <logger-name>** Controls which DHCP daemon logger names will create log entries, or * for all. See the Kea documentation for Logging for a list of values and their meanings.
- **match-client-id <boolean>** When true, DHCP will attempt to match clients first based on client ID and then by MAC address if the client ID doesn’t produce a match. When false, it prefers the MAC address.
- **next-server <IP Address>** Specifies a TFTP server to be used by a client.
- **rebind-timer <n>** Sets the period, in seconds, at which a client must rebind its address.
renew-timer <n> Sets the period, in seconds, at which a client must renew its lease.

valid-lifetime <n> The period of time, in seconds, for which a lease will be valid.

Some of these values may be set here globally, and again inside subnets or pools. In each case, the more specific value will be used. For example, if an option is defined in a pool, that would be used in place of a global or subnet definition; A subnet option will be favored over a global option. In this way, the global space may define defaults and then these defaults can be changed if needed for certain areas.

15.1.1 DHCP Options

DHCP Options provide information to clients beyond the basic address assignment. These options give clients other aspects of the network configuration, tell clients how they should behave on the network, and give them information about services available on the network. Common examples are a default gateway, DNS Servers, Network Time Protocol servers, network booting behavior, and dozens of other possibilities.

See also:

For a list of Standard IPv4 DHCP options, see Standard IPv4 DHCP Options. This list also includes the type of data expected and whether or not they take multiple values.

The general form of an option is:

```
tnsr(config-kea-dhcp4)# option <name>
tnsr(config-kea-dhcp4-opt)# data <comma-separated values>
tnsr(config-kea-dhcp4-opt)# exit
```

This example defines a global domain name for all clients in all subnets:

```
tnsr(config-kea-dhcp4)# option domain-name
tnsr(config-kea-dhcp4-opt)# data example.com
tnsr(config-kea-dhcp4-opt)# exit
```

This example defines a default gateway for a specific subnet:

```
tnsr(config-kea-subnet4)# option routers
tnsr(config-kea-subnet4-opt)# data 10.2.0.1
tnsr(config-kea-subnet4-opt)# exit
```

To see a list of option names, enter:

```
tnsr(config-kea-dhcp4)# option ?
```

When defining options the data can take different forms. The DHCP daemon uses comma-separated value (CSV) format by default and it will automatically convert the text representation of a value to the expected data in the daemon.

Inside the option configuration mode, the following choices are available:

- **always-send <boolean>** Controls whether the DHCP server will always send this option in a response, or only when requested by a client. The default behavior varies by option and is documented in Standard IPv4 DHCP Options

- **csv-format <boolean>** Toggles between either CSV formatted data or raw binary data. This defaults to true unless an option does not have a default definition. In nearly all cases this option should be left at the default.

- **data <data>** Arbitrary option data. Do not enclose in quotes. To see option data types and expected formats, see Standard IPv4 DHCP Options

- **space <name>** Option space in which this entry exists, defaults to dhcp4.
### Standard IPv4 DHCP Options

This list contains information about the standard IPv4 DHCP options, sourced from the Kea Administrator Manual section on DHCP Options.

For a list of the Types and their possible values, see DHCP Option Types.

<table>
<thead>
<tr>
<th>Name</th>
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Continued on next page
### Table 1 – continued from previous page

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<td>client-ndi</td>
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<td>record (uint8, uint8)</td>
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<td>vivco-suboptions</td>
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<td>vivso-suboptions</td>
<td>125</td>
<td>binary</td>
<td>false</td>
<td>false</td>
</tr>
</tbody>
</table>

#### DHCP Option Types

- **binary**  An arbitrary string of bytes, specified as a set of hexadecimal digits.
- **boolean** Boolean value with allowed values `true` or `false`.
- **empty**   No value, data is carried in suboptions.
- **fqdn**    Fully qualified domain name (e.g. `www.example.com`).
- **ipv4-address** IPv4 address in dotted-decimal notation (e.g. `192.0.2.1`).
- **ipv6-address** IPv6 address in compressed colon notation (e.g. `2001:db8::1`).
- **record**  Structured data of other types (except `record` and `empty`).
- **string**  Any arbitrary text.
- **int32**   32 bit signed integer with values between \(-2147483648\) and \(2147483647\).
- **uint8**   8 bit unsigned integer with values between 0 and 255.
- **uint16**  16 bit unsigned integer with values between 0 and 65535.
- **uint32**  32 bit unsigned integer with values between 0 and 4294967295.

#### 15.1.2 Subnet Configuration

A subnet defines a network in which the DHCP server will provide addresses to clients, for example:

```
tnsr(config-kea-dhcp4)# subnet 10.2.0.0/24
tnsr(config-kea-subnet4)# interface GigabitEthernet0/14/2
```

From within the subnet4 configuration mode, the following commands can be used:

- `id <id>` Sets an optional unique identifier for this subnet.
interface <name> Required. The interface on which the subnet is located.

option Defines an option specific to this subnet (DHCP Options).

pool Defines a pool of addresses to serve inside this subnet. (Address Pool Configuration).

reservation <ipv4-address> Defines a host reservation to tie a client MAC address to a static IP address assignment.

At a minimum, the subnet itself must contain an interface definition and a pool.

15.1.3 Address Pool Configuration

A pool controls which addresses inside the subnet can be used by clients, for example:

```
tnsr(config-kea-subnet4)# pool 10.2.0.128-10.2.0.191
tnsr(config-kea-subnet4-pool)#
```

A pool may be defined as an address range (inclusive) as shown above in <ipv4-addr>-<ipv4-addr> format, or as a prefix, such as 10.2.0.128/26.

Options can be defined inside a pool that only apply to clients receiving addresses from that pool.

15.1.4 Host Reservations

A reservation sets up a static IP address reservation for a client inside a subnet. For example:

```
tnsr(config-kea-subnet4)# reservation 10.2.0.20
tnsr(config-kea-subnet4-reservation)#
```

This reservation ensures that a client always obtains the same IP address, and can also provide the client with DHCP options that differ from the main subnet configuration.

Reservations are defined from within config-kea-subnet4 mode, and take the form of reservation <ipv4-address>. That command then enters config-kea-subnet4-reservation mode, which contains the following options:

- **hostname <hostname>** The hostname for this client.
- **mac-address <mac-address>** Mandatory. The MAC address of the client, used to uniquely identify the client and assign this reserved IP address. The same MAC address cannot be used in more than one reservation on a single subnet.
- **option <dhcp4-option>** DHCP options specific to this client. See DHCP Options for details on configuring DHCP options.

At a minimum, a reservation entry requires the ipv4-address which defines the reservation itself, and a mac-address to identify the client.

**Warning:** While it is possible to define a reservation inside a pool, this can lead to address conflicts in certain cases, such as when a different client already holds a lease for the new reservation.

The best practice is to keep reservations outside of the dynamic assignment pool.

Host reservation example:
15.2 DHCP Service Control and Status

15.2.1 Enable the DHCP Service

Enable the DHCP4 server:

```bash
tnsr(config)# dhcp4 enable
tnsr(config)#
```

15.2.2 Disable the DHCP Service

Similar to the DHCP enable command, disable the DHCP4 service from configuration mode:

```bash
tnsr(config)# dhcp4 disable
tnsr(config)#
```

15.2.3 Check the DHCP Service Status

Check the status of the DHCP services from configuration mode:

```bash
tnsr(config)# service dhcp status
DHCPv4 server: active
DHCPv6 server: inactive
DHCP DDNS: inactive
Control Agent: inactive
Kea DHCPv4 configuration file: /etc/kea/kea-dhcp4.conf
Kea DHCPv6 configuration file: /etc/kea/kea-dhcp6.conf
Kea DHCP DDNS configuration file: /etc/kea/kea-dhcp-ddns.conf
Kea Control Agent configuration file: /etc/kea/kea-ctrl-agent.conf
keactrl configuration file: /etc/kea/keactrl.conf
```

15.2.4 View the DHCP Configuration

View the current Kea DHCP Daemon and Control TNSR Configuration:

```bash
tnsr# show kea
```

View the current Kea DHCP Daemon TNSR Configuration:

```bash
tnsr# show kea dhcp4
```

View the current Kea DHCP daemon configuration file:
View the current Kea Control TNSR Configuration:

View the current Kea Control Configuration file:

15.3 DHCP Service Example

Configure the DHCP IPv4 Service from configuration mode (Configuration Mode). This example uses the interface and subnet from Example Configuration:

The above example configures example.com as the domain name supplied to all clients. For the specific subnet in the example, the TNSR IP address inside the subnet is supplied by DHCP as the default gateway for clients, and DHCP will instruct clients to use 8.8.8.8 and 8.8.4.4 for DNS servers.

Note: The subnet definition requires an interface.
TNSR uses the Unbound Domain Name System Resolver to handle DNS resolution and client queries.

Unbound is a recursive caching DNS resolver. Unbound can validate DNS data integrity with DNSSEC, and supports query privacy using DNS over TLS.

By default Unbound will act as a DNS resolver, directly contacting root DNS servers and other authoritative DNS servers in search of answers to queries. Unbound can also act as a DNS Forwarder, sending all DNS queries to specific upstream servers.

16.1 DNS Resolver Configuration

Unbound can be configured with a wide array of optional parameters to fine-tune its behavior. Due to the large number of options, this documentation is split into several parts, with related options listed together.

These options are all found in config-unbound mode, which is entered by the command unbound server from configuration mode (Configuration Mode).

**enable/disable** These commands enable or disable options that do not require additional parameters, they can only be turned on or off. The specific options are discussed in other areas of this chapter such as Security Tuning and Cache & Performance Tuning.

**verbosity <n>** Sets the verbosity of the logs, from 0 (no logs) through 5 (high). Default value is 1. Each level provides the information from the lower levels plus additional data.
- Level 1: Operational Information
- Level 2: Additional details
- Level 3: Per-query logs with query level information
- Level 4: Algorithm level information
- Level 5: Client identification for cache misses

**interface <x.x.x.x> [port <n>]** Configures an interface that Unbound will use for binding, and an optional port specification. In most cases there should be an interface definition for a TNSR IP address in each local network, plus a definition for localhost (127.0.0.1 as shown in Resolver Mode Example). The port number defaults to 53 and should not be changed in most use cases.

**port <n>** Sets the default port which Unbound will use to listen for client queries. Defaults to 53.

**enable/disable ip4** Tells Unbound to use, or not use, IPv4 for answering or performing queries. Default is enabled. Unless TNSR has no IPv4 connectivity, this should be left enabled.
enable/disable ip6  Tells Unbound to use, or not use, IPv6 for answering or performing queries. Default is enabled. Unless there is a situation where TNSR is configured with IPv6 addresses but lacks working connectivity to upstream networks via IPv6, this should remain enabled.

enable/disable udp  Tells Unbound to use, or not use, UDP for answering or performing queries. Default is enabled. In nearly all cases, DNS requires UDP to function, except special cases such as a pure DNS over TLS environment. Thus, this should nearly always be left enabled.

enable/disable tcp  Tells Unbound to use, or not use, TCP for answering or performing queries. Default is enabled. TCP is generally required for functional DNS, especially for queries with large answers. DNS over TLS also requires TCP. Unless a use case specifically calls for UDP DNS only, this should remain enabled.

access-control  Configures access control list entries for Unbound. See Access Control Lists.

forward-zone  Enters config-unbound-fwd-zone mode. See Forward Zones.

16.1.1 Access Control Lists

Access Control Lists in Unbound determine which clients can and cannot perform queries against the DNS Resolver as well as aspects of client behavior.

The default behavior is to allow access from TNSR itself (localhost), but refuse queries from other clients.

Example:

```
 tnsr(config)# unbound server
 tnsr(config-unbound)# access-control 10.2.0.0/24 allow
```

The general form of the command is:

```
 tnsr(config-unbound)# access-control <IPv4 or IPv6 Network Prefix> <action>
```

The IPv4 or IPv6 Network Prefix is a network specification, such as 10.2.0.0/24 or 2001:db8::/64. For a single address, use /32 for IPv4 or /128 for IPv6.

The Action types are:

- **allow**  Allow access to recursive and local data queries for clients in the specified network.
- **allow_snoop**  Allow access to recursive and local data queries for clients in the specified network, additionally this allows access to cache snooping. Cache snooping is a technique to use nonrecursive queries to examine the contents of the cache for debugging or identifying malicious data.
- **refuse**  Stops queries from clients in the specified network, but sends a DNS response code REFUSED error. This is the default behavior for networks other than localhost, since it is friendly and protocol-safe response behavior.
- **refuse_non_local**  Similar to refuse but allows queries for authoritative local data. Recursive queries are refused.
- **deny**  Drops and does not respond to queries from clients in the specified network. In most cases a refuse action is preferable since DNS is not designed to handle a non-response. A lack of response may cause clients to send additional unwanted queries.
- **deny_non_local**  Allows queries for authoritative local-data only, all other queries are dropped without a response.
16.1.2 Forward Zones

In Unbound, a Forward Zone controls how queries are handled on a per-zone basis. This can be used to send queries for a specific domain or zone to a specific DNS server, or it can be used to setup forwarding mode sending all queries to one or more upstream recursive DNS servers.

**Forward Zone Examples**

Example to override the default resolver behavior and forward all queries to an upstream DNS server:

```
 tnsr(config)# unbound server
 tnsr(config-unbound)# forward-zone .
 tnsr(config-unbound-fwd-zone)# nameserver address 8.8.8.8
 tnsr(config-unbound-fwd-zone)# nameserver address 8.8.4.4
```

This forwards the root zone (.) and all zones underneath to the specified servers, in this case, 8.8.8.8 and 8.8.4.4.

Example to send queries for one specific domain to an alternate server:

```
 tnsr(config)# unbound server
 tnsr(config-unbound)# forward-zone example.com
 tnsr(config-unbound-fwd-zone)# nameserver address 192.0.2.5
```

This example sends all queries for example.com and subdomains underneath example.com to the server at 192.0.2.5. This is useful for sending queries for internal domains to a local authoritative DNS server, or an internal DNS server reachable through a VPN.

**Forward Zone Configuration**

To enter config-unbound-fwd-zone mode, start from config-unbound mode and use the forward-zone <zone-name> command. The <zone-name> takes the form of the domain part of a fully qualified domain name (FQDN), but may also be . to denote the root zone.

- **nameserver address <ip-address> [port <port>] [auth-name <name>]** Specifies a DNS server for this zone by IP address. Optionally, a port number may be given (default 53). auth-name sets the FQDN of the DNS server for use in validating certificates with DNS over TLS.

- **nameserver host <host-name>** Specifies a DNS server for this zone by FQDN. This hostname will be resolved before use.

- **enable/disable forward-first** When enabled, if a query fails to the forwarding DNS servers it will be retried using resolver mode through the root DNS servers. By default this behavior is disabled.

- **enable/disable forward-tls-upstream** When enabled, queries to the DNS servers in this zone are sent using DNS over TLS, typically on port 853. This mode provides query privacy by encrypting communication between Unbound and upstream DNS servers in the zone. Default is disabled as this feature is not yet widely supported by other platforms.

Multiple DNS server address or host entries may be given for a forward zone. These servers are not queried sequentially and are not necessarily queried simultaneously. Unbound tracks the availability and performance of each DNS server in the zone and will attempt to use the most optimal server for a query.
16.1.3 Local Zones

Unbound can host local zone data to complement, control, or replace upstream DNS data. This feature is commonly used to supply local clients with host record responses that do not exist in upstream DNS servers, or to supply local clients with a different response, akin to a DNS view.

Local Zone Example

This basic example configures a local zone for example.com and two hostnames inside. If a client queries TNSR for these host records, it will respond with the answers configured in the local zone. If a client requests records for a host under example.com not listed in this local zone, then the query is resolved as usual though the usual resolver or forwarding server mechanisms.

```
Tnsr(config)# unbound server
Tnsr(config-unbound)# local-zone example.com
Tnsr(config-unbound-local-zone)# type transparent
Tnsr(config-unbound-local-zone)# hostname server.example.com
Tnsr(config-unbound-local-host)# address 192.0.2.5
Tnsr(config-unbound-local-host)# exit
Tnsr(config-unbound-local-zone)# hostname db.example.com
Tnsr(config-unbound-local-host)# address 192.0.2.6
Tnsr(config-unbound-local-host)# exit
```

Local Zone Configuration

Local zones are configured in config-unbound mode (DNS Resolver Configuration) using the local-zone <zone-name> command. This defines a new local zone and enters config-unbound-local-zone mode.

Within config-unbound-local-zone mode, the following commands are available:

- **description < descr >** A short text description of the zone
- **type < type >** The type for this local zone, which can be one of:
  - **transparent** Gives local data, and resolves normally for other names. If the query matches a defined host but not the record type, the client is sent a NOERROR, NODATA response. This is the most common type and most likely the best choice for most scenarios.
  - **typetransparent** Similar to transparent, but will forward requests for records that match by name but not by type.
  - **deny** Serve local data, drop queries otherwise.
  - **inform** Like transparent, but logs the client IP address.
  - **inform_deny** Drops queries and logs the client IP address.
  - **no_default** Normally resolve AS112 zones.
  - **redirect** Serves zone data for any subdomain in the zone.
  - **refuse** Serve local data, else reply with REFUSED error.
  - **static** Serve local data, else NXDOMAIN or NODATA answer.
- **hostname <fqdn >** Defines a new hostname within the zone, and enters config-unbound-local-host mode. A local zone may contain multiple hostname entries.
Note: Include the domain name when creating a hostname entry.

Inside config-unbound-local-host mode, the following commands are available:

- **description <descr>** A short text description of this host
- **address <ip-address>** The IPv4 or IPv6 address to associate with this hostname for forward and reverse (PTR) lookups.

### 16.1.4 Security Tuning

Unbound can be tuned to provide stronger (or weaker) security and privacy, depending on the needs of the network and features supported by clients and upstream servers.

- **enable caps-for-id** Experimental support for draft dns-0x20. This feature combats potentially spoofed replies by randomly flipping the 0x20 bit of ASCII letters, which switches characters between upper and lower case. The answer is checked to ensure the case in the response matches the request exactly. This is disabled by default since it is experimental, but is safe to enable unless the upstream server does not copy the query question to the response identically. Most if not all servers follow this convention, but it is unknown if this behavior is truly universal.

- **enable harden dnssec-stripped** Require DNSSEC for trust-anchored zones. If the DNSSEC data is absent, the zone is marked as bogus. If disabled and no DNSSEC data is received in the response, the zone is marked insecure. Default behavior is enabled. If disabled, there is a risk of a forced downgrade attack on the response that disables security on the zone.

- **enable harden glue** Trust glue only if the server is authorized. Default is enabled.

- **enable hide identity** When enabled, queries are refused for id.server and hostname.bind, which prevents clients from obtaining the server identity. Default behavior is disabled.

- **enable hide version** When enabled, queries are refused for version.server and version.bind, preventing clients from determining the version of Unbound. Default behavior is disabled.

- **thread unwanted-reply-threshold <threshold>** When set, Unbound tracks the total number of unwanted replies in each thread. If the threshold is reached, Unbound will take defensive action and logs a warning. This helps prevent cache poisoning by clearing the RRsSet and message caches when triggered. By default this behavior is disabled. If this behavior is desired, a starting value of 10000000 (10 million) is best. Change the value in steps of 5-10 million as needed.

- **jostle timeout <t>** Timeout in milliseconds, used when the server is very busy. This timeout should be approximately the same as the time it takes for a query to reach an upstream server and receive a response (round trip time). If a large number of queries are received by Unbound, than half the active queries are allowed to complete and the other half are replaced by new queries. This helps reduce the effectiveness of a denial of service attack by allowing the server to ignore slow queries when under load. The default value is 200 msec.

### 16.1.5 Cache & Performance Tuning

- **port outgoing range <n>** Sets the number of source ports Unbound may use per thread to connect when making outbound queries to upstream servers. A larger number of ports provides protection against spoofing. Default value varies by platform. A large number of ports yields better performance but it also consumes more host resources.

- **edns reassembly size <s>** Number to advertise as the EDNS reassembly buffer size, in bytes. This value is sent in queries and must not be set larger than the default message buffer size, 6552. The
default value is 4096, which is recommended by RFC. May be set lower to alleviate problems with fragmentation resulting in timeouts. If the default value is too large, try 1472, or 512 in extreme cases. Avoid setting that low as it will cause many queries to fall back to TCP which can negatively impact performance.

`host cache num-hosts <num>` Number of hosts to hold in the cache, defaults to 10000. Larger caches can result in increased performance but consume more host resources.

`host cache slabs <i>` Number of slabs in the host cache. Larger numbers help prevent lock contention by threads when performing cache operations. The value is a power of 2, between 0..10.

`host cache ttl <t>` The amount of time, in seconds, that entries in the host cache are kept. Default value is 900 seconds.

`enable key prefetch` When enabled, Unbound will start fetching DNSKEYS when it sees a DS record instead of waiting until later in the process. Prefetching keys will consume more CPU, but reduces latency. The default is disabled.

`key cache slabs <i>` Number of slabs in the key cache. Larger numbers help prevent lock contention by threads when performing key cache operations. The value is a power of 2, between 0..10. Setting to a number close to the number of CPUs/cores in the host is best.

`enable message prefetch` Prefetch message cache items before they expire to keep entries in the cache updated. When enabled, Unbound will consume approximately 10% more throughput and CPU time but it will keep popular items primed in the cache for better client performance. Disabled by default.

`message cache size <i>` Size of the message cache, in bytes. The message cache stores DNS meta-information such as message formats. Default value is 4 MB.

`message cache slabs <i>` Number of slabs in the message cache. Larger numbers help prevent lock contention by threads when performing message cache operations. The value is a power of 2, between 0..10. Setting to a number close to the number of CPUs/cores in the host is best.

`rrset cache size <i>` Size of the RRset cache, in bytes. The RRset cache stores resource records. Default value is 4 MB.

`rrset cache slabs <i>` Number of slabs in the RRset cache. Larger numbers help prevent lock contention by threads when performing RRset cache operations. The value is a power of 2, between 0..10. Setting to a number close to the number of CPUs/cores in the host is best.

`rrset-message cache ttl maximum <max>` Maximum time that values in the RRset and message caches are kept in the cache, specified in seconds. The default value is 86400 (1 day). When set lower, Unbound will be forced to query for data more often, but it will also ignore very large TTLs in DNS responses.

`rrset-message cache ttl minimum <max>` Minimum time that values in the RRset and message caches are kept in the cache, specified in seconds. The default value is 0, which honors the TTL specified in the DNS response. Higher values may ignore the TTL set by the response, which means a record may be out of sync with the source, but it also prevents queries from being repeated frequently when a very low TTL is set by the domain.

`socket receive-buffer size <i>` SO_RCVBUF socket receive buffer size for incoming queries on the listening port(s). Larger values result in less drops during spikes in activity. The default is 0 which uses the system default value. Cannot be set higher than the maximum value for the operating system, such as the one shown in the `net.core.rmem_max` sysctl OID.

`tcp buffers incoming <i>` Number of incoming TCP buffers that Unbound will allocate per thread. Larger values can handle higher loads, but will consume more resources. The default value is 10. A value of 0 will disable acceptance of TCP queries.
**tcp buffers outgoing <n>**  Number of outgoing TCP buffers that Unbound will allocate per thread. Larger values can handle higher loads, but will consume more resources. The default value is 10. A value of 0 will disable TCP queries to authoritative DNS servers.

**thread num-queries <n>**  Number of queries serviced by each thread simultaneously. If more queries arrive and there is no room to answer them, the new queries will be dropped, unless older/slower queries can be dropped by using the jostle timeout. Default varies by platform but is typically 512 or 1024.

**thread num-threads <n>**  Number of threads created by Unbound for serving clients. Defaults to one thread per CPU/core. To disable threading, set to 1.

**enable serve-expired**  When enabled, Unbound will immediately serve answers to clients using expired cache entries if they exist. Unbound still performs the query and will update the cache with the result. This can result in faster, but potentially incorrect, answers for client queries. Default is disabled.

### 16.2 DNS Resolver Service Control and Status

#### 16.2.1 Enable the DNS Resolver

Enable the DNS Resolver:

```
tnsr(config)# unbound enable
tnsr(config)#
```

#### 16.2.2 Disable the DNS Resolver

Similar to the `enable` command, disable the DNS Resolver from configuration mode:

```
tnsr(config)# unbound disable
tnsr(config)#
```

#### 16.2.3 Check the DNS Resolver Status

Check the status of the DNS Resolver from configuration mode:

```
tnsr(config)# service unbound status
  * unbound.service - Unbound recursive Domain Name Server
    Loaded: loaded (/usr/lib/systemd/system/unbound.service; disabled; vendor preset: →
    --disabled)
    Active: active (running) since Wed 2018-08-22 15:26:05 EDT; 55min ago
    Process: 26675 ExecStartPre=/usr/sbin/unbound-anchor -a /var/lib/unbound/root.key -
    →c /etc/unbound/icannbundle.pem (code=exited, status=0/SUCCESS)
    Process: 26673 ExecStartPre=/usr/sbin/unbound-checkconf (code=exited, status=0/
    →SUCCESS)
    Main PID: 26679 (unbound)
    CGroup: /system.slice/unbound.service
      26679 /usr/sbin/unbound -d

Aug 22 15:26:05 tnsr.example.com systemd[1]: Starting Unbound recursive Domain Name →Server...
```

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Aug 22 15:26:05 tnsr.example.com unbound-checkconf[26673]: unbound-checkconf: no errors in /etc/unbound/unbound.conf
Aug 22 15:26:05 tnsr.example.com systemd[1]: Started Unbound recursive Domain Name Server.
Aug 22 15:26:05 tnsr.example.com unbound[26679]: [26679:0] notice: init module 0: subnet
Aug 22 15:26:05 tnsr.example.com unbound[26679]: [26679:0] notice: init module 1: validator
Aug 22 15:26:05 tnsr.example.com unbound[26679]: [26679:0] info: start of service (unbound 1.6.6).

16.2.4 View the DNS Resolver Configuration

View the current Unbound DNS Resolver daemon configuration file:

```
tnsr# show unbound config-file
```

16.3 DNS Resolver Examples

Configure the DNS Resolver Service from configuration mode (*Configuration Mode*). These examples use the interface and subnet from *Example Configuration*.

16.3.1 Resolver Mode Example

For Resolver mode, the configuration requires only a few basic options:

```
tnsr# configure
tnsr(config)# unbound server
tnsr(config-unbound)# interface 127.0.0.1
tnsr(config-unbound)# interface 10.2.0.1
tnsr(config-unbound)# access-control 10.2.0.0/24 allow
tnsr(config-unbound)# exit
tnsr(config)# unbound enable
```

This example enables the Unbound DNS Resolver and configures it to listen on localhost as well as 10.2.0.1 (GigabitEthernet0/14/2, labeled LAN in the example). The example also allows clients inside that subnet, 10.2.0.0/24, to perform DNS queries and receive responses.

16.3.2 Forwarding Mode Example

For Forwarding mode, use the configuration above plus these additional commands:

```
tnsr# configure
tnsr(config)# unbound server
tnsr(config-unbound)# forward-zone .
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.8.8
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.4.4
```

(continues on next page)
This example builds on the previous example but instead of working in resolver mode, it will send all DNS queries to the upstream DNS servers 8.8.8.8 and 8.8.4.4.
The Network Time Protocol (NTP) service on TNSR synchronizes the host clock with reference sources, typically remote servers. It also acts as an NTP server for clients.

17.1 NTP Configuration

The NTP daemon has a variety of options to fine-tune its timekeeping behavior.

```
  interface sequence <seq> <action> <address>
  
  Interface binding options. The default behavior when no interface configuration entries are present is to bind to all available addresses on the host.

  seq The sequence number controls the order of the interface definitions in the NTP daemon configuration.

  action The action taken for NTP traffic on this interface, it can be one of:

  drop Bind the daemon to this interface, but drop NTP traffic.

  ignore Do not bind the daemon to this interface.

  listen Bind the daemon to this interface and use it for NTP traffic.

  address The address or interface to bind. This may be:

  prefix An IPv4/IPv6 prefix, which will bind to only that specific address.

  interface An interface name, which will bind to every address on that interface.

  all Bind to all interfaces and addresses on TNSR.

  server <address|host> <server>
  
  Defines an NTP peer with which the daemon will attempt to synchronize the clock. This command enters config-ntp-server mode. The server may be specified as:

  address <IPv4/IPv6 Address> An IPv4 or IPv6 address specifying a single NTP server.

  host <fqdn> A fully qualified domain name, which will be resolved using DNS.
```

Within config-ntp-server mode, additional commands are available that control how NTP interacts with the specified server:

```
  iburst Use 8 packets on unreachable servers, which results in faster synchronization at startup and when a peer is recovering.

  maxpoll <poll> Maximum polling interval for NTP messages. This is specified as a power of 2, in seconds. May be between 7 and 17, defaults to 10 (1024 seconds).

  noselect Instructs NTP to not use the server for synchronization, but it will still connect and display statistics from the server.
```
prefer When set, NTP will prefer this server if it and multiple other servers are all viable candidates of equal quality.

operational-mode server This entry is a single server. When the server is specified as an FQDN, if the DNS response contains multiple entries then only one is selected. Can also be used with IPv4/IPv6 addresses directly, rather than FQDN entries.

operational-mode pool This entry is a pool of servers. Only compatible with FQDN hosts. NTP will expect multiple records in the DNS response and will use all of these entries as distinct servers. This is a reliable way to configure multiple NTP peers with minimal configuration.

Warning: An operational-mode is required.

tinker panic <n> Sets the NTP panic threshold, in seconds. This is a sanity check which will cause NTP to fail if the difference between the local and remote clocks is too great. Commonly set to 0 to disable this check so that NTP will still synchronize when its clock is off by a large factor. The default value is 1000.

tos orphan <n> Configures the stratum of orphan mode servers from 1 to 16. When all UTC reference peers below this stratum are unreachable, clients in the same subnet may use each other as references as a last resort.

driftfile <file> Full path to the filename used by the NTP daemon to store clock drift information to improve accuracy over time. This file and its directory must be writable by the ntp user or group.

statsdir <file> Full path to statistics directory used by the NTP daemon. This directory must be writable by the ntp user or group.

<enable|disable> monitor Enables or disables the monitoring facility used to poll the NTP daemon for information about peers and other statistics. This is enabled by default, and is also enabled if limited is present in any restrict entries. This is required for show ntp <x> commands which display peer information to function.

17.1.1 NTP Restrictions

NTP restrictions control how NTP treats traffic from peers. The NTP Service Example at the start of this section contains a good set of restrictions to use as a starting point.

These restrictions are configured using the restrict command from within config-ntp mode.

restrict <default|source|host|prefix> This command enters config-ntp-restrict mode.

The restriction is placed upon an address specified as:

  default The default restriction for any host.
  source Default restrictions for associated hosts.
  host An address specified as an FQDN to be resolved using DNS.
  prefix An IPv4 or IPv6 network specification.

In config-ntp-restrict mode, the following settings control what hosts matching this restriction can do:

  kod Sends a Kiss of Death packet to misbehaving clients. Only works when paired with the limited option.
limited Enforce rate limits on clients. This does not apply to queries from ntpq/ntpd or the show ntp <x> commands.

nomodify Allows clients to query read only server state information, but does not allow them to make changes.

nopeer Deny unauthorized associations. When using a server entry in pool mode, this should be present in the default restriction but not in the source restriction.

noquery Deny ntpq/ntpd/show ntp <x> queries for NTP daemon information. Does not affect NTP acting as a time server.

noserve Disables time service. Still allows ntpq/ntpd/show ntp <x> queries

notrap Decline mode 6 trap service to clients.

17.1.2 NTP Logging

The NTP Logging configuration controls which type of events are logged by the NTP daemon using syslog, and the verboxness of the logs. By default, the NTP daemon will log all synchronization messages.

The logging configuration is set using the logconfig command from within config-ntp mode.

```
logconfig sequence <seq> <action> <class> <type>
```

- `seq` Specifies the sequence for log entries so that the order of parameters may be controlled by the configuration.

- `action` Specifies the action for this log entry, as one of:
  - `set` Set the mask for the log entry. Typically this would be used for the first entry to control which message class+type is logged as the base set of log entries.
  - `add` Add log entries matching this specification to the specified total set of logs.
  - `delete` Do not log entries matching this specification in the total set of logs.

- `class` Specifies the message class, which can be one of:
  - `all` All message classes
  - `clock` Messages about local clock events and information.
  - `peer` Messages about peers.
  - `sync` Messages about the synchronization state.
  - `sys` Messages about system events and status.

- `type` Specifies the type of messages to log for each class:
  - `all` All types of messages.
  - `events` Event messages.
  - `info` Informational messages.
  - `statistics` Statistical information.
  - `status` Status changes.
17.2 NTP Service Control and Status

17.2.1 Enable the NTP Service

Enable the NTP server:

```
tnsr(config)# ntp enable
```

17.2.2 Disable the NTP Service

Similar to the NTP enable command, disable the NTP service from configuration mode:

```
tnsr(config)# ntp disable
```

17.2.3 Check the NTP Service Status

Check the status of the NTP services from configuration mode:

```
tnsr(config)# service ntp status
```

```
* ntpd.service - Network Time Service
  Loaded: loaded (/usr/lib/systemd/system/ntpd.service; disabled; vendor preset: disabled)
  Active: active (running) since Thu 2018-11-15 07:05:57 EST; 2 weeks 5 days ago
  Main PID: 1744 (ntpd)
  CGroup: /system.slice/ntpd.service
        └─1744 /usr/sbin/ntpd -u ntp:ntp -g

Dec 04 11:38:44 ntpd[1744]: Listen normally on 21 mytap 10.2.99.1 UDP 123
Dec 04 11:38:44 ntpd[1744]: Listen normally on 22 vpp5 fe80::208:a2ff:fe09:95b5 UDP 123
Dec 04 11:38:44 ntpd[1744]: Listen normally on 23 vpp1 fe80::208:a2ff:fe09:95b1 UDP 123
Dec 04 11:38:44 ntpd[1744]: Listen normally on 24 vpp1 fe80::: UDP 123
Dec 04 11:38:44 ntpd[1744]: new interface(s) found: waking up resolver
```

17.2.4 View NTP Peers

The NTP peer list shows the peers known to the NTP daemon, along with information about their network availability and quality. For more information on peer associations, see View NTP Associations.

```
Id   Host    Stratum Reach Poll Delay Offset Jitter
----- ------- ------- ----- ----- ---- ----- ---- ----
17417 5.9.80.113 2 0xff 512 134.456 -1.936 3.904
17418 95.216.39.155 2 0xff 512 151.370 -1.582 4.883
17419 145.239.118.233 2 0xec 512 126.181 4.112 21.541
17420 178.128.4.44 2 0xff 512 80.998 2.906 4.140
```
17.2.5 View NTP Associations

The NTP peer associations list shows how the NTP daemon is using each peer, along with its status. These peers are listed by ID. For more information on each peer, see View NTP Peers.

```
Id Status Persistent Auth En Authentic Reachable Broadcast Selection Event Count
--- ------ ---------- ------- --------- --------- --------- --------- ---------- ---
17417 0x931a true false false true false outlier sys_peer 1
17418 0x941a true false false true false candidate sys_peer 1
17419 0x941a true false false true false candidate sys_peer 1
17420 0x961a true false false true false sys.peer sys_peer 1
```

17.2.6 View NTP Daemon Configuration File

View the current NTP Daemon configuration file, generated by the settings in TNSR:

```
tnsr# show ntp config-file
#
# NTP config autogenerated
#
tinker panic 0
tos orphan 12
logconfig =syncall +clockall
restrict ::/0 kod limited nomodify nopeer notrap
restrict default kod limited nomodify nopeer notrap
restrict source kod limited nomodify notrap
pool pool.ntp.org maxpoll 9
```

17.3 NTP Service Example

Configure the NTP Service from configuration mode (Configuration Mode). This example uses pool.ntp.org in pool mode so that multiple DNS results are used as reference servers.

```
tnsr(config)# ntp server
tnsr(config-ntp)# tos orphan 12
tnsr(config-ntp)# tinker panic 0
tnsr(config-ntp)# logconfig sequence 1 set sync all
tnsr(config-ntp)# logconfig sequence 2 add clock all
tnsr(config-ntp)# restrict default
tnsr(config-ntp-restrict)# kod
tnsr(config-ntp-restrict)# limited
tnsr(config-ntp-restrict)# nomodify
tnsr(config-ntp-restrict)# nopeer
tnsr(config-ntp-restrict)# notrap
tnsr(config-ntp-restrict)# exit
```

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17.4 NTP Best Practices

Use a minimum of three servers, either as three separate server entries or a pool containing three or more servers. This is to ensure that if the clock on any one server becomes skewed, the remaining two sources can be used to determine that the skewed server is no longer viable. Otherwise NTP would have to guess which one is accurate and which is skewed.

There are a large number of public NTP servers available under pool.ntp.org. The pool.ntp.org DNS entry will return a number of randomized servers in each DNS query response. These can be used individually or as pools. The easiest way is to use the pool operational mode, which uses all returned servers as if they were specified individually.

When using entries as individual server entries, these responses can be subdivided into mutually exclusive pools of peers to avoid overlap. For example, if a configuration specifies pool.ntp.org multiple times for server entries, the same IP address could accidentally be selected twice. In this case, use 0.pool.ntp.org, 1.pool.ntp.org, 2.pool.ntp.org, and so on. When queried in this way, the responses will be unique for each number.

Furthermore, there are also pools available for regional and other divisions. For example, to only receive responses for servers in the United States, use us.pool.ntp.org as a pool or <n>.us.pool.ntp.org as servers. For more information, see https://www.ntppool.org/en/
The Link Layer Discovery Protocol (LLDP) service provides a method for discovering which routers are connected to a LAN segment, and offers a way to discover the topology of a network.

18.1 Configuring the LLDP Service

LLDP is configured in two places: Global router parameters and per-interface parameters.

18.1.1 LLDP Router Configuration

Three LLDP commands are available in configuration mode (Configuration Mode) to configure global LLDP parameters for this router:

- **lldp system-name**  The router hostname advertised by LLDP.
- **lldp tx-interval**  Transmit interval, which controls the time between LLDP messages in seconds.
- **lldp tx-hold**  Transmit hold time, which is a multiple of the transmit interval used for the Time-To-Live (TTL) of the LLDP message.

**Tip:** If the transmit interval is 5 and the transmit hold time is 4, then the advertised TTL of the LLDP message is 20 (4*5=20).

Example:

```
tnsr(config)# lldp system-name MyRouter
tnsr(config)# lldp tx-hold 3
tnsr(config)# lldp tx-interval
```

These parameters can be changed at any time.

18.1.2 LLDP Interface Configuration

Additional LLDP commands are available in config-interface mode (Interface Command) to configure per-interface LLDP identification:

- **lldp port-name**  The name of the interface as advertised by LLDP.
- **lldp management (ipv4|ipv6) <ip-address>**  The IPv4 and/or IPv6 address advertised by LLDP as a means to manage this router on this interface.
**lldp management oid <oid>** An object identifier associated with the management IP address on this interface.

Example:

```
tnsr(config)# interface TenGigabitEthernet3/0/0
tnsr(config-interface)# lldp port-name MyPort
tnsr(config-interface)# lldp management ipv4 192.0.2.123
tnsr(config-interface)# lldp management ipv6 2001:db8::1:2:3:4
tnsr(config-interface)# exit
tnsr(config)#
```

**Warning:** Due to a limitation of the underlying API, all LLDP interface parameters must be configured at the same time and cannot be changed. This will be fixed in a later release.
TNSR supports Public Key Infrastructure (PKI) X.509 certificates for various uses by the router and supporting software. PKI uses a pair of keys to encrypt and authenticate data, one public and one private. The private key is known only to its owner, and the public key can be known by anyone.

PKI works in an asymmetric fashion. A message is encrypted using the public key, and can only be decrypted by the private key. The private key can also be used to digitally sign a message to prove it originated from the key holder, and this signature can be validated using the public key. Combined with certificates, this provides a means to identify an entity and encrypt communications.

A Certificate Authority (CA) independently verifies the identity of the entity making a request for a certificate, and then signs a request, yielding a certificate. This certificate can then be validated against the certificate of the CA itself by anyone who has access to that CA certificate. In some cases, this CA may be an intermediate, meaning it is also signed by another CA above it. All together, this creates a chain of trust starting with the root CA all the way down to individual certificates. So as long as the CA is trustworthy, any certificate it has signed can be considered trustworthy.

Due to their size and private nature, certificates and keys are stored on the filesystem and not in the XML configuration. PKI files are stored under the following locations:

- Certificate Authorities: /etc/pki/tls/tnsr/CA/
- Certificates and Signing Requests: /etc/pki/tls/tnsr/certs/
- Private Keys: /etc/pki/tls/tnsr/private/

A key pair, CSR, and certificate associated with each other must all have the same name.

The process for creating a certificate is as follows:

- Create keys for name.
- Create a certificate signing request for name with the attributes to use for the certificate.
- Submit the CSR to a CA, which will sign the CSR and return a certificate.
- Enter or import the certificate contents for name into TNSR.

### 19.1 Key Management

**Warning:** Private keys are secret. These keys should never need to leave the firewall, with the exception of backups. The CA does not need the private key to sign a request.

TNSR can generate RSA key pairs with sizes of 2048, 3072, or 4096 bits. Larger keys are more secure than shorter keys. RSA Keys smaller than 2048 bits are no longer considered secure in practice, and are thus not allowed.
19.1.1 Generate a Key Pair

To generate a new key pair named mycert with a length of 4096 bits:

```
    tnsr# pki private-key mycert generate key-length 4096
---BEGIN PRIVATE KEY-----
[...]
---END PRIVATE KEY-----
```

The key pair is stored in a file at /etc/pki/tls/tnsr/private/<name>.key.

**Note:** Remember that the private key, CSR, and certificate must all use identical names!

19.1.2 Importing a Key Pair

In addition to generating a key pair on TNSR, a private key may also be imported from an outside source. The key data can be imported in one of two ways:

- Use `pki private-key <name> enter` then copy and paste the PEM data
- Copy the PEM format key file to the TNSR host, then use `pki private-key <name> import <file>` to import from a file from the current working directory.

**Copy and Paste**

First, use the `enter` command:

```
    tnsr# pki private-key mycert enter
    Type or paste a PEM-encoded private key. Include the lines containing 'BEGIN PRIVATE KEY' and 'END PRIVATE KEY'
```

Next, paste the key data:

```
---BEGIN PRIVATE KEY-----
<key data>
---END PRIVATE KEY-----
```

**Import from File**

First, make sure that the copy of the key file is in PEM format.

Next, copy the key file to TNSR and start the CLI from the directory containing this file. The filename extension is not significant, and may be key, pem, txt, or anything else depending on how the file was originally created.

Next, use the `import` command:

```
    tnsr# pki private-key mycert import mycert.key
```

19.1.3 Other Key Operations

To view a list of all current keys known to TNSR:
To view the contents of the private key named `mycert` in PEM format:

```
> tnsr# pki private-key mycert get
-----BEGIN PRIVATE KEY-----
<key data>
-----END PRIVATE KEY-----
```

**Warning:** When making a backup copy of this key, store the backup in a protected, secure location. Include the armor lines (BEGIN, END) when making a backup copy of the key.

To delete a key pair which is no longer necessary:

```
> tnsr# pki private-key <name> delete
```

**Warning:** Do not delete a private key associated with a CSR or Certificate which is still in use!

### 19.2 Certificate Signing Request Management

A certificate signing request, or CSR, combines the public key along with a list of attributes that uniquely identify an entity such as a TNSR router. Once created, the CSR is exported and sent to the Certificate Authority (CA). The CA will sign the request and return a certificate.

#### 19.2.1 Set Certificate Signing Request Attributes

The first step in creating a CSR is to set the attributes which identify this firewall. These attributes will be combined to form the certificate Subject:

```
> tnsr# pki signing-request set common-name tnsr.example.com
> tnsr# pki signing-request set country US
> tnsr# pki signing-request set state Texas
> tnsr# pki signing-request set city Austin
> tnsr# pki signing-request set org Example Co
> tnsr# pki signing-request set org-unit IT
```

The attributes include:

- **common-name** The common name of the entity the certificate will identify, typically the fully qualified domain name of this host, or a username.
- **country** The country in which the entity is located.
- **state** The state or province in which the entity is located.
- **city** The city in which the entity is located.
- **org** The company name associated with the entity.
- **org-unit** The department or division name inside the company.
Note: At a minimum, a common-name must be set to generate a CSR.

Next, set the required digest algorithm which will be used to create a hash of the certificate data:

```
tnsr# pki signing-request set digest sha256
```

This algorithm can be any of the following choices, from weakest to strongest: md5, sha1, sha224, sha256, sha384, or sha512.

Note: SHA-256 is the recommended minimum strength digest algorithm.

Before generating the CSR, review the configured attributes for the CSR:

```
tnsr# pki signing-request settings show
Certificate signing request fields:
  common-name: tnsr.example.com
  country: US
  state: Texas
  city: Austin
  org: Example Co
  org-unit: IT
  digest: sha256
```

If any attributes are incorrect, change them using the commands shown previously.

### 19.2.2 Generate a Certificate Signing Request

If the attributes are all correct, generate the CSR using the same name as the private key created previously. TNSR will output CSR data to the terminal in PEM format:

```
tnsr# pki signing-request mycert generate
-----BEGIN CERTIFICATE REQUEST-----
<csr data>
-----END CERTIFICATE REQUEST-----
```

The CSR data is stored in a file at `/etc/pki/tls/tnsr/certs/<name>.csr`

Note: Remember that the private key, CSR, and certificate must all use identical names!

The CSR data for existing entries can be displayed in PEM format:

```
tnsr# pki signing-request mycert get
-----BEGIN CERTIFICATE REQUEST-----
<csr data>
-----END CERTIFICATE REQUEST-----
```

Copy and paste the CSR data, including the armor lines (BEGIN, END), from the terminal into a local file, and submit that copy of the CSR to the CA for signing.
Warning: Remember, the private key for the CSR is not required for signing. Do not send the private key to the CA.

19.2.3 Other CSR Operations

A CSR entry may be deleted once the certificate has been imported to TNSR:

```
tnsr# pki signing-request <name> delete
```

To view a list of all CSR entries known to TNSR:

```
tnsr# pki signing-request list
```

To reset the CSR attribute contents:

```
tnsr# pki signing-request settings clear
```

19.3 Certificate Management

After submitting the certificate signing request to the CA, the CA will sign the request and return a signed copy of the certificate. Typically this will be sent in PEM format, the same format used for the CSR and private key.

The certificate data can be imported in one of two ways:

- Use `pki certificate <name> enter` then copy and paste the PEM data
- Copy the PEM format certificate file to the TNSR host, then use `pki certificate <name> import <file>` to import from a file from the current working directory.

The certificate data is stored in a file at `/etc/pki/tls/tnsr/certs/<name>.crt` after entering or importing the contents.

Warning: When importing a certificate created outside of TNSR, the private key must be imported and present before TNSR can import the certificate.

19.3.1 Copy and Paste

First, use the `enter` command:

```
tnsr# pki certificate mycert enter
Type or paste a PEM-encoded certificate.
Include the lines containing 'BEGIN CERTIFICATE' and 'END CERTIFICATE'
```

Note: Remember that the private key, CSR, and certificate must all use identical names!

Next, paste the certificate data:
19.3.2 Import from File

First, make sure that the copy of the certificate file is in PEM format. The CA may have delivered the certificate in
PEM format, or another format. Convert the certificate to PEM format if it did not come that way.

Next, copy the certificate file to TNSR and start the CLI from the directory containing the certificate file. The filename
extension is not significant, and may be pem, crt, txt, or anything else depending on how the file was delivered
from the CA.

Next, use the import command:

```bash
tnsr# pki certificate mycert import mycert.pem
```

19.3.3 Other Certificate Operations

To view a list of all certificates known to TNSR:

```bash
tnsr# pki certificate list
```

To view the PEM data for a specific certificate known to TNSR:

```bash
tnsr# pki certificate <name> get
```

To delete a certificate:

```bash
tnsr# pki certificate <name> delete
```

19.4 Certificate Authority Management

As mentioned in Public Key Infrastructure, a Certificate Authority (CA) provides a starting point for a chain of trust
between entities using certificates. A CA will sign a certificate showing that it is valid, and as long as an entity trusts
the CA, it knows it can trust certificates signed by that CA.

By creating or importing a CA into TNSR, TNSR can use that CA to validate other certificates or sign new certificate
requests. These certificates can then be used to identify clients connecting to the RESTconf service or other similar
purposes.

A CA can be managed in several ways in TNSR. For example:

- Import a CA generated by another device by copy/paste in the CLI
- Import a CA generated by another device from a file
- Generate a new private key and CSR, then self-sign the CSR and set the CA property. The resulting CA is
  automatically available as a TNSR CA.
19.4.1 Import a CA

TNSR can import a CA from the terminal with copy/paste, or from a file. When importing a CA, the key is optional for validation but required for signing. To import the key, see Key Management. Import the key with the same name as the CA.

To import a CA from the terminal, use the `enter` command. In this example, a CA named `tnsrca` will be imported from the terminal by TNSR:

```
# pki ca tnsrca enter
Type or paste a PEM-encoded certificate.
Include the lines containing 'BEGIN CERTIFICATE' and 'END CERTIFICATE'
-----BEGIN CERTIFICATE-----
<cert data>
-----END CERTIFICATE-----
tnsr(config)#
```

Next, import the private key using the same name:

```
tnsr(config)# pki private-key tnsrca enter
Type or paste a PEM-encoded private key.
Include the lines containing 'BEGIN PRIVATE KEY' and 'END PRIVATE KEY'
-----BEGIN PRIVATE KEY-----
<key data>
-----END PRIVATE KEY-----
```

Alternately, import the CA and key from the filesystem:

```
tnsr(config)# pki ca otherca import otherca.crt
tnsr(config)# pki private-key otherca import otherca.key
```

19.4.2 Creating a Self-Signed CA

TNSR can also create a self-signed CA instead of importing an external CA. For internal uses, this is generally a good practice since TNSR does not need to rely on public CA entries to determine trust for its own clients.

First, generate a new private key for the CA:

```
tnsr(config)# pki private-key selfca generate
-----BEGIN PRIVATE KEY-----
<key data>
-----END PRIVATE KEY-----
```

Next, create a new CSR for the CA:

```
tnsr(config)# pki signing-request set common-name selfca
tenr(config)# pki signing-request set digest sha256
tenr(config)# pki signing-request selfca generate
-----BEGIN CERTIFICATE REQUEST-----
<csr data>
-----END CERTIFICATE REQUEST-----
```

Finally, have TNSR self-sign the CSR while setting the CA flag on the resulting certificate:

```
tnsr(config)# pki signing-request selfca sign self enable-ca true
-----BEGIN CERTIFICATE-----
```

(continues on next page)
After signing, the newly created CA is ready for immediate use:

```
tnsr(config)# pki ca list
  tnsrca
  selfca
```

### 19.4.3 Intermediate CAs

In some cases a CA may rely on another CA. For example, if a root CA signs an intermediate CA and the intermediate CA signs a certificate, then both the root CA and intermediate CA are required by the validation process.

To show this relationship in TNSR, a CA may be appended to another CA:

```
tnsr(config)# pki ca <root ca name> append <intermediate ca name>
```

In the above command, both CA entries must be present in TNSR before using the `append` command.

### 19.4.4 Using a CA to sign a CSR

A CA in TNSR with a private key present can also sign a client certificate. The typical use case for this is for RESTconf clients which must have a certificate recognized by a known CA associated with the RESTconf service.

First, generate a client private key and CSR:

```
tnsr(config)# pki private-key tnsrclient generate
  -----BEGIN PRIVATE KEY-----
  <key data>
  -----END PRIVATE KEY-----

  tnsr(config)# pki signing-request set common-name tnsrclient.example.com
  tnsr(config)# pki signing-request set digest sha256
  tnsr(config)# pki signing-request tnsrclient generate
  -----BEGIN CERTIFICATE REQUEST-----
  <csr data>
  -----END CERTIFICATE REQUEST-----
```

Then, sign the certificate:

```
tnsr(config)# pki signing-request tnsrclient sign ca-name tnsrca days-valid 365
  --digest sha512 enable-ca false
  -----BEGIN CERTIFICATE-----
  <cert data>
  -----END CERTIFICATE-----
```

The `sign` command takes several parameters, each of which has a default safe for use with client certificates in this context. The above example uses these defaults, but specifies them manually to show how the parameters function. The available parameters are:

- `days-valid` The number of days the resulting certificate will be valid. The default is 365 days (one year). When the certificate expires, it must be signed again for a new term. Certificates with a shorter lifetime are more secure, but longer lifetimes are more convenient.
- `digest` The hash algorithm used to sign the certificate. The default value is `sha512`.
**enable-ca** A boolean value which sets the CA flag in the resulting certificate. If a CSR is signed as a CA, the resulting certificate can then be used to sign other certificates. For end user certificates this is not necessary or desired, so the default is false.

### 19.4.5 Other CA Operations

The remaining basic CA operations allow management of CA entries.

To view a list of all CA entries:

```
tenr(config)# pki ca list
    tnsrca
    selfca
```

To view the contents of a CA certificate:

```
tenr(config)# pki ca tnsrca get
    -----BEGIN CERTIFICATE-----
    <cert data>
    -----END CERTIFICATE-----
```

To delete a CA entry:

```
tenr(config)# pki ca tnsrca delete
```
Bidirectional Forwarding Detection (BFD) is used to detect faults between two routers across a link, even if the physical link does not support failure detection. TNSR uses UDP as a transport for BFD between directly connected routers (single hop/next hop) as described in RFC 5880 and RFC 5881.

Each BFD session monitors one link. Multiple BFD sessions are necessary to detect faults on multiple links. BFD sessions must be manually configured between endpoints as there is no method for automated discovery.

BFD supports session authentication using SHA1 and we recommend using authentication when possible to secure BFD sessions.

When using BFD, both endpoints transmit “Hello” packets back and forth between each other. If these packets are not received within the expected time frame, the link is considered down. Links may also be administratively configured as down, and will not recover until manually changed.

20.1 BFD Sessions

A BFD session defines a relationship between TNSR and a peer so they can exchange BFD information and detect link faults. These sessions are configured by using the `bfd session <name>` command, which enters `config-bfd` mode, and defines a BFD session using the given word for a name.

Example:

```
tnsr# conf
tnsr(config)# bfd session otherrouter
tnsr(config-bfd)# interface GigabitEthernet0/14/0
tnsr(config-bfd)# local address 203.0.113.2
tnsr(config-bfd)# peer address 203.0.113.25
tnsr(config-bfd)# desired-min-tx 100000
tnsr(config-bfd)# required-min-rx 100000
tnsr(config-bfd)# detect-multiplier 3
```

20.1.1 Session Parameters

- **interface <if-name>**  The Ethernet interface on which to enable BFD
- **local address <ip-address>**  The local address used as a source for BFD packets. This address must be present on `<if-name>`. 
**peer address <ip-address>** The remote BFD peer address. The local and remote peer IP addresses must use the same address family (either IPv4 or IPv6)

**desired-min-tx <microseconds>** The desired minimum transmit interval, in microseconds

**required-min-rx <microseconds>** The required minimum transmit interval, in microseconds

**detect-multiplier <n-packets>** A non-zero value that is, roughly speaking, due to jitter, the number of packets that have to be missed in a row to declare the session to be down. Must be between 1 and 255.

Additional parameters for authentication are covered in *BFD Session Authentication*.

### 20.1.2 Changing the BFD Administrative State

Under normal conditions the state of a link monitored by BFD is handled automatically. The link state can also be set manually when necessary.

To disable a link and mark it administratively down:

```
tnsr# bfd session <name>
tnsr(config-bfd) # disable
```

To remove the administrative down and return the link to BFD management:

```
tnsr# bfd session <name>
tnsr(config-bfd) # enable
```

### 20.1.3 Viewing BFD Session Status

To see the configuration and status of a BFD session, use the *show bfd session* command:

```
tnsr# show bfd session
Session Number: 0
  Local IP Addr: 203.0.113.2
  Peer IP Addr: 203.0.113.25
  State: down
  Required Min Rx Interval: 100000 usec
  Desired Min Tx Interval: 100000 usec
  Detect Multiplier: 3
  BFD Key Id: 123
  Configuration Key Id: 14
  Authenticated: true
```

### 20.2 BFD Session Authentication

TNSR supports SHA1 and meticulous SHA1 authentication. In either mode, a secret key is used to create a hash of the outgoing packets. The key itself is not sent in the packets, only the hash and the ID of the key.

A sequence number is used to help avoid replay attacks. With SHA1, this sequence number is incremented occasionally. With meticulous SHA1, the sequence number is incremented on every packet.

The receiving peer will check for a key matching the given ID and then compare a hash of the BFD payload against the hash sent by the peer. If it matches and the sequence number is valid, the packet is accepted.
20.2.1 Define BFD Keys

There are two keys defined for each BFD session:

conf-key-id The Configuration Key ID. An unsigned 32-bit integer which identifies an internal unique key in TNSR. Neither the key itself nor this ID are ever communicated to peers. The secret component of this key must be generated outside of TNSR. It is a group of 1 to 20 hex pair values, such as 4a40369b4df32ed0652b548400.

bfd-key-id The BFD key ID. An unsigned 8-bit integer (0–255) which is the key ID carried in BFD packets, used for verifying authentication.

**Warning:** Both conf-key-id and bfd-key-id must be specified, or neither can be present.

To define a new configuration key ID:

```bash
tnsr(config)# bfd conf-key-id <conf-key-id>
tnsr(config-bfdkey)# authentication type (keyed-sha1|meticulous-keyed-sha1)
tnsr(config-bfdkey)# secret < (<hex-pair>)[1-20] >
```

For example:

```bash
tnsr(config)# bfd conf-key-id 123456789
tnsr(config-bfdkey)# authentication type meticulous-keyed-sha1
tnsr(config-bfdkey)# secret 4a40369b4df32ed0652b548400
```

20.2.2 Setup BFD Authentication

Authentication will only be active if both the bfd-key-id and conf-key-id are defined for a BFD session. An additional delayed keyword is also supported for BFD session which tells BFD to hold off any authentication action until a peer attempts to authenticate.

To activate authentication, add the chosen identifiers to a BFD session:

```bash
tnsr(config)# bfd session <bfd-session>
tnsr(config-bfd)# bfd-key-id <bfd-key-id>
tnsr(config-bfd)# conf-key-id <conf-key-id>
tnsr(config-bfd)# delayed (true|false)
```

For example:

```bash
tnsr(config)# bfd session otherrouter
tnsr(config-bfd)# bfd-key-id 123
tnsr(config-bfd)# conf-key-id 123456789
tnsr(config-bfd)# delayed false
```

20.2.3 View BFD Keys

To view a list of keys and their types, use the show bfd keys command:
```
tnSR# show bfd keys
Conf Key   Type               Use Count
--------- --------------------- ----------
123456789  meticulous-keyed-shal 1
234567890  keyed-shal          0
```

To view only one specific key, pass its ID to the same command:
```
tnSR# show bfd keys conf-key-id 123456789
Conf Key   Type               Use Count
--------- --------------------- ----------
123456789  meticulous-keyed-shal 1
```
TNSR includes a tnsr user by default. Administrators may create additional users to provide separate workspaces for each user. In this workspace the user may save and load configurations.

**Warning:** User access is controlled by NACM and the NACM default behavior varies by platform and when the TNSR installation was created. See *NETCONF Access Control Model (NACM)* for details.

### 21.1 User Configuration

Entering `config-auth` mode requires a username. When modifying an existing user, the username is available for autocompletion. The command will also accept a new username, which it creates when the configuration is committed. Creating a new user requires providing a means of authentication:

```
tnsr(config)# auth user <user-name>
```

A user may be deleted using the `no` form:

```
tnsr(config)# no auth user <user-name>
```

The `exit` command leaves `config-auth` mode:

```
tnsr(config-auth)# exit
tnsr(config)#
```

When exiting `config-auth` mode, TNSR commits changes to the user, which will create or update the entry for the user in the host operating system.

### 21.2 Authentication Methods

There are two methods for authenticating users: passwords and user keys.

#### 21.2.1 Password Authentication

The password method takes a password entered in plain text, but stores a hashed version of the password in the configuration:
**21.2.2 User Key Authentication**

The second method of authentication is by user key. A user key is the same format as created by `ssh-keygen`.

To add a user key for authentication, use the `user-keys` command inside `config-auth` mode:

```
tnsr(config-auth)# user-keys <key-name>
```

The user key is read directly from the CLI. After the command is executed by pressing Enter, the CLI will wait for the key to be entered, typically by pasting it into the terminal or by typing. The end of input is indicated by a blank line. The normal CLI features are bypassed during this process.
NETCONF ACCESS CONTROL MODEL (NACM)

NETCONF Access Control Model (NACM) provides a means by which access can be granted to or restricted from groups in TNSR.

NACM is group-based and these groups and group membership lists are maintained in the NACM configuration. User authentication is not handled by NACM, but by other processes depending on how the user connects. For examples, see User Management and HTTP Server.

See also:
The data model and procedures for evaluating whether a user is authorized to perform a given action are defined in RFC 8341.

**Warning:** TNSR Does not provide protection against changing the rules in such a way that causes a loss of access. Should a lockout situation occur, see *Regaining Access if Locked Out by NACM*.

### 22.1 NACM Example

The example configuration in this section is the same default configuration shipped on TNSR version 18.08 mentioned in *NACM Defaults*.

**Warning:** In the following example, NACM is disabled first and activated at the end of the configuration. This avoids locking out the user when they are in the middle of creating the configuration, in case they unintentionally exit or commit before finishing.

```
tnsr(config)# nacm disable
ntsr(config)# nacm exec-default deny
ntsr(config)# nacm read-default deny
ntsr(config)# nacm write-default deny
ntsr(config)# nacm group admin
ntsr(config-nacm-group)# member root
ntsr(config-nacm-group)# member tnsr
ntsr(config-nacm-group)# exit
ntsr(config)# nacm rule-list admin-rules
ntsr(config-nacm-rule-list)# group admin
ntsr(config-nacm-rule-list)# rule permit-all
ntsr(config-nacm-rule)# module *
ntsr(config-nacm-rule)# access-operations *
ntsr(config-nacm-rule)# action permit
```

(continues on next page)
22.2 View NACM Configuration

The current NACM configuration can be viewed with the `show nacm` command:

```
tnsr# show nacm

NACM
====
NACM Enable: true
Default Read policy : deny
Default Write policy: deny
Default Exec policy : deny

Group: admin
--------
    root
    tnsr

Rule List: admin-rules
------------
Groups: 
    admin

Name     Action Op Module Type
------- ------ -- ------ ----
permit-all permit * *
```

This may be narrowed down to only show part of the configuration.

To view all groups:

```
tnsr# show nacm group

NACM
====

Group: admin
--------
    root
    tnsr

Group: readonly
--------
    olly
    reed
```

To view a specific group, use `show nacm group <group-name>`:
To view all rule lists:

```
 tnsr# show nacm rule-list

 NACM
 ===
 Rule List: admin-rules
  ----------------------
  Groups:
   admin

  Name  Action  Op  Module  Type
  -------  ----- ---- ------ ----
  permit-all  permit * *

 Rule List: ro-rules
  ----------------------
  Groups:

  Name  Action  Op  Module  Type
  -------  ----- ---- ------ ----
  ro  permit  exec *
  read  deny * *
```

To view a specific rule list, use `show nacm rule-list <list-name>`:

```
 tnsr# show nacm rule-list admin-rules

 NACM
 ===
 Rule List: admin-rules
  ----------------------
  Groups:
   admin

  Name  Action  Module  Type
  -------  ------ ---- ----
  permit-all  permit * *
```

### 22.3 Enable or Disable NACM

**Warning:** Do not enable NACM unless the rules and groups are correctly and completely configured, otherwise access to TNSR may be cut off. If access is lost, see *Regaining Access if Locked Out by NACM*.
To enable NACM:

```
tnsr(config)# nacm enable
```

To disable NACM:

```
tnsr(config)# nacm disable
```

### 22.4 NACM Default Policy Actions

Alter the default policy for executing commands:

```
tnsr(config)# nacm exec-default <deny|permit>
```

Alter the default policy for reading status output:

```
tnsr(config)# nacm read-default <deny|permit>
```

Alter the default policy for writing configuration changes:

```
tnsr(config)# nacm write-default <deny|permit>
```

### 22.5 NACM Username Mapping

NACM does not authenticate users itself, but it does need to know the username to determine group membership. The method of authentication determines the username as seen by NACM. For example, users authenticated by username and password (e.g. PAM auth for RESTCONF or the CLI) will have that same username in TNSR.

**See also:**

For more information on how users are authenticated, see *User Management* for CLI access and *HTTP Server* for access via RESTCONF.

CLI users can check their TNSR username with the `whoami` command.

NACM obeys the following rules to determine a username:

- **SSH Password** NACM username is the same as the login username
- **SSH User Key** NACM username is the same as the login username
- **HTTP Server Password** NACM username is the same as the login username
- **HTTP Server Client Certificate** NACM username is the Common Name of the user certificate (`cn=` subject component)

### 22.6 NACM Groups

To create a group, use the `nacm group <group-name>` command:

```
tnsr(config)# nacm group admin
```
This changes to the config-nacm-group mode where group members can be defined using the member <username> command:

```bash
tnsr(config-nacm-group)# member root
tnsr(config-nacm-group)# member tnsr
```

The username in this context is the mapped username described in *NACM Username Mapping*.

**Warning:** Host operating system users that were created manually and not managed through TNSR cannot be used as group members. See *User Management* for information on managing users in TNSR.

To remove a member, use the `no` form of the command:

```bash
tnsr(config)# nacm group admin
tnsr(config-nacm-group)# no member tnsr
```

To remove a group, use `no nacm group <group-name>`:

```bash
tnsr(config)# no nacm group admin
```

### 22.7 NACM Rule Lists

NACM rules are contained inside a rule list. A rule list may contain multiple rules, and they are used in the order they are entered. Rule lists are also checked in the order they were created. Consider the order of lists and rules carefully when crafting rule lists.

Create a rule list:

```bash
tnsr(config)# nacm rule-list ro-rules
```

Set the group to which the rule list applies, use `group <group-name>`:

```bash
tnsr(config-nacm-rule-list)# group readonly
```

See also:

For information on defining groups, see *NACM Username Mapping*.

### 22.8 NACM Rules

When configuring a rule list (config-nacm-rule-list mode), the `rule <name>` command defines a new rule:

```bash
tnsr(config-nacm-rule-list)# rule permit-all
```

After entering this command, the CLI will be in config-nacm-rule mode.

From here, a variety of behaviors for the rule can be set, including:

- `access-operations <name>` The type of operation matched by this rule. Allowed values include:
  - `*` Match all operations
  - `create` Any protocol operation that creates a new data node.
**delete** Any protocol operation that removes a data node.

**exec** Execution access to the specified protocol operation.

**read** Any protocol operation or notification that returns the value of a data node.

**update** Any protocol operation that alters an existing data node.

**action** `<deny|permit>` The action to take when this rule is matched, either `deny` to deny access or `permit` to allow access.

**comment** `<text>` Arbitrary text describing the purpose of this rule.

Next, the following types can be used to specify the restriction to be enacted by this rule:

**module** `<*>` The name of the Yang module covered by this rule, for example `netgate-nat`.

The complete list of modules can be viewed in the CLI by entering `module ?` from this mode. The REST API documentation also contains a list of modules.

**path** `<path-name>` XML path to restrict with this rule.

**rpc** `<rpc-name>` The name of an RPC call to be restricted by this rule, such as `edit-config`, `get-config`, and so on.

### 22.8.1 NACM Rule Examples

As shown in **NACM Example**, the following set of commands defines a rule list and then creates a rule to permit access to everything in TNSR:

```
*tnsr(config)# nacm rule-list admin-rules
*tnsr(config-nacm-rule-list)# group admin
*tnsr(config-nacm-rule-list)# rule permit-all
*tnsr(config-nacm-rule)# module *
*tnsr(config-nacm-rule)# access-operations *
*tnsr(config-nacm-rule)# action permit
*tnsr(config-nacm-rule)# exit
*tnsr(config-nacm-rule-list)# exit
```

Using the available `module` and `access-operation`, rules are possible that limit in more fine-grained ways.

This next example will allow a user in the **limited** group to see information from commands like `show`, but not make changes to the configuration:

```
*tnsr(config)# nacm rule-list limited-rules
*tnsr(config-nacm-rule-list)# group limited
*tnsr(config-nacm-rule-list)# rule read-only
*tnsr(config-nacm-rule)# module *
*tnsr(config-nacm-rule)# access-operations read
*tnsr(config-nacm-rule)# access-operations exec
*tnsr(config-nacm-rule)# action permit
*tnsr(config-nacm-rule)# exit
*tnsr(config-nacm-rule-list)# exit
```

Selective restrictions are also possible with rules that limit access to specific modules while allowing access to everything else. In this example, users in the **limited** group may access any module except for NTP:

```
*tnsr(config)# nacm rule-list limited-rules
*tnsr(config-nacm-rule-list)# group limited
*tnsr(config-nacm-rule-list)# rule no-ntp
```

(continues on next page)
22.9 NACM Rule Processing Order

When consulting defined rule lists, NACM acts in the following manner:

- If NACM is disabled, it skips all checks, otherwise it proceeds
- NACM consults group lists to find which groups contain this user
- NACM checks each rule list in the order they are defined
- NACM checks the group membership for each of these rule lists
- NACM compares the group defined on the rule list to the groups for this user, and if there is a match, it checks rules in the list
- NACM checks the rules in the order they are defined inside the rule list
- NACM compares the current access operation to the rule and if it matches, the rest of the rule is tested
- NACM attempts to match the following criteria, if defined on the rule:
  - The module on the rule name must match the requested module or *.
  - The rpc-name matches the RPC call in the request
  - The path matches the XML path to the requested data
- If the rule is matched, NACM consults the action on the rule and acts as indicated, either permitting or denying access
- NACM repeats these checks until there are no more rules, and then no more rule lists
- If no rules matched, NACM consults the default policies for the attempted operation and takes the indicated action

22.10 Regaining Access if Locked Out by NACM

If the NACM configuration prevents an administrator from accessing TNSR in a required way, NACM can be disabled or its configuration removed to regain access.

22.10.1 Method 1: Temporarily Disable NACM

With a complicated NACM configuration, the easiest way to regain access is to disable NACM, fix the configuration, and then enable it again. This involves disabling NACM in /etc/tnsr.xml, which is copied from one of the
following locations, depending on which services are stopped/started: /etc/tnsr/tnsr-none.xml, /etc/tnsr/tnsr-running.xml, and /etc/tnsr/tnsr-startup.xml. The best practice is to edit all three files.

- Stop TNSR
- Edit /etc/tnsr/tnsr-startup.xml
- Locate the line with CLICON_NACM_MODE and change it to:
  
  `<CLICON_NACM_MODE>disabled</CLICON_NACM_MODE>`

- Repeat the edit in /etc/tnsr/tnsr-none.xml and /etc/tnsr/tnsr-running.xml
- Restart TNSR
- Use the TNSR CLI to fix the broken NACM rules
- Save the new configuration
- Stop TNSR
- Edit /etc/tnsr/tnsr-startup.xml
- Locate the line with CLICON_NACM_MODE and change it to:
  
  `<CLICON_NACM_MODE>internal</CLICON_NACM_MODE>`

- Repeat the edit in /etc/tnsr/tnsr-none.xml and /etc/tnsr/tnsr-running.xml
- Restart TNSR

TNSR will start with the new, fixed, NACM configuration. If access is still not working properly, repeat the process making changes to NACM until it is, or proceed to the next method to start over.

### 22.10.2 Method 2: Remove NACM Configuration

- Stop TNSR
- Edit /var/tnsr/startup_db
- Remove the entire `<nacm>...</nacm>` section from startup_db
- Start TNSR

TNSR will restart without any NACM configuration and it can then be reconfigured from scratch as shown in NACM Example.

### 22.11 NACM Defaults

TNSR version 18.08 or later includes a default set of NACM rules. These rules allow members of group admin to have unlimited access and sets the default policies to deny. This configuration includes the users tnsr and root in the group admin.

See also:

To see the specific rules from the default configuration, see NACM Example or view the current NACM configuration as described in View NACM Configuration.

For users of older installations or those who have removed the default NACM configuration, NACM defaults to disabled with no defined groups or rule lists, and with the following default policies:
<table>
<thead>
<tr>
<th>Policy</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Read policy</td>
<td>permit</td>
</tr>
<tr>
<td>Default Write policy</td>
<td>deny</td>
</tr>
<tr>
<td>Default Exec policy</td>
<td>permit</td>
</tr>
</tbody>
</table>
TNSR includes an HTTP server, currently powered by nginx. This HTTP server provides clients with access to the RESTCONF API, and there are plans to extend it to provide other services in the future.

### 23.1 HTTP Server Configuration

The server is configured using the `http server` command to enter http mode:

```
 tnsh# configure
 tnsh(config)# http server
 tnsh(config-http)#
```

The server can be disabled with the following command:

```
 tnsh(config)# no http server
```

#### 23.1.1 Managing the HTTP Server Process

The HTTP server process can be managed using the `service` command:

```
 tnsh# configure
 tnsh(config)# service http <command>
```

Where `<command>` can be any of:

- **start**: Start the HTTP server
- **stop**: Stop the HTTP server
- **restart**: Restart (stop and then start) the HTTP server
- **status**: Print the status of the HTTP server process

### 23.2 HTTPS Encryption

The HTTP server can optionally utilize TLS (HTTPS) to secure communications between the client and server.

**Warning**: Though HTTPS is optional, we strongly recommend its use for optimal security.
HTTPS requires a server certificate present on the TNSR device, and this server certificate must be configured in the HTTP server:

```
 tnsr(config)# http server
 tnsr(config-http)# server certificate <cert-name>
```

See also:
For more information on managing certificates on TNSR, see Public Key Infrastructure.

## 23.3 Authentication

The HTTP server supports three types of client authentication to protect access to its resources: Client certificate authentication, password authentication, and none (no authentication):

```
 tnsr(config-http)# authentication type (client-certificate|password|none)
```

### 23.3.1 Client Certificate

The most secure means of protecting access to the HTTP server is via client certificates:

```
 tnsr(config-http)# authentication type client-certificate
 tnsr(config-http)# authentication client-certificate-ca <cert-name>
```

To verify client certificates, a Certificate Authority (CA) is configured in TNSR and all client certificates must be signed by this CA. The client certificate must be used by the client when attempting to connect to the HTTP server. Clients without a certificate are rejected.

See also:
For more information on managing certificates on TNSR, see Public Key Infrastructure.

When using client certificates the Common Name (cn= parameter) of the client certificate is taken as the username. That username is then processed through NACM to determine group access privileges for the RESTCONF API.

### 23.3.2 Password

Password authentication for the HTTP server is handled via Pluggable Authentication Modules (PAM) support:

```
 tnsr(config-http)# authentication type password
```

Users can be authenticated against any source supported by PAM modules in the operating system.

Once authenticated, the username is processed through NACM to determine group access privileges for the RESTCONF API.

### 23.3.3 None

The least secure option is to disable authentication entirely:

```
 tnsr(config-http)# authentication type none
```
Warning: This option must only be used for testing and never in a production environment.
This removes all security protecting the RESTCONF API. Without authentication, any client can send requests or make changes using the API, which is extremely dangerous.

23.4 RESTCONF Server

The primary service provided by the HTTP server is the API Endpoints which uses RESTCONF. This RESTCONF service can be enabled and disabled as needed within the HTTP server configuration.

To enable access to the RESTCONF API:

```
tnsr(config-http)# enable restconf
```

To disable access to the RESTCONF API:

```
tnsr(config-http)# disable restconf
```
TNSR CONFIGURATION EXAMPLE RECIPES

This section is a cookbook full of example recipes which can be used to quickly configure TNSR in a variety of ways. The use cases covered by these recipes are real-world problems encountered by Netgate customers.

These example scenarios pull together concepts discussed in more detail throughout the rest of this documentation to accomplish larger goals.

### 24.1 RESTCONF Service Setup with Certificate-Based Authentication and NACM

#### Covered Topics
- Use Case
- Example Scenario
- TNSR Setup
- Client Configuration
- Example Usage
- Adding More Users

#### 24.1.1 Use Case

RESTCONF is desirable for its ability to implement changes to TNSR remotely using the API, but allowing remote changes to TNSR also raises security concerns. When using RESTCONF, security is extremely important to protect the integrity of the router against unauthorized changes.

**Note:** RESTCONF deals in JSON output and input, which is easily parsed by a variety of existing libraries for programming and scripting languages.

#### 24.1.2 Example Scenario

In this example, TNSR will be configured to allow access via RESTCONF, but the service will be protected in several key ways:
• The RESTCONF service is configured for TLS to encrypt the transport
• The RESTCONF service is configured to require a client certificate, which is validated against a private Certificate Authority known to TNSR
• NACM determines if the certificate common-name (username) is allowed access to view or make changes via RESTCONF

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNSR Hostname</td>
<td>tnsr.example.com</td>
</tr>
<tr>
<td>RESTCONF Username</td>
<td>myuser</td>
</tr>
<tr>
<td>NACM Group Name</td>
<td>admins</td>
</tr>
<tr>
<td>Additional User</td>
<td>anotheruser</td>
</tr>
</tbody>
</table>

24.1.3 TNSR Setup

Generate Certificates

Create a self-signed Certificate Authority:

```
  tnsr(config)# pki private-key selfca generate
  tnsr(config)# pki signing-request set common-name selfca
  tnsr(config)# pki signing-request set digest sha256
  tnsr(config)# pki signing-request selfca generate
  tnsr(config)# pki signing-request selfca sign self enable-ca true
```

Create a certificate for the user myuser, signed by selfca:

```
  tnsr(config)# pki private-key myuser generate key-length 4096
  tnsr(config)# pki signing-request set common-name myuser
  tnsr(config)# pki signing-request set digest sha256
  tnsr(config)# pki signing-request myuser generate
  tnsr(config)# pki signing-request myuser sign ca-name selfca days-valid 365 digest sha512 enable-ca false
```

Create a certificate for the RESTCONF service to use. The common-name should be the hostname of the TNSR router, which should also exist in DNS:

```
  tnsr(config)# pki private-key restconf generate key-length 4096
  tnsr(config)# pki signing-request set common-name tnsr.example.com
  tnsr(config)# pki signing-request set digest sha256
  tnsr(config)# pki signing-request restconf generate
  tnsr(config)# pki signing-request restconf sign ca-name selfca days-valid 365 digest sha512 enable-ca false
```

Setup NACM

Disable NACM while making changes, to avoid locking out the account making the changes:

```
  tnsr(config)# nacm disable
```

Set default policies:
tnsr(config)# nacm exec-default deny
tnsr(config)# nacm read-default deny
tnsr(config)# nacm write-default deny

Setup an admin group containing the default users plus myuser, which will match the common-name of the user certificate created above:

tnsr(config)# nacm group admin
tnsr(config-nacm-group)# member root
tnsr(config-nacm-group)# member tnsr
tnsr(config-nacm-group)# member myuser
tnsr(config-nacm-group)# exit

Setup rules to permit any action by members of the admin group:

tnsr(config)# nacm rule-list admin-rules
tnsr(config-nacm-rule-list)# group admin
tnsr(config-nacm-rule-list)# rule permit-all
tnsr(config-nacm-rule)# module *
tnsr(config-nacm-rule)# access-operations *
tnsr(config-nacm-rule)# action permit
tnsr(config-nacm-rule)# exit
tnsr(config-nacm-rule-list)# exit

Enable NACM:

tnsr(config)# nacm enable
tnsr(config)# exit

Enable RESTCONF

Enable RESTCONF and configure it for TLS and client certificate authentication:

tnsr(config)# http server
tnsr(config-http)# server certificate restconf
tnsr(config-http)# authentication type client-certificate
tnsr(config-http)# authentication client-certificate-ca selfca
tnsr(config-http)# enable restconf

24.1.4 Client Configuration

On TNSR, export the CA certificate, user certificate, and user certificate key. Place the resulting files in a secure place on a client system, in a directory with appropriate permissions, readable only by the user. Additionally, the private key file must only be readable by the user. For this example, the files will be placed in ~/tnsr/.

First, export the CA certificate. Copy and paste this into a local file, named tnsr-selfca.crt:

```
tnsr# pki ca selfca get
-----BEGIN CERTIFICATE-----
[...]
-----END CERTIFICATE-----
```

Next, export the user certificate, copy and paste it and save in a local file named tnsr-myuser.crt:
Finally, export the user certificate private key, copy and paste it and save in a local file named tnsr-myuser.key. Remember to protect this file so it is only readable by this user:

```
$ tnsr# pki private-key myuser get
-----BEGIN PRIVATE KEY-----
[...]
-----END PRIVATE KEY-----
```

This example uses `curl` to access RESTCONF, so ensure it is installed and available on the client computer.

### 24.1.5 Example Usage

This simple example shows fetching the contents of an ACL from RESTCONF as well as adding a new ACL entry. There are numerous possibilities here, for more details see the REST API documentation.

In this example, there is an existing ACL named `blockbadhosts`. It contains several entries including a default allow rule with a sequence number of 5000.

These examples are all run from the client configured above.

**Note:** This is a simple demonstration using `cURL` and shell commands. This makes it easy to demonstrate how the service works, and how RESTCONF URLs are formed, but does not make for a good practical example.

In real-world cases these types of queries would be handled by a program or script that interacts with RESTCONF, manipulating data directly and a lot of the details will be handled by RESTCONF and JSON programming libraries.

#### Retrive a specific ACL

Retrieve the entire contents of the `blockbadhosts` ACL:

**Command:**

```bash
$ curl --cert ~/tnsr/tnsr-myuser.crt \
   --key ~/tnsr/tnsr-myuser.key \
   --cacert ~/tnsr/tnsr-selfca.crt \
   -X GET \
   https://tnsr.example.com/restconf/data/netgate-acl:acl-config/acl-table/acl-list=blockbadhosts
```

**Output:**

```
{
   "acl-list": [ 
   {
      "acl-name": "blockbadhosts",
      "acl-description": "Block bad hosts",
      "acl-rules": {
         "acl-rule": [ 
        
```

(continues on next page)
"sequence": 1,
"action": "deny",
"src-ip-prefix": "203.0.113.14/32"
},
{
"sequence": 2,
"action": "deny",
"src-ip-prefix": "203.0.113.15/32"
},
{
"sequence": 555,
"action": "deny",
"src-ip-prefix": "5.5.5.5/32"
},
{
"sequence": 5000,
"acl-rule-description": "Default Permit",
"action": "permit"
}
]
}
]
}
]

The cURL parameters and RESTCONF URL can be dissected as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>cURL Client Certificate</td>
<td>--cert ~/tnsr/tnsr-myuser.crt</td>
</tr>
<tr>
<td>cURL Client Certificate Key</td>
<td>--key ~/tnsr/tnsr-myuser.key</td>
</tr>
<tr>
<td>cURL CA Cert to validate TLS</td>
<td>--cacert ~/tnsr/tnsr-selfca.crt</td>
</tr>
<tr>
<td>Request type (GET)</td>
<td>-X GET</td>
</tr>
<tr>
<td>RESTCONF Server protocol/host</td>
<td><a href="https://tnsr.example.com">https://tnsr.example.com</a></td>
</tr>
<tr>
<td>RESTCONF API location</td>
<td>/restconf/data/</td>
</tr>
<tr>
<td>ACL config area (prefix:name)</td>
<td>netgate-acl:acl-config/</td>
</tr>
<tr>
<td>ACL table</td>
<td>acl-table/</td>
</tr>
<tr>
<td>ACL List, with restriction</td>
<td>acl-list=blockbadhosts</td>
</tr>
</tbody>
</table>

**Note:** Lists of items with a unique key can be restricted as shown above. The API documentation also calls this out as well, showing an optional `={(name)}` in the query.

**Retrieve a specific rule of a specific ACL**

View only the default permit rule of the ACL:

Command:

```bash
$ curl --cert ~/tnsr/tnsr-myuser.crt \
  --key ~/tnsr/tnsr-myuser.key \
  --cacert ~/tnsr/tnsr-selfca.crt \
  -X GET \
  https://tnsr.example.com/restconf/data/netgate-acl:acl-config/acl-table/acl-˓
  →list=blockbadhosts/acl-rules/acl-rule=5000
```

(continues on next page)
Add a new rule to an existing ACL

Insert a new ACL rule entry with the following parameters:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request Type</td>
<td>-X PUT (add content)</td>
</tr>
<tr>
<td>ACL Name</td>
<td>blockbadhosts</td>
</tr>
<tr>
<td>ACL Rule Sequence</td>
<td>10</td>
</tr>
<tr>
<td>ACL Rule Action</td>
<td>deny</td>
</tr>
<tr>
<td>ACL Rule Source Address</td>
<td>10.222.111.222/32</td>
</tr>
</tbody>
</table>

The new data passed in the `-d` parameter is JSON but with all whitespace removed so it can be more easily expressed on a command line.

The URL is the same as if the query is retrieving the rule in question.

**Warning:** Note the presence of the sequence number in both the supplied JSON data and in the URL. This must match.

Command:

```
$ curl --cert ~/tnsr/tnsr-myuser.crt \
   --key ~/tnsr/tnsr-myuser.key \
   --cacert ~/tnsr/tnsr-selfca.crt \ 
   -X PUT \ 
   -d '{"netgate-acl:acl-rule":[{"sequence": 10,"action":"deny","src-ip-prefix":"10.222.111.222/32"}]}' \ 
```

Output: This command has no output when it works successfully.

Retrieving the contents of the ACL again to see that the new rule is now present:
Command:

```bash
$ curl --cert ~/tnsr/tnsr-myuser.crt \
--key ~/tnsr/tnsr-myuser.key \
--cacert ~/tnsr/tnsr-selfca.crt \
-X GET \
https://tnsr.example.com/restconf/data/netgate-acl:acl-config/acl-table/acl-list=blockbadhosts
```

Output:

```json
{
   "netgate-acl:acl-list": [
      {
         "acl-name": "blockbadhosts",
         "acl-description": "Block bad hosts",
         "acl-rules": [
            {
               "sequence": 1,
               "action": "deny",
               "src-ip-prefix": "203.0.113.14/32"
            },
            {
               "sequence": 2,
               "action": "deny",
               "src-ip-prefix": "203.0.113.15/32"
            },
            {
               "sequence": 10,
               "action": "deny",
               "src-ip-prefix": "10.222.111.222/32"
            },
            {
               "sequence": 555,
               "action": "deny",
               "src-ip-prefix": "5.5.5.5/32"
            },
            {
               "sequence": 5000,
               "acl-rule-description": "Default Permit",
               "action": "permit"
            }
         ]
      }
   ]
}
```

Remove a specific rule from an ACL

Say that entry is no longer needed and it is safe to remove. That can be done with a DELETE request for the URL corresponding to its sequence number:

Command:
Output: This does not produce any output if it completed successfully.
Retrieve the contents of the ACL again to confirm it was removed.

### 24.1.6 Adding More Users

To create additional RESTCONF users, only two actions are required on TNSR: Generate a certificate for the new user, and then add the user to NACM. This example adds a new user named anotheruser.

Generate a new user certificate:

```
> tnsr(config)# pki private-key anotheruser generate key-length 4096
> tnsr(config)# pki signing-request set common-name anotheruser
> tnsr(config)# pki signing-request set digest sha256
> tnsr(config)# pki signing-request anotheruser generate
> tnsr(config)# pki signing-request anotheruser sign ca-name selfca days-valid 365
>   --digest sha512 enable-ca false
```

Add this user to the NACM admin group:

```
> tnsr(config)# nacm group admin
> tnsr(config-nacm-group)# member anotheruser
> tnsr(config-nacm-group)# exit
```

Then, the user certificate can be copied to a new client and used as explained previously.

### 24.2 TNSR IPsec Hub for pfSense

Current scenario:
HQ (hub) with 3 branch (spoke) sites, with secure interconnection between their local networks. One of the branch routers is assumed to be BGP capable. Internet access for one of the sites should be provided through the hub node.

**Covered Topics**

- **Input Data**
  - Scenario Topology
  - TNSR and Peer Network Configuration
  - TNSR and Peer IPsec Configuration
- **Setup Details**
  - Initial setup
  - TNSR Setup
24.2.1 Input Data

The information in this section defines the local configuration which is covered in this recipe. These input values can be substituted by the actual corresponding values for a real-world implementation.

Scenario Topology

![Scenario Topology Diagram]

Fig. 1: TNSR IPsec Hub
TNSR and Peer Network Configuration

Table 1: TNSR Setup

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN Interface</td>
<td>GigabitEthernetb/0/0</td>
</tr>
<tr>
<td>LAN Network</td>
<td>192.168.0.0/24</td>
</tr>
<tr>
<td>LAN IP Address static</td>
<td>192.168.0.1/24</td>
</tr>
<tr>
<td>WAN Interface</td>
<td>GigabitEthernet13/0/0</td>
</tr>
<tr>
<td>WAN IP Address DHCP</td>
<td>10.129.0.10/24</td>
</tr>
<tr>
<td>IPSec VTI Peer 1 IP Address</td>
<td>10.131.1.1/30</td>
</tr>
<tr>
<td>IPSec VTI Peer 2 IP Address</td>
<td>10.131.2.1/30</td>
</tr>
<tr>
<td>IPSec VTI Peer 3 IP Address</td>
<td>10.131.3.1/30</td>
</tr>
</tbody>
</table>

Table 2: Peer 1 Network Setup

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN Interface</td>
<td>LAN</td>
</tr>
<tr>
<td>LAN Network</td>
<td>192.168.1.0/24</td>
</tr>
<tr>
<td>LAN IP Address static</td>
<td>192.168.1.1/24</td>
</tr>
<tr>
<td>WAN Interface</td>
<td>WAN</td>
</tr>
<tr>
<td>WAN IP Address DHCP</td>
<td>10.129.0.11/24</td>
</tr>
<tr>
<td>IPSec VTI TNSR IP Address</td>
<td>10.131.1.2/30</td>
</tr>
</tbody>
</table>

Table 3: Peer 2 Network Setup

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN Interface</td>
<td>LAN</td>
</tr>
<tr>
<td>LAN Network</td>
<td>192.168.2.0/24</td>
</tr>
<tr>
<td>LAN IP Address static</td>
<td>192.168.2.1/24</td>
</tr>
<tr>
<td>WAN Interface</td>
<td>WAN</td>
</tr>
<tr>
<td>WAN IP Address DHCP</td>
<td>10.129.0.12/24</td>
</tr>
<tr>
<td>IPSec VTI TNSR IP Address</td>
<td>10.131.2.2/30</td>
</tr>
</tbody>
</table>

Table 4: Peer 3 Network Setup

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN Interface</td>
<td>LAN</td>
</tr>
<tr>
<td>LAN Network</td>
<td>192.168.3.0/24</td>
</tr>
<tr>
<td>LAN IP Address static</td>
<td>192.168.3.1/24</td>
</tr>
<tr>
<td>WAN Interface</td>
<td>WAN</td>
</tr>
<tr>
<td>WAN IP Address DHCP</td>
<td>10.129.0.13/24</td>
</tr>
<tr>
<td>IPSec VTI TNSR IP Address</td>
<td>10.131.3.2/30</td>
</tr>
</tbody>
</table>

TNSR and Peer IPsec Configuration

General IPsec settings are the same for every node.
### 24.2.2 Setup Details

#### Initial setup

It is assumed that devices have generic default setup, do not have any existing configuration errors, and are ready to be configured.

**Note:** In this scenario every device obtains its own static IP address on its WAN interface from an external lab gateway which is not a part of the considered scenario.

#### TNSR Setup

#### LAN settings

Setup LAN interface with static IP address:

```
tnsr tnsr# configure
tnsr tnsr(config)# interface GigabitEthernetb/0/0
tnsr tnsr(config-interface)# description LAN
tnsr tnsr(config-interface)# ip address 192.168.0.1/24
tnsr tnsr(config-interface)# enable
tnsr tnsr(config-interface)# exit
tnsr tnsr(config)# exit
```
WAN settings

Setup WAN interface for obtaining IP address via DHCP:

```
  tnsr tnsr# configure
  tnsr tnsr(config)# interface GigabitEthernet13/0/0
  tnsr tnsr(config-interface)# description WAN
  tnsr tnsr(config-interface)# dhcp client ipv4 hostname tnsr
  tnsr tnsr(config-interface)# enable
  tnsr tnsr(config-interface)# exit
  tnsr tnsr(config)# exit
```

DHCP server

Setup DHCP server on LAN interface with following settings:

```
<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHCP IP address pool</td>
<td>192.168.0.100 to 192.168.0.199</td>
</tr>
<tr>
<td>Default gateway</td>
<td>TNSR LAN IP address</td>
</tr>
<tr>
<td>DNS</td>
<td>8.8.8.8 and 1.1.1.1</td>
</tr>
</tbody>
</table>
```

```
  tnsr tnsr# configure
  tnsr tnsr(config)# dhcp4 server
  tnsr tnsr(config-kea-dhcp4)# description LAN DHCP
  tnsr tnsr(config-kea-dhcp4)# interface listen GigabitEthernetb/0/0
  tnsr tnsr(config-kea-dhcp4)# subnet 192.168.0.0/24
  tnsr tnsr(config-kea-subnet4)# interface GigabitEthernetb/0/0
  tnsr tnsr(config-kea-subnet4)# pool 192.168.0.100-192.168.0.199
  tnsr tnsr(config-kea-subnet4-pool)# exit
  tnsr tnsr(config-kea-subnet4)# option routers
  tnsr tnsr(config-kea-subnet4-opt)# data 192.168.0.1
  tnsr tnsr(config-kea-subnet4-opt)# exit
  tnsr tnsr(config-kea-subnet4)# option domain-name-servers
  tnsr tnsr(config-kea-subnet4-opt)# data 8.8.8.8, 1.1.1.1
  tnsr tnsr(config-kea-subnet4-opt)# exit
  tnsr tnsr(config-kea-subnet4)# exit
  tnsr tnsr(config-kea-dhcp4)# exit
  tnsr tnsr(config)# dhcp4 enable
  tnsr tnsr(config)# exit
```

NAT

```
  tnsr tnsr# configure
  tnsr tnsr(config)# nat global-options nat44 forwarding true
  tnsr tnsr(config)# nat pool interface GigabitEthernet13/0/0
  tnsr tnsr(config)# interface GigabitEthernetb/0/0
  tnsr tnsr(config-interface)# ip nat inside
  tnsr tnsr(config-interface)# exit
  tnsr tnsr(config)# interface GigabitEthernet13/0/0
  tnsr tnsr(config-interface)# ip nat outside
```

(continues on next page)
**Peer 1 Basic Setup**

**LAN settings**

Setup LAN interface with static IP address.

- Navigate to **Interfaces > LAN**
- Set **IPv4 Configuration Type** to *Static IPv4*
- Set **IPv4 Address** to `192.168.1.1` and mask as `24`
- Click **Save**
- Click **Apply Changes**

**WAN settings**

Setup WAN interface for obtaining an IP address via DHCP. This could also be a static setup, following a similar form to the LAN settings above.

- Navigate to **Interfaces > WAN**
- Set **IPv4 Configuration Type** to *DHCP*
- Click **Save**
- Click **Apply Changes**

**DHCP server**

Setup DHCP server on LAN interface with following settings:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHCP IP address pool</td>
<td><code>192.168.1.100</code> to <code>192.168.1.199</code></td>
</tr>
<tr>
<td>Default gateway</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
<tr>
<td>DNS</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
</tbody>
</table>

- Navigate to **Services > DHCP Server**, **LAN** tab
- Set **Range From** as `192.168.1.100` and **To** as `192.168.1.199`
- Click **Save**

**Peer 2 Basic Setup**

**LAN settings**

Setup LAN interface with static IP address.
• Navigate to Interfaces > LAN
• Set IPv4 Configuration Type to Static IPv4
• Set IPv4 Address to 192.168.2.1 and mask as 24
• Click Save
• Click Apply Changes

**WAN settings**

Setup WAN interface for obtaining an IP address via DHCP. This could also be a static setup, following a similar form to the LAN settings above.

• Navigate to Interfaces > WAN
• Set IPv4 Configuration Type to DHCP
• Click Save
• Click Apply Changes

**DHCP server**

Setup DHCP server on LAN interface with following settings:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHCP IP address pool</td>
<td>192.168.2.100 to 192.168.2.199</td>
</tr>
<tr>
<td>Default gateway</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
<tr>
<td>DNS</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
</tbody>
</table>

• Navigate to Services > DHCP Server, LAN tab
• Set Range From as 192.168.2.100 and To as 192.168.2.199
• Click Save

**Peer 3 Basic Setup**

**LAN settings**

Setup LAN interface with static IP address.

• Navigate to Interfaces > LAN
• Set IPv4 Configuration Type to Static IPv4
• Set IPv4 Address to 192.168.3.1 and mask as 24
• Click Save
• Click Apply Changes
**WAN settings**

Setup WAN interface for obtaining an IP address via DHCP. This could also be a static setup, following a similar form to the LAN settings above.

- Navigate to Interfaces > WAN
- Set IPv4 Configuration Type to DHCP
- Click Save
- Click Apply Changes

**DHCP server**

Setup DHCP server on LAN interface with following settings:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHCP IP address pool</td>
<td>192.168.3.100 to 192.168.3.199</td>
</tr>
<tr>
<td>Default gateway</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
<tr>
<td>DNS</td>
<td>LAN IP address (pfSense Default)</td>
</tr>
</tbody>
</table>

- Navigate to Services > DHCP Server, LAN tab
- Set Range From as 192.168.3.100 and To as 192.168.3.199
- Click Save

**24.2.3 Access between local and remote networks via IPsec**

This section describes minimal IPsec and routing settings in order to obtain secure interconnectivity between LAN networks for every device.

This document assumes that devices have generic initial setup successfully completed and are able to reach each other via WAN network.

**TNSR**

**IPsec Configuration**

IPsec setup for each pfSense node

**IPsec to Peer 1**

Enter config state:

```
<tnsr> tnsr# configure
```

Creating IPsec instance with id 1:
tnsr tnsr(config)# ipsec tunnel 1
tnsr tnsr(config-ipsec-tunnel)# local-address 10.129.0.10
tnsr tnsr(config-ipsec-tunnel)# remote-address 10.129.0.11

P1 encryption settings:

```
tnsr tnsr(config-ipsec-tunnel)# crypto ike
tnsr tnsr(config-ipsec-crypto-ike)# version 2
tnsr tnsr(config-ipsec-crypto-ike)# lifetime 28800
tnsr tnsr(config-ipsec-crypto-ike)# proposal 1
tnsr tnsr(config-ike-proposal)# encryption aes128
tnsr tnsr(config-ike-proposal)# integrity sha1
tnsr tnsr(config-ike-proposal)# group modp2048
tnsr tnsr(config-ike-proposal)# exit
```

Creating peer IDs:

```
tnsr tnsr(config-ipsec-crypto-ike)# identity local
  tnsr tnsr(config-ike-identity)# type address
  tnsr tnsr(config-ike-identity)# value 10.129.0.10
  tnsr tnsr(config-ike-identity)# exit

tnsr tnsr(config-ipsec-crypto-ike)# identity remote
  tnsr tnsr(config-ike-identity)# type address
  tnsr tnsr(config-ike-identity)# value 10.129.0.11
  tnsr tnsr(config-ike-identity)# exit
```

Authentication:

```
tnsr tnsr(config-ipsec-crypto-ike)# authentication local
  tnsr tnsr(config-ike-authentication)# round 1
  tnsr tnsr(config-ike-authentication-round)# type psk
  tnsr tnsr(config-ike-authentication-round)# psk 01234567
  tnsr tnsr(config-ike-authentication-round)# exit
  tnsr tnsr(config-ike-authentication)# exit

tnsr tnsr(config-ipsec-crypto-ike)# authentication remote
  tnsr tnsr(config-ike-authentication)# round 1
  tnsr tnsr(config-ike-authentication-round)# type psk
  tnsr tnsr(config-ike-authentication-round)# psk 01234567
  tnsr tnsr(config-ike-authentication-round)# exit
  tnsr tnsr(config-ike-authentication)# exit
```

P2 settings:

```
tnsr tnsr(config-ipsec-crypto-ike)# child 1
  tnsr tnsr(config-ike-child)# lifetime 3600
  tnsr tnsr(config-ike-child)# proposal 1
  tnsr tnsr(config-ike-child-proposal)# encryption aes128
  tnsr tnsr(config-ike-child-proposal)# integrity sha1
  tnsr tnsr(config-ike-child-proposal)# group modp2048
  tnsr tnsr(config-ike-child-proposal)# exit
  tnsr tnsr(config-ike-child)# exit
  tnsr tnsr(config-ipsec-crypto-ike)# exit
```

Configuring tunnel interface
IPsec to Peer 2

Enter config state:

```
tnsr tnsr# configure
```

Creating IPsec instance with id 2:

```
tnsr tnsr(config)# ipsec tunnel 1
   tnsr tnsr(config-ipsec-tunnel)# local-address 10.129.0.10
   tnsr tnsr(config-ipsec-tunnel)# remote-address 10.129.0.12
   tnsr tnsr(config-ipsec-tunnel)# crypto config-type ike
```

P1 encryption settings:

```
tnsr tnsr(config-ipsec-tunnel)# crypto ike
   tnsr tnsr(config-ipsec-crypto-ike)# version 2
   tnsr tnsr(config-ipsec-crypto-ike)# lifetime 28800
   tnsr tnsr(config-ipsec-crypto-ike)# proposal 1
   tnsr tnsr(config-ike-proposal)# encryption aes128
   tnsr tnsr(config-ike-proposal)# integrity sha1
   tnsr tnsr(config-ike-proposal)# group modp2048
   tnsr tnsr(config-ike-proposal)# exit
```

Creating peer ID’s:

```
tnsr tnsr(config-ipsec-crypto-ike)# identity local
   tnsr tnsr(config-ike-identity)# type address
   tnsr tnsr(config-ike-identity)# value 10.129.0.10
   tnsr tnsr(config-ike-identity)# exit
   tnsr tnsr(config-ipsec-crypto-ike)# identity remote
   tnsr tnsr(config-ike-identity)# type address
   tnsr tnsr(config-ike-identity)# value 10.129.0.12
   tnsr tnsr(config-ike-identity)# exit
```

Authentication:

```
tnsr tnsr(config-ipsec-crypto-ike)# authentication local
   tnsr tnsr(config-ike-authentication)# round 1
   tnsr tnsr(config-ike-authentication-round)# type psk
   tnsr tnsr(config-ike-authentication-round)# psk 01234567
   tnsr tnsr(config-ike-authentication-round)# exit
   tnsr tnsr(config-ike-authentication)# exit
   tnsr tnsr(config-ipsec-crypto-ike)# authentication remote
   tnsr tnsr(config-ike-authentication)# round 1
   tnsr tnsr(config-ike-authentication-round)# type psk
   tnsr tnsr(config-ike-authentication-round)# psk 01234567
   tnsr tnsr(config-ike-authentication-round)# exit
   tnsr tnsr(config-ike-authentication)# exit
```

P2 settings:
tnsr tnsr(config-ipsec-crypto-ike)# child 1
tnsr tnsr(config-ike-child)# lifecycle 3600
tnsr tnsr(config-ike-child)# proposal 1
tnsr tnsr(config-ike-child-proposal)# encryption aes128
tnsr tnsr(config-ike-child-proposal)# integrity sha1
tnsr tnsr(config-ike-child-proposal)# group modp2048
tnsr tnsr(config-ike-child-proposal)# exit
tnsr tnsr(config-ike-child)# exit
tnsr tnsr(config-ipsec-crypto-ike)# exit

Configuring tunnel interface:

tnsr tnsr(config)# interface ipsec2
tnsr tnsr(config-interface)# ip address 10.131.2.1/30
tnsr tnsr(config-interface)# exit
tnsr tnsr(config)# exit

IPsec to Peer 3

Enter config state:

tnsr tnsr# configure

Creating IPsec instance with id 1:

tnsr tnsr(config)# ipsec tunnel 1
tnsr tnsr(config-ipsec-tunnel)# local-address 10.129.0.10
tnsr tnsr(config-ipsec-tunnel)# remote-address 10.129.0.13
tnsr tnsr(config-ipsec-tunnel)# crypto config-type ike

P1 encryption settings:

tnsr tnsr(config-ipsec-tunnel)# crypto ike
tnsr tnsr(config-ipsec-crypto-ike)# version 2
tnsr tnsr(config-ipsec-crypto-ike)# lifecycle 28800
tnsr tnsr(config-ipsec-crypto-ike)# proposal 1
tnsr tnsr(config-ike-proposal)# encryption aes128
tnsr tnsr(config-ike-proposal)# integrity sha1
tnsr tnsr(config-ike-proposal)# group modp2048
tnsr tnsr(config-ike-proposal)# exit

Creating peer ID's:

tnsr tnsr(config-ipsec-crypto-ike)# identity local
tnsr tnsr(config-ike-identity)# type address
tnsr tnsr(config-ike-identity)# value 10.129.0.10
tnsr tnsr(config-ike-identity)# exit
tnsr tnsr(config-ipsec-crypto-ike)# identity remote
tnsr tnsr(config-ike-identity)# type address
tnsr tnsr(config-ike-identity)# value 10.129.0.13
tnsr tnsr(config-ike-identity)# exit

Authentication:
P2 settings:

Configuring tunnel interface:

Routing

This section describes routing setup. This scenario assumes one of the pfSense IPsec peers, Peer 1, uses a dynamic routing protocol (BGP) and the remaining two IPsec peers use static routing.

Peer 1 BGP Routing

Enter config state:

Defining redistributed networks, peer 2 and 3:

Setup BGP instance:
tnsr tnsr(config)# route dynamic bgp
tnsr tnsr(config-frr-bgp)# server 65000
tnsr tnsr(config-bgp)# router-id 192.168.0.1

Defining neighbor:

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config-bgp)# neighbor 10.131.1.2</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-neighbors)# remote-as 65001</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-neighbors)# enable</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-neighbors)# exit</td>
<td></td>
</tr>
</tbody>
</table>

Setup peer in certain address-family space:

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config-bgp)# address-family ipv4 unicast</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni)# neighbor 10.131.1.2</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni-nbr)# activate</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni-nbr)# exit</td>
<td></td>
</tr>
</tbody>
</table>

Defining local network in certain address-family space:

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni)# network 192.168.0.0/24</td>
<td></td>
</tr>
</tbody>
</table>

Defining redistributed networks

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni)# redistribute kernel route-map VPN-ROUTES-MAP</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp-ip4uni)# exit</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-bgp)# exit</td>
<td></td>
</tr>
</tbody>
</table>

Enabling BGP if one is not enabled:

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config-frr-bgp)# enable</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-frr-bgp)# exit</td>
<td></td>
</tr>
</tbody>
</table>

Better to restart service in order to be sure changes applied effectively:

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr(config)# service bgp restart</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config)# exit</td>
<td></td>
</tr>
</tbody>
</table>

### Peer 2 Static Routing

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr# configure</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config)# route ipv4 table ipv4-VRF:0</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-route-table-v4)# route 192.168.2.0/24</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-route-table-v4)# next-hop 0 via 10.131.2.2 ipsec3</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-route-table-v4)# exit</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config)# exit</td>
<td></td>
</tr>
</tbody>
</table>

### Peer 3 Static Routing

<table>
<thead>
<tr>
<th>Command</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr tnsr# configure</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config)# route ipv4 table ipv4-VRF:0</td>
<td></td>
</tr>
<tr>
<td>tnsr tnsr(config-route-table-v4)# route 192.168.3.0/24</td>
<td></td>
</tr>
</tbody>
</table>

(continues on next page)
Peer 1 Setup

IPsec Settings

Phase 1

- Navigate to VPN > IPsec
- Click Add P1
- Set Key Exchange version to IKEv2
- Set Internet Protocol to IPv4
- Set Interface to WAN
- Set Remote Gateway to 10.129.0.10
- Set Authentication Method to Mutual PSK
- Set My identifier to My IP address
- Set Peer identifier to Peer IP address
- Set Pre-Shared Key to 01234567
- Set Encryption:
  - Algorithm to AES
  - Key length to 128 bit
  - Hash to SHA1
  - DH Group to 14 (2048 bit)
- Set Lifetime as 28800
- Click Save

Phase 2

- On the newly created Phase 1 entry, click Show Phase 2 Entries
- Click Add P2
- Set Mode to Routed (VTI)
- Set Local Network to 10.131.2.2 and mask 30
- Set Remote Network to 10.131.2.1
- Set Protocol to ESP
- Set Encryption Algorithms to AES and 128 bit
• Uncheck all other **Encryption Algorithms** entries
• Set **Hash Algorithms** to *SHA1*
• Uncheck all other **Hash Algorithms** entries
• Set **PFS key group** to 14 (2048 bit)
• Set **Lifetime** as 3600
• Click **Save**
• Click **Apply Changes**

**Interface**

• Navigate to **Interfaces > Interface Assignments**
• From the **Available network ports** list, choose *ipsecNNNN (IPsec VTI)* (The ID number will vary)
• Click **Add**
• Note the newly created interface name, such as OPTX
• Navigate to **Interfaces > OPTX**
• Check **Enable**
• Click **Save**
• Click **Apply Changes**

**Routing**

• Navigate to **System > Package Manager** and install the FRR package
• Browse to **Services > FRR Global/Zebra**
• Check **Enable FRR**
• Set **Master Password** to any value

**Note:** This is a requirement for the zebra management daemon to run, this password is not used by clients.

• Check **Enable logging**
• Set **Router ID** to **192.168.1.1**

In this case, it is the LAN interface IP address, assuming it will be always be available for routing between LAN subnets.
• Click **Save**
• Navigate to the **[BGP]** tab
• Check **Enable BGP Routing**
• Check **Log Adjacency Changes**
• Set **Local AS** to **65001**
• Set **Router ID** to **192.168.1.1**
• Set **Networks to Distribute** to 192.168.1.0/24
• Navigate to the **Neighbors** tab
• Click **Add**
• Set **Name/Address** to 10.131.1.1 (TNSR VTI interface IP address)
• Set **Remote AS** to 65000
• Click **Save**

At this point, routes to 192.168.0.0/24, 192.168.2.0/24, and 192.168.3.0/24 will be learned by BGP and installed in the routing table. If it is not so, check **Status > FRR** on the **BGP** tab. That page contains useful BGP troubleshooting information. Additionally, check the routing log at **Status > System Logs** on the **Routing** tab under **System**.

**Firewall**

To allow connections into the local LAN from remote IPsec sites, create necessary pass rules under **Firewall > Rules** on the **IPsec** tab. These rules would have a **Source** set to the remote LAN or whichever network is the source of the traffic to allow.

For simplicity, this example has a rule to pass IPv4 traffic from any source to any destination since the only IPsec interface traffic will be from 192.168.0.0/22.

**NAT**

TNSR will perform NAT for this peer, so outbound NAT is not necessary. It may be left at the default, which will not touch IPsec traffic, or outbound NAT may be disabled entirely which will also prevent LAN subnet traffic from exiting out the WAN unintentionally.

**Peer 2 Setup**

**IPsec Settings**

**Phase 1**

• Navigate to **VPN > IPsec**
• Click **Add P1**
• Set **Key Exchange version** to **IKEv2**
• Set **Internet Protocol** to **IPv4**
• Set **Interface** to **WAN**
• Set **Remote Gateway** to 10.129.0.10
• Set **Authentication Method** to **Mutual PSK**
• Set **My identifier** to **My IP address**
• Set **Peer identifier** to **Peer IP address**
• Set **Pre-Shared Key** to 01234567
• Set Encryption:
– Algorithm to AES
– Key length to 128 bit
– Hash to SHA1
– DH Group to 14 (2048 bit)

• Set Lifetime as 28800
• Click Save

Phase 2

• On the newly created Phase 1 entry, click Show Phase 2 Entries
• Click Add P2
• Set Mode to Routed (VTI)
• Set Local Network to 10.131.3.2 and mask 30
• Set Remote Network to 10.131.3.1
• Set Protocol to ESP
• Set Encryption Algorithms to AES and 128 bit
• Uncheck all other Encryption Algorithms entries
• Set Hash Algorithms to SHA1
• Uncheck all other Hash Algorithms entries
• Set PFS key group to 14 (2048 bit)
• Set Lifetime as 3600
• Click Save
• Click Apply Changes

Interface

• Navigate to Interfaces > Interface Assignments
• From the Available network ports list, choose ipsecNNNN (IPsec VTI) (The ID number will vary)
• Click Add
• Note the newly created interface name, such as OPTX
• Navigate to Interfaces > OPTX
• Check Enable
• Click Save
• Click Apply Changes
Routing

- Navigate to System > Routing, Static Routes tab
- Click Add
- Set Destination network to 192.168.0.0 and mask 23
- Set Gateway to the newly created VTI interface gateway, which has an address of 10.131.2.1
- Click Save
- Click Add
- Set Destination network to 192.168.3.0 and mask 24
- Set Gateway to the newly created VTI interface gateway, which has an address of 10.131.2.1
- Click Save
- Click Apply Changes

Firewall

To allow connections into the local LAN from remote IPsec sites, create necessary pass rules under Firewall > Rules on the IPSec tab. These rules would have a Source set to the remote LAN or whichever network is the source of the traffic to allow.

For simplicity, this example has a rule to pass IPv4 traffic from any source to any destination since the only IPsec interface traffic will be from 192.168.0.0/22.

NAT

TNSR will perform NAT for this peer, so outbound NAT is not necessary. It may be left at the default, which will not touch IPsec traffic, or outbound NAT may be disabled entirely which will also prevent LAN subnet traffic from exiting out the WAN unintentionally.

Peer 3 Setup

IPsec Settings

Phase 1

- Navigate to VPN > IPsec
- Click Add P1
- Set Key Exchange version to IKEv2
- Set Internet Protocol to IPv4
- Set Interface to WAN
- Set Remote Gateway to 10.129.0.10
- Set Authentication Method to Mutual PSK
- Set My identifier to My IP address
• Set Peer identifier to Peer IP address
• Set Pre-Shared Key to 01234567
• Set Encryption:
  – Algorithm to AES
  – Key length to 128 bit
  – Hash to SHA1
  – DH Group to 14 (2048 bit)
• Set Lifetime as 28800
• Click Save

Phase 2

• On the newly created Phase 1 entry, click Show Phase 2 Entries
• Click Add P2
• Set Mode to Routed (VTI)
• Set Local Network to 10.131.4.2 and mask 30
• Set Remote Network to 10.131.4.1
• Set Protocol to ESP
• Set Encryption Algorithms to AES and 128 bit
• Uncheck all other Encryption Algorithms entries
• Set Hash Algorithms to SHA1
• Uncheck all other Hash Algorithms entries
• Set PFS key group to 14 (2048 bit)
• Set Lifetime as 3600
• Click Save
• Click Apply Changes

Interface

• Navigate to Interfaces > Interface Assignments
• From the Available network ports list, choose ipsecNNNN (IPsec VTI) (The ID number will vary)
• Click Add
• Note the newly created interface name, such as OPTX
• Navigate to Interfaces > OPTX
• Check Enable
• Click Save
• Click Apply Changes
Routing

- Navigate to **System > Routing Static Routes** tab
- Click **Add**
- Set **Destination network** to 192.168.0.0 and mask 23
- Set **Gateway** to the newly created VTI interface gateway, which has an address of 10.131.3.1
- Click **Save**
- Click **Add**
- Set **Destination network** to 192.168.2.0 and mask 24
- Set **Gateway** to the newly created VTI interface gateway, which has an address of 10.131.3.1
- Click **Save**
- Click **Apply Changes**

Firewall

To allow connections into the local LAN from remote IPsec sites, create necessary pass rules under **Firewall > Rules** on the **IPsec** tab. These rules would have a **Source** set to the remote LAN or whichever network is the source of the traffic to allow.

For simplicity, this example has a rule to pass IPv4 traffic from any source to any destination since the only IPsec interface traffic will be from 192.168.0.0/22.

NAT

TNSR will perform NAT for this peer, so outbound NAT is not necessary. It may be left at the default, which will not touch IPsec traffic, or outbound NAT may be disabled entirely which will also prevent LAN subnet traffic from exiting out the WAN unintentionally.

Access to the internet for remote network

This section describes minimal routing and NAT settings which provide access to the Internet for one of the remote networks. In current case this is Peer 1 that exchanges routing information with TNSR via BGP.

This document assumes that devices have IPsec setup successfully completed, able to reach each other via IPsec tunnel using path information from the dynamic routing protocol.

TNSR

NAT/PAT

Setup NAT for remote network, in this case PAT is used.

**Note:** Defining NAT inside interface for internet traffic sourced from Peer 1. Outside interface and PAT were defined earlier.
Peer 1 Policy Route

Routing

Setup access to the internet via IPsec VTI interface with a policy-based routing rule.

- Navigate to Firewall > Rules
- Create (or modify existing default pass ipv4 LAN any) rule:
  - Set Address Family to IPv4
  - Set Protocol to ANY
  - Set Source to LAN net
  - Set Destination to ANY
  - Click Display Advanced
  - Set Gateway to <IPsec interface name>_VTIV4
  - Click Save

Note: VTI on pfSense does not support reply-to. Despite this policy routing rule on Peer1 which covers all traffic, there must also be kernel routes to remote LANs for the return traffic to find the way back.

24.3 Edge Router Speaking eBGP with Static Redistribution for IPv4 And IPv6

Covered Topics

- Use Case
- Example Scenario
- TNSR Configuration Steps
- JSON Configuration

24.3.1 Use Case

Especially in cases where an enterprise is multi-homed with it’s own block of network addresses, it may become necessary to configure dynamic routing between network service providers. This is accomplished by use of external BGP (eBGP).
In this use case, the enterprise will use TNSR to speak eBGP with two network service providers, in order to exchange routes which may be redistributed from static/connected routing.

### 24.3.2 Example Scenario

In this example, the enterprise using TNSR will have a fictitious autonomous system number (ASN) of 65505. The network service providers in this example will have ASNs of 65510 and 65520. The enterprise using TNSR will redistribute a single /24 network from static into BGP. That network will then be advertised to each of the service providers. The service providers will announce a full routing table to the TNSR instance.

#### Scenario Topology

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNSR Autonomous System Number</td>
<td>65505</td>
</tr>
<tr>
<td>ISP_A Autonomous System Number</td>
<td>65510</td>
</tr>
<tr>
<td>ISP_B Autonomous System Number</td>
<td>65520</td>
</tr>
<tr>
<td>IPv4 Network to be announced</td>
<td>192.0.2.0/24</td>
</tr>
<tr>
<td>IPv6 Network to be announced</td>
<td>2001:db8:a100:1005::/64</td>
</tr>
<tr>
<td>TNSR to ISP_A IPv4 Network Address</td>
<td>203.0.113.8/30</td>
</tr>
<tr>
<td>TNSR to ISP_A IPv6 Global Address</td>
<td>2001:db8:a00:ffaa::/64</td>
</tr>
<tr>
<td>TNSR to ISP_B IPv4 Network Address</td>
<td>100.64.0.48/30</td>
</tr>
<tr>
<td>TNSR to ISP_B IPv6 Global Address</td>
<td>2001:db8:fb00:ffbb::/64</td>
</tr>
</tbody>
</table>

### 24.3.3 TNSR Configuration Steps

**Steps needed in TNSR to complete this configuration**

- **Step 1: Configure Interfaces**
- **Step 2: Enable BGP**
- **Step 3: Create prefix-lists for route export via BGP**
- **Step 4: Create static route for networks to be advertised in BGP**
- **Step 5: Configure BGP global options**
- **Step 6: Configure BGP global neighbor options**
- **Step 7: Configure BGP neighbor address-family IPv4 unicast options**
- **Step 8: Configure BGP neighbor address-family IPv6 unicast options**

#### Step 1: Configure Interfaces

```bash
tnsr# conf
tnsr(config)# interface GigabitEthernet0/13/0
tnsr(config-interface)# description "To ISP A"
tnsr(config-interface)# ip address 203.0.113.9/30
```

(continues on next page)
24.3. Edge Router Speaking eBGP with Static Redistribution for IPv4 And IPv6

Fig. 2: TNSR BGP Router (IPv4)
Example: IPv6

Fig. 3: TNSR BGP Router (IPv6)
tnsr(config-interface)# ipv6 address 2001:db8:1000:aaaa::2/64
tnsr(config-interface)# enable
tnsr(config-interface)# exit

Step 2: Enable BGP

tnsr(config)# route dynamic bgp
tnsr(config-frr-bgp)# enable
tnsr(config-frr-bgp)# exit

Step 3: Create prefix-lists for route export via BGP

tnsr(config)# route dynamic prefix-list EXPORT_IPV4
tnsr(config-prefix-list)# description "IPv4 Routes to Export"
tnsr(config-prefix-list)# seq 10 permit 192.0.2.0/24
tnsr(config-prefix-list)# exit

tnsr(config)# route dynamic prefix-list EXPORT_IPV6
tnsr(config-prefix-list)# description "IPv6 Routes to Export"
tnsr(config-prefix-list)# seq 10 permit 2001:db8:a100:1005::/64
tnsr(config-prefix-list)# exit

Step 4: Create static route for networks to be advertised in BGP

tnsr(config)# route ipv4 table ipv4-VRF:0
tnsr(config-route-table-v4)# route 192.0.2.0/24
tnsr(config-rttbl4-next-hop)# next-hop 1 via local
tnsr(config-rttbl4-next-hop)# exit
tnsr(config-route-table-v4)# exit

tnsr(config)# route ipv6 table ipv6-VRF:0
tnsr(config-route-table-v6)# route 2001:db8:a100:1005::/64
tnsr(config-rttbl6-next-hop)# next-hop 1 via local
tnsr(config-rttbl6-next-hop)# exit
tnsr(config-route-table-v6)# exit
tnsr(config)#
Step 5: Configure BGP global options

```bash
tnsr(config)# route dynamic bgp
tnsr(config-frr-bgp)# server 65505
tnsr(config-bgp)# router-id 203.0.113.9
tnsr(config-bgp)# address-family ipv4 unicast
tnsr(config-bgp-ip4uni)# redistribute kernel
  tnsr(config-bgp-ip4uni)# exit
tnsr(config-bgp)# address-family ipv6 unicast
tnsr(config-bgp-ip4uni)# redistribute kernel
  tnsr(config-bgp-ip4uni)# exit
tnsr(config-bgp)#
```

Step 6: Configure BGP global neighbor options

```bash
tnsr(config-bgp)# neighbor 203.0.113.10
  tnsr(config-bgp-neighbor)# remote-as 65510
  tnsr(config-bgp-neighbor)# description "ISP_A IPv4"
  tnsr(config-bgp-neighbor)# enable
  tnsr(config-bgp-neighbor)# exit

tnsr(config-bgp)# neighbor 2001:db8:1000:aaaa::1
  tnsr(config-bgp-neighbor)# remote-as 65510
  tnsr(config-bgp-neighbor)# description "ISP_A IPv6"
  tnsr(config-bgp-neighbor)# enable
  tnsr(config-bgp-neighbor)# exit

tnsr(config-bgp)# neighbor 100.64.0.50
  tnsr(config-bgp-neighbor)# remote-as 65520
  tnsr(config-bgp-neighbor)# description "ISP_B IPv4"
  tnsr(config-bgp-neighbor)# enable
  tnsr(config-bgp-neighbor)# exit

tnsr(config-bgp)# neighbor 2001:db8:9999:ffff::1
  tnsr(config-bgp-neighbor)# remote-as 65520
  tnsr(config-bgp-neighbor)# description "ISP_B IPv6"
  tnsr(config-bgp-neighbor)# enable
  tnsr(config-bgp-neighbor)# exit

tnsr(config-bgp)#
```

Step 7: Configure BGP neighbor address-family IPv4 unicast options

```bash
tnsr(config-bgp)# address-family ipv4 unicast
  tnsr(config-bgp-ip4uni)# neighbor 203.0.113.10
    tnsr(config-bgp-ip4uni-nbr)# prefix-list EXPORT_IPv4 out
    tnsr(config-bgp-ip4uni-nbr)# activate
    tnsr(config-bgp-ip4uni-nbr)# exit
  tnsr(config-bgp-ip4uni)# neighbor 100.64.0.50
    tnsr(config-bgp-ip4uni-nbr)# prefix-list EXPORT_IPv4 out
    tnsr(config-bgp-ip4uni-nbr)# activate
    tnsr(config-bgp-ip4uni-nbr)# exit
  tnsr(config-bgp-ip4uni)# exit
  tnsr(config-bgp-ip4uni)# exit
  tnsr(config-bgp)#
```
Step 8: Configure BGP neighbor address-family IPv6 unicast options

```
tnsr(config-bgp)# address-family ipv6 unicast
tnsr(config-bgp-ip4uni)# neighbor 2001:db8:1000:aaaa::1
  tnsr(config-bgp-ip4uni-nbr)# prefix-list EXPORT_IPv6 out
  tnsr(config-bgp-ip4uni-nbr)# activate
  tnsr(config-bgp-ip4uni-nbr)# exit
  tnsr(config-bgp-ip4uni-nbr)# neighbor 2001:db8:9999:ffff::1
  tnsr(config-bgp-ip4uni-nbr)# prefix-list EXPORT_IPv6 out
  tnsr(config-bgp-ip4uni-nbr)# activate
  tnsr(config-bgp-ip4uni-nbr)# exit
  tnsr(config-bgp)# exit
  tnsr(config-frr-bgp)# exit
  tnsr(config)#
```

24.3.4 JSON Configuration

Listing 1: Download: tnsr-bgp-edge-router.json

```
{
  "data": {
    "bgp-config": {
      "global-options": {
        "enable": true
      },
      "routers": [
        {
          "asn": 65505,
          "router-id": "203.0.113.9",
          "address-families": {
            "address-family": [
              {
                "family": "ipv4",
                "subfamily": "labeled-unicast"
              },
              {
                "family": "ipv4",
                "subfamily": "multicast"
              },
              {
                "family": "ipv4",
                "subfamily": "unicast",
                "neighbors": {
                  "neighbor": [
                    {
                      "peer": "100.64.0.50",
                      "activate": true,
                      "prefix-list-out": "EXPORT_IPv4"
                    },
                    {
                      "peer": "203.0.113.10",
                      "activate": true,
                      "prefix-list-out": "EXPORT_IPv4"
                    }
                  ]
                }
              }
            ]
          }
        }
      ]
    }
  }
```

(continues on next page)
"redistributions": [
  "named-sources": [
    "route-source": [
      "source": "kernel",
      "present": true
    ]
  ],
  "family": "ipv4",
  "subfamily": "vpn"
],
"family": "ipv6",
"subfamily": "labeled-unicast"
],
"family": "ipv6",
"subfamily": "unicast",
"neighbors": {
  "neighbor": [
    "peer": "2001:db8:1000:aaaa::1",
    "activate": true,
    "prefix-list-out": "EXPORT_IPv6"
  ],
  "peer": "2001:db8:9999:ffff::1",
  "activate": true,
  "prefix-list-out": "EXPORT_IPv6"
]
"redistributions": [
  "named-sources": [
    "route-source": [
      "source": "kernel",
      "present": true
    ]
  ],
  "family": "ipv6",
  "subfamily": "vpn"
]
```json
[,
  {
    "family": "l2vpn",
    "subfamily": "evpn"
  },
  {
    "family": "vpnv4",
    "subfamily": "unicast"
  },
  {
    "family": "vpnv6",
    "subfamily": "unicast"
  }
],
"neighbors": {
  "neighbor": [
    {
      "peer": "100.64.0.50",
      "capability-negotiate": true,
      "description": "<![CDATA["ISP_B IPv4"]>",
      "interface": "GigabitEthernet0/14/0",
      "remote-asn": 65520,
      "enable": true
    },
    {
      "peer": "2001:db8:1000:aaaa::1",
      "capability-negotiate": true,
      "description": "<![CDATA["ISP_A IPv6"]>",
      "interface": "GigabitEthernet0/13/0",
      "remote-asn": 65510,
      "enable": true
    },
    {
      "peer": "2001:db8:9999:ffff::1",
      "capability-negotiate": true,
      "description": "<![CDATA["ISP_B IPv6"]>",
      "interface": "GigabitEthernet0/14/0",
      "remote-asn": 65520,
      "enable": true
    },
    {
      "peer": "203.0.113.10",
      "capability-negotiate": true,
      "description": "<![CDATA["ISP_A IPv4"]>",
      "interface": "GigabitEthernet0/13/0",
      "remote-asn": 65510,
      "enable": true
    }
  ]
},
"interfaces-config": {
  "interface": [
    ...
  ]
},
(continues on next page)```
{ "name": "GigabitEthernet0/13/0",
  "description": "<![CDATA["To ISP A"]>",
  "enabled": true,
  "ipv4": {
    "enabled": true,
    "forwarding": false,
    "address": {
      "ip": "203.0.113.9/30"
    }
  },
  "ipv6": {
    "enabled": true,
    "forwarding": false,
    "address": {
      "ip": "2001:db8:1000:aaaa::2/64"
    }
  }
},

{ "name": "GigabitEthernet0/14/0",
  "description": "<![CDATA["To ISP B"]>",
  "enabled": true,
  "ipv4": {
    "enabled": true,
    "forwarding": false,
    "address": {
      "ip": "100.64.0.49/30"
    }
  },
  "ipv6": {
    "enabled": true,
    "forwarding": false,
    "address": {
      "ip": "2001:db8:9999:ffff::2/64"
    }
  }
},

{ "name": "GigabitEthernet0/15/0",
  "enabled": true,
  "ipv4": {
    "enabled": true,
    "forwarding": false,
    "address": {
      "ip": "10.255.255.19/24"
    }
  }
}]

"http-config": {
  "restconf": {
    "enable": true
  },
  "authentication": {
    "auth-type": "none"
  },
"prefix-list-config": {
    "prefix-lists": {
        "list": [
            { "name": "EXPORT_IPv4", "description": "IPv4 Routes to Export" },
            { "name": "EXPORT_IPv6", "description": "IPv6 Routes to Export" },
        ],
    },

    "route-table-config": {
        "static-routes": {
            "route-table": {
                "name": "ipv4-VRF:0", "address-family": "ipv4",
                "ipv4-routes": {
                    "route": {
                        "destination-prefix": "192.0.2.0/24",
                        "next-hop": {
                            "hop": [ { "hop-id": 1, "local": true } ]
                        }
                    }
                }
            }
        }
    }
}
24.4 Service Provider Route Reflectors and Client for iBGP IPv4

Covered Topics

• Use Case
• Example Scenario
• TNSR Configuration Steps
• JSON Configuration

24.4.1 Use Case

In large service provider networks it is necessary to divide the routing functionality into two or more layers: a backbone layer and a gateway layer. This allows backbone routers to be focused on core routing and switching to/from other areas of the routing domain, and gateway routers may then be focused on interconnecting other service provider customers.

24.4.2 Example Scenario

In this example, the service provider will have a fictitious autonomous system number (ASN) of 65505. Each network POP, of which only one will be detailed here, will feature 2 backbone routers which will be configured as route-reflectors. These backbone routers will be participating in BGP Cluster ID 100. Other POPs will likely be different Cluster IDs.
There will also be a single gateway router which will be a client of the backbone route-reflectors. Of course, in real world scenarios there would likely be many more gateway routers, each serving a full complement of customers.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNSR Autonomous System Number</td>
<td>65505</td>
</tr>
<tr>
<td>IPv4 Networks to be announced</td>
<td>192.0.2.0/24, 203.0.113.0/24</td>
</tr>
<tr>
<td>BGP Route-Reflector Cluster ID</td>
<td>100</td>
</tr>
</tbody>
</table>

Scenario Topology

24.4.3 TNSR Configuration Steps

Steps needed in TNSR to complete this configuration

- **Step 1**: Configure Interfaces
- **Step 2**: Enable BGP
- **Step 3**: Create prefix-lists for route import into BGP on Route-Reflectors
- **Step 4**: Create route-map for route import into iBGP on route-reflectors
- **Step 5**: Create static route for networks to be advertised in BGP
- **Step 6**: Configure BGP global options
- **Step 7**: Configure iBGP peer-group for backbone route-reflectors and add neighbor
- **Step 8**: Configure RR-CLIENT peer-group for route-reflector clients and add neighbor
- **Step 9**: Configure both peer-group address-family options on route-reflectors
- **Step 10**: Configure iBGP on gateway router to both route-reflectors

Step 1: Configure Interfaces

RR1:

```
rr1 tnsr# conf
rr1 tnsr(config)# interface GigabitEthernet0/13/0
rr1 tnsr(config-interface)# description "To Backbone Network"
rr1 tnsr(config-interface)# ip address 203.0.113.13/30
rr1 tnsr(config-interface)# enable
rr1 tnsr(config-interface)# exit
rr1 tnsr(config)# interface GigabitEthernet0/14/0
rr1 tnsr(config-interface)# description "To RR2 Router"
rr1 tnsr(config-interface)# ip address 203.0.113.21/30
rr1 tnsr(config-interface)# enable
rr1 tnsr(config-interface)# exit
rr1 tnsr(config)# interface GigabitEthernet0/15/0
rr1 tnsr(config-interface)# description "To GW router"
rr1 tnsr(config-interface)# ip address 203.0.113.5/30
rr1 tnsr(config-interface)# enable
```

(continues on next page)
Fig. 4: TNSR BGP Route Reflector
RR2:

```
rr2 tnsr# conf
rr2 tnsr(config)# interface GigabitEthernet0/13/0
rr2 tnsr(config-interface)# description "To Backbone Network"
rr2 tnsr(config-interface)# ip address 203.0.113.17/30
rr2 tnsr(config-interface)# enable
rr2 tnsr(config-interface)# exit
rr2 tnsr(config)# interface GigabitEthernet0/14/0
rr2 tnsr(config-interface)# description "To RR1 Router"
rr2 tnsr(config-interface)# ip address 203.0.113.22/30
rr2 tnsr(config-interface)# enable
rr2 tnsr(config-interface)# exit
rr2 tnsr(config)# interface GigabitEthernet0/15/0
rr2 tnsr(config-interface)# description "To GW router"
rr2 tnsr(config-interface)# ip address 203.0.113.9/30
rr2 tnsr(config-interface)# enable
rr2 tnsr(config-interface)# exit
rr2 tnsr(config)#
```

GW:

```
gw tnsr# conf
gw tnsr(config)# interface GigabitEthernet0/13/0
gw tnsr(config-interface)# description "To RR1 Router"
 gw tnsr(config-interface)# ip address 203.0.113.6/30
gw tnsr(config-interface)# enable
gw tnsr(config-interface)# exit
 gw tnsr(config)# interface GigabitEthernet0/14/0
 gw tnsr(config-interface)# description "To RR2 Router"
 gw tnsr(config-interface)# ip address 203.0.113.10/30
 gw tnsr(config-interface)# enable
 gw tnsr(config-interface)# exit
 gw tnsr(config)# interface GigabitEthernet0/15/0
 gw tnsr(config-interface)# desc "To Customer Router"
 gw tnsr(config-interface)# ip address 203.0.113.25/30
 gw tnsr(config-interface)# enable
 gw tnsr(config-interface)# exit
 gw tnsr(config)#
```

**Step 2: Enable BGP**

RR1:

```
rr1 tnsr(config)# route dynamic bgp
rr1 tnsr(config-frr-bgp)# enable
rr1 tnsr(config-frr-bgp)# exit
rr1 tnsr(config)#
```

RR2:
Step 3: Create prefix-lists for route import into BGP on Route-Reflectors

RR1:
rr1 tnsr(config)# route dynamic prefix-list REDISTRIBUTE_IPv4
rr1 tnsr(config-prefix-list)# description "IPv4 Routes to Import"
rr1 tnsr(config-prefix-list)# seq 10 permit 192.0.2.0/24
rr1 tnsr(config-prefix-list)# seq 20 permit 203.0.113.0/24
rr1 tnsr(config-prefix-list)# exit
rr1 tnsr(config)#

RR2:
rr2 tnsr(config)# route dynamic prefix-list REDISTRIBUTE_IPv4
rr2 tnsr(config-prefix-list)# description "IPv4 Routes to Import"
rr2 tnsr(config-prefix-list)# seq 10 permit 192.0.2.0/24
rr2 tnsr(config-prefix-list)# seq 20 permit 203.0.113.0/24
rr2 tnsr(config-prefix-list)# exit
rr2 tnsr(config)#

Step 4: Create route-map for route import into iBGP on route-reflectors

RR1:
rr1 tnsr(config)# route dynamic route-map REDISTRIBUTE_IPv4 permit sequence 10
rr1 tnsr(config-route-map)# match ip address prefix-list REDISTRIBUTE_IPv4
rr1 tnsr(config-route-map)# set origin igp
rr1 tnsr(config-route-map)# exit
rr1 tnsr(config)#

RR2:
rr2 tnsr(config)# route dynamic route-map REDISTRIBUTE_IPv4 permit sequence 10
rr2 tnsr(config-route-map)# match ip address prefix-list REDISTRIBUTE_IPv4
rr2 tnsr(config-route-map)# set origin igp
rr2 tnsr(config-route-map)# exit
rr2 tnsr(config)#

Step 5: Create static route for networks to be advertised in BGP

RR1:
**Step 6: Configure BGP global options**

**RR1:**

```
rr1 tnsr(config)# route dynamic bgp
rr1 (config-frr-bgp)# server 65505
rr1 tnsr(config-bgp)# router-id 203.0.113.21
rr1 tnsr(config-bgp)# cluster-id 100
rr1 tnsr(config-bgp)# address-family ipv4 unicast
rr1 tnsr(config-bgp-ip4uni)# redistribute kernel route-map REDISTRIBUTE_IPv4
rr1 tnsr(config-bgp-ip4uni)# exit
rr1 tnsr(config-bgp)#
```

**RR2:**

```
rr2 tnsr(config)# route dynamic bgp
rr2 (config-frr-bgp)# server 65505
rr2 tnsr(config-bgp)# router-id 203.0.113.22
rr2 tnsr(config-bgp)# cluster-id 100
rr2 tnsr(config-bgp)# address-family ipv4 unicast
rr2 tnsr(config-bgp-ip4uni)# redistribute kernel route-map REDISTRIBUTE_IPv4
rr2 tnsr(config-bgp-ip4uni)# exit
rr2 tnsr(config-bgp)#
```

**GW:**

```
gw tnsr(config)# route dynamic bgp
gw (config-frr-bgp)# server 65505
gw tnsr(config-bgp)# router-id 203.0.113.6
gw tnsr(config-bgp)#
```
Step 7: Configure iBGP peer-group for backbone route-reflectors and add neighbor

**RR1:**
```
rr1 tnsr(config-bgp)# neighbor iBGP
rr1 tnsr(config-bgp-neighbor)# remote-as 65505
rr1 tnsr(config-bgp-neighbor)# description "iBGP Sessions"
rr1 tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/14/0
rr1 tnsr(config-bgp-neighbor)# enable
rr1 tnsr(config-bgp-neighbor)# exit
rr1 tnsr(config-bgp)# neighbor 203.0.113.22
rr1 tnsr(config-bgp-neighbor)# peer-group iBGP
rr1 tnsr(config-bgp-neighbor)# enable
rr1 tnsr(config-bgp-neighbor)# exit
```

**RR2:**
```
rr2 tnsr(config-bgp)# neighbor iBGP
rr2 tnsr(config-bgp-neighbor)# remote-as 65505
rr2 tnsr(config-bgp-neighbor)# description "iBGP Sessions"
rr2 tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/14/0
rr2 tnsr(config-bgp-neighbor)# enable
rr2 tnsr(config-bgp-neighbor)# exit
rr2 tnsr(config-bgp)# neighbor 203.0.113.21
rr2 tnsr(config-bgp-neighbor)# peer-group iBGP
rr2 tnsr(config-bgp-neighbor)# enable
rr2 tnsr(config-bgp-neighbor)# exit
```

Step 8: Configure RR-CLIENT peer-group for route-reflector clients and add neighbor

**RR1:**
```
rr1 tnsr(config-bgp)# neighbor RR-CLIENT
rr1 tnsr(config-bgp-neighbor)# remote-as 65505
rr1 tnsr(config-bgp-neighbor)# description "RR-Client Sessions"
rr1 tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/15/0
rr1 tnsr(config-bgp-neighbor)# enable
rr1 tnsr(config-bgp-neighbor)# exit
rr1 tnsr(config-bgp)# neighbor 203.0.113.6
rr1 tnsr(config-bgp-neighbor)# peer-group RR-CLIENT
rr1 tnsr(config-bgp-neighbor)# enable
rr1 tnsr(config-bgp-neighbor)# exit
```

**RR2:**
```
rr2 tnsr(config-bgp)# neighbor RR-CLIENT
rr2 tnsr(config-bgp-neighbor)# remote-as 65505
rr2 tnsr(config-bgp-neighbor)# description "RR-Client Sessions"
rr2 tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/15/0
rr2 tnsr(config-bgp-neighbor)# enable
rr2 tnsr(config-bgp-neighbor)# exit
rr2 tnsr(config-bgp)# neighbor 203.0.113.10
rr2 tnsr(config-bgp-neighbor)# peer-group RR-CLIENT
rr2 tnsr(config-bgp-neighbor)# enable
rr2 tnsr(config-bgp-neighbor)# exit
```
Step 9: Configure both peer-group address-family options on route-reflectors

RR1:

```
rr1 tnsr(config-bgp)# address-family ipv4 unicast
rr1 tnsr(config-bgp-ip4uni)# neighbor iBGP
rr1 tnsr(config-bgp-ip4uni-nbr)# next-hop-self
rr1 tnsr(config-bgp-ip4uni-nbr)# activate
rr1 tnsr(config-bgp-ip4uni-nbr)# exit
rr1 tnsr(config-bgp-ip4uni)# neighbor RR-CLIENT
rr1 tnsr(config-bgp-ip4uni-nbr)# route-reflector-client
rr1 tnsr(config-bgp-ip4uni-nbr)# activate
rr1 tnsr(config-bgp-ip4uni-nbr)# exit
rr1 tnsr(config-bgp-ip4uni)# exit
rr1 tnsr(config-bgp)#
```

RR2:

```
rr2 tnsr(config-bgp)# address-family ipv4 unicast
rr2 tnsr(config-bgp-ip4uni)# neighbor iBGP
rr2 tnsr(config-bgp-ip4uni-nbr)# next-hop-self
rr2 tnsr(config-bgp-ip4uni-nbr)# activate
rr2 tnsr(config-bgp-ip4uni-nbr)# exit
rr2 tnsr(config-bgp-ip4uni)# neighbor RR-CLIENT
rr2 tnsr(config-bgp-ip4uni-nbr)# route-reflector-client
rr2 tnsr(config-bgp-ip4uni-nbr)# activate
rr2 tnsr(config-bgp-ip4uni-nbr)# exit
rr2 tnsr(config-bgp-ip4uni)# exit
rr2 tnsr(config-bgp)#
```

Step 10: Configure iBGP on gateway router to both route-reflectors

GW:

```
gw tnsr(config-bgp)# neighbor 203.0.113.5
gw tnsr(config-bgp-neighbor)# remote-as 65505
gw tnsr(config-bgp-neighbor)# description "RR1 Session"
gw tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/13/0
gw tnsr(config-bgp-neighbor)# enable
gw tnsr(config-bgp-neighbor)# exit
gw tnsr(config-bgp)# neighbor 203.0.113.9
gw tnsr(config-bgp-neighbor)# remote-as 65505
gw tnsr(config-bgp-neighbor)# description "RR2 Session"
gw tnsr(config-bgp-neighbor)# update-source GigabitEthernet0/14/0
gw tnsr(config-bgp-neighbor)# enable
gw tnsr(config-bgp-neighbor)# exit
gw tnsr(config-bgp)# address-family ipv4 unicast
gw tnsr(config-bgp-ip4uni)# neighbor 203.0.113.5
gw tnsr(config-bgp-ip4uni-nbr)# activate
gw tnsr(config-bgp-ip4uni-nbr)# exit
gw tnsr(config-bgp-ip4uni)# neighbor 203.0.113.9
gw tnsr(config-bgp-ip4uni-nbr)# activate
gw tnsr(config-bgp-ip4uni-nbr)# exit
gw tnsr(config-bgp-ip4uni)# exit
gw tnsr(config-bgp)#
```
24.4.4 JSON Configuration

RR1

Listing 2: Download: tnsr-bgp-router-reflector-rr1.json

```json
{
    "data": {
        "bgp-config": {
            "global-options": {
                "enable": true
            },
            "routers": {
                "router": [
                    {
                        "asn": 65505,
                        "cluster-id": "100",
                        "router-id": "203.0.113.21",
                        "address-families": {
                            "address-family": [
                                {
                                    "family": "ipv4",
                                    "subfamily": "labeled-unicast"
                                },
                                {
                                    "family": "ipv4",
                                    "subfamily": "multicast"
                                },
                                {
                                    "family": "ipv4",
                                    "subfamily": "unicast",
                                    "neighbors": {
                                        "neighbor": [
                                            {
                                                "peer": "RR-CLIENT",
                                                "activate": true,
                                                "route-reflector-client": true
                                            },
                                            {
                                                "peer": "iBGP",
                                                "activate": true,
                                                "next-hop-self": true
                                            }
                                        ]
                                    },
                                    "redistributions": {
                                        "named-sources": {
                                            "route-source": [
                                                {
                                                    "source": "kernel",
                                                    "route-map": "REDISTRIBUTE_IPV4"
                                                }
                                            ]
                                        }
                                    }
                                ]
                            }
                        }
                    }
                ]
            }
        }
    }
}(continues on next page)
51 | {  
|   "family": "ipv4",  
|   "subfamily": "vpn"
| },
56 | {  
|   "family": "ipv6",  
|   "subfamily": "labeled-unicast"
| },
61 | {  
|   "family": "ipv6",  
|   "subfamily": "multicast"
| },
66 | {  
|   "family": "ipv6",  
|   "subfamily": "unicast"
| },
71 | {  
|   "family": "ipv6",  
|   "subfamily": "vpn"
| },
76 | {  
|   "family": "l2vpn",  
|   "subfamily": "evpn"
| },
81 | {  
|   "family": "vpnv4",  
|   "subfamily": "unicast"
| },
86 | {  
|   "family": "vpnv6",  
|   "subfamily": "unicast"
| }
85 | "neighbors": {
|   "neighbor": {
90 |   "peer": "203.0.113.22",
95 |   "capability-negotiate": true,
100 |   "peer-group-name": "iBGP",
105 |   "enable": true
| },
110 |   "peer": "203.0.113.6",
115 |   "capability-negotiate": true,
120 |   "peer-group-name": "RR-CLIENT",
125 |   "enable": true
| },
130 |   "peer": "RR-CLIENT",
135 |   "capability-negotiate": true,
140 |   "description": "<![CDATA["RR-Client Sessions"]]>",
145 |   "remote-asn": 65505,
150 |   "enable": true,
155 |   "update-source": "GigabitEthernet0/15/0"
| },
(continues on next page)
"peer": "iBGP",
"capability-negotiate": true,
"description": "<![CDATA["iBGP Sessions"]>",
"remote-asn": 65505,
"enable": true,
"update-source": "GigabitEthernet0/14/0"
}
}
]
}
}
]
"
"interfaces-config": {
  "interface": [
    {
      "name": "GigabitEthernet0/13/0",
      "description": "<![CDATA["To Backbone Network"]>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.13/30"
        }
      },
      "ipv6": {
        "enabled": true,
        "forwarding": false
      }
    },
    {
      "name": "GigabitEthernet0/14/0",
      "description": "<![CDATA["To RR2 Router"]>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.21/30"
        }
      },
      "ipv6": {
        "enabled": true,
        "forwarding": false
      }
    },
    {
      "name": "GigabitEthernet0/15/0",
      "description": "<![CDATA["To GW router"]>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.5/30"
        }
      }
    }
  ]
}
},
  "ipv6": {
    "enabled": true,
    "forwarding": false
  }
},
"prefix-list-config": {
  "prefix-lists": {
    "list": [
      {
        "name": "REDISTRIBUTE_IPV4",
        "description": "<![CDATA[IPv4 Routes to Import]]>",
        "rules": {
          "rule": [
            {
              "sequence": 10,
              "action": "permit",
              "prefix": "192.0.2.0/24"
            },
            {
              "sequence": 20,
              "action": "permit",
              "prefix": "203.0.113.0/24"
            }
          ]
        }
      }
    ]
  }
},
"route-map-config": {
  "route-maps": {
    "map": [
      {
        "name": "REDISTRIBUTE_IPV4",
        "rules": {
          "rule": [
            {
              "sequence": 10,
              "policy": "permit",
              "match": {
                "ip-address-prefix-list": "REDISTRIBUTE_IPV4"
              },
              "set": {
                "origin": "igp"
              }
            }
          ]
        }
      }
    ]
  }
},
"route-table-config": {
  "static-routes": {
    
(continues on next page)
"route-table": [  
  {  
    "name": "ipv4-VRF:0",
    "address-family": "ipv4",
    "ipv4-routes": {  
      "route": [  
        {  
          "destination-prefix": "192.0.2.0/24",
          "next-hop": {  
            "hop": [  
              {  
                "hop-id": 1,
                "local": true
              }  
            ]  
          }  
        },  
        {  
          "destination-prefix": "203.0.113.0/24",
          "next-hop": {  
            "hop": [  
              {  
                "hop-id": 1,
                "local": true
              }  
            ]  
          }  
        }  
      ]  
    }  
  }  
]  

RR2  


```json  
{  
  "data": {  
    "bgp-config": {  
      "global-options": {  
        "enable": true
      },  
      "routers": {  
        "router": [  
          {  
            "asn": 65505,
            "cluster-id": "100",
            "router-id": "203.0.113.22",
            "address-families": {
```
"address-family": [
  {
    "family": "ipv4",
    "subfamily": "unicast",
    "neighbors": {
      "neighbor": [
        {
          "peer": "RR-CLIENT",
          "activate": true,
          "route-reflector-client": true
        },
        {
          "peer": "iBGP",
          "activate": true,
          "next-hop-self": true
        }
      ]
    },
    "redistributions": {
      "named-sources": {
        "route-source": {
          "source": "kernel",
          "route-map": "REDEistribute_IPV4"
        }
      }
    }
  },
  {
    "family": "ipv6",
    "subfamily": "unicast",
    "redistributions": null
  }
],
"neighbors": {
  "neighbor": [
    {
      "peer": "203.0.113.10",
      "capability-negotiate": true,
      "peer-group-name": "RR-CLIENT",
      "enable": true
    },
    {
      "peer": "203.0.113.21",
      "capability-negotiate": true,
      "peer-group-name": "iBGP",
      "enable": true
    },
    {
      "peer": "RR-CLIENT",
      "capability-negotiate": true,
      "description": "<![CDATA["RR-Client Sessions"]]>",
      "remote-asn": 65505,
      "enable": true,
      "update-source": "GigabitEthernet0/15/0"
  ]}


```json
{  
  "peer": "iBGP",
  "capability-negotiate": true,
  "description": "<![CDATA["iBGP Sessions"]>>",
  "remote-asn": 65505,
  "enable": true,
  "update-source": "GigabitEthernet0/14/0"
}
```

"interfaces-config": {
  "interface": [
    {
      "name": "GigabitEthernet0/13/0",
      "description": "<![CDATA["To Backbone Network"]>>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.17/30"
        }
      },
      "ipv6": {
        "enabled": true,
        "forwarding": false
      }
    },
    {
      "name": "GigabitEthernet0/14/0",
      "description": "<![CDATA["To RR1 Router"]>>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.22/30"
        }
      },
      "ipv6": {
        "enabled": true,
        "forwarding": false
      }
    },
    {
      "name": "GigabitEthernet0/15/0",
      "description": "<![CDATA["To GW router"]>>",
      "enabled": true,
      "ipv4": {
        "enabled": true,
        "forwarding": false,
        "address": {
          "ip": "203.0.113.22/30"
        }
      },
      "ipv6": {
        "enabled": true,
        "forwarding": false
      }
    }
  ]
}
```

(continues on next page)
"ip": "203.0.113.9/30"
},
    "ipv6": {
        "enabled": true,
        "forwarding": false
    }
},
"prefix-list-config": {
    "prefix-lists": {
        "list": [
            {
                "name": "REDISTRIBUTE_IPV4",
                "description": "<![CDATA[IPv4 Routes to Import]]>",
                "rules": {
                    "rule": [
                        {
                            "sequence": 10,
                            "action": "permit",
                            "prefix": "192.0.2.0/24"
                        },
                        {
                            "sequence": 20,
                            "action": "permit",
                            "prefix": "203.0.113.0/24"
                        }
                    ]
                }
            }
        ]
    }
},
"route-map-config": {
    "route-maps": {
        "map": [
            {
                "name": "REDISTRIBUTE_IPV4",
                "rules": {
                    "rule": [
                        {
                            "sequence": 10,
                            "policy": "permit",
                            "match": {
                                "ip-address-prefix-list": "REDISTRIBUTE_IPV4"
                            },
                            "set": {
                                "origin": "igp"
                            }
                        }
                    ]
                }
            }
        ]
    }
},
"redistribute": {
    "service-provider": {
        "route-reflector": {
            "clients": [
                {
                    "ip": "203.0.113.9/30"
                }
            ]
        }
    }
}
}
"route-table-config": {
  "static-routes": [
    "route-table": [
      {
        "name": "ipv4-VRF:0",
        "address-family": "ipv4",
        "ipv4-routes": {
          "route": [
            {
              "destination-prefix": "192.0.2.0/24",
              "next-hop": {
                "hop": [
                  {
                    "hop-id": 1,
                    "local": true
                  }
                ]
              }
            },
            {
              "destination-prefix": "203.0.113.0/24",
              "next-hop": {
                "hop": [
                  {
                    "hop-id": 1,
                    "local": true
                  }
                ]
              }
            }
          ]
        }
      }
    }
  ]
}

GW

Listing 4: Download: tnsr-bgp-router-reflector-gw.json

```json
{
  "data": {
    "bgp-config": {
      "global-options": {
        "enable": true
      },
      "routers": {
        "router": [
          {
            "asn": 65505,
            "router-id": "203.0.113.6",
            "address-families": {
```
"address-family": [
  {
    "family": "ipv4",
    "subfamily": "labeled-unicast"
  },
  {
    "family": "ipv4",
    "subfamily": "multicast"
  },
  {
    "family": "ipv4",
    "subfamily": "unicast",
    "neighbors": {
      "neighbor": [
        {
          "peer": "203.0.113.5",
          "activate": true
        },
        {
          "peer": "203.0.113.9",
          "activate": true
        }
      ]
    }
  },
  {
    "family": "ipv4",
    "subfamily": "vpn"
  },
  {
    "family": "ipv6",
    "subfamily": "labeled-unicast"
  },
  {
    "family": "ipv6",
    "subfamily": "unicast"
  },
  {
    "family": "ipv6",
    "subfamily": "vpn"
  },
  {
    "family": "l2vpn",
    "subfamily": "evpn"
  },
  {
    "family": "vpnv4",
    "subfamily": "unicast"
  },
  {
    "family": "vpnv6",
    "subfamily": "unicast"
}]
(continues on next page)
"neighbors": {
    "neighbor": [
        {
            "peer": "203.0.113.5",
            "capability-negotiate": true,
            "description": "<![CDATA["RR1 Session"]]>",
            "remote-asn": 65505,
            "enable": true,
            "update-source": "GigabitEthernet0/13/0"
        },
        {
            "peer": "203.0.113.9",
            "capability-negotiate": true,
            "description": "<![CDATA["RR2 Session"]]>",
            "remote-asn": 65505,
            "enable": true,
            "update-source": "GigabitEthernet0/14/0"
        }
    ]
},

"interfaces-config": {
    "interface": [
        {
            "name": "GigabitEthernet0/13/0",
            "description": "<![CDATA["To RR1 Router"]]>",
            "enabled": true,
            "ipv4": {
                "enabled": true,
                "forwarding": false,
                "address": {
                    "ip": "203.0.113.6/30"
                }
            },
            "ipv6": {
                "enabled": true,
                "forwarding": false
            }
        },
        {
            "name": "GigabitEthernet0/14/0",
            "description": "<![CDATA["To RR2 Router"]]>",
            "enabled": true,
            "ipv4": {
                "enabled": true,
                "forwarding": false,
                "address": {
                    "ip": "203.0.113.10/30"
                }
            },
            "ipv6": {
                "enabled": true,
            }
        }
    ]
}
24.5 LAN + WAN with NAT (Basic SOHO Router Including DHCP and DNS Resolver)

Covered Topics

- Use Case
- Example Scenario
- TNSR Configuration
  - Basic Connectivity
  - DHCP
  - Outbound NAT
  - DNS Resolver
- Local PC Configuration

24.5.1 Use Case

A typical use case for TNSR is a device that sits between a local area network (LAN) in an office or home and a wide area network (WAN) such as the Internet.

At a minimum, such a TNSR instance routes traffic between the LAN and the WAN. In many cases, it provides additional services that are useful for a LAN, including:

- DHCP to provide hosts in the LAN with IP addresses.
• DNS to respond to name resolution queries from hosts in the LAN
• NAT (Network Address Translation), to map one public IPv4 address to internal (private) IP addresses assigned to hosts on the LAN.

24.5.2 Example Scenario

This example configures TNSR with basic the basic functions mentioned earlier: DHCP, DNS, and NAT

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local PC</td>
<td>DHCP: 172.16.1.100/24</td>
</tr>
<tr>
<td>TNSR Local Interface</td>
<td>GigabitEthernet0/14/2</td>
</tr>
<tr>
<td>TNSR Local Address</td>
<td>172.16.1.1/24</td>
</tr>
<tr>
<td>TNSR Internet Interface</td>
<td>GigabitEthernet0/14/1</td>
</tr>
<tr>
<td>TNSR Internet Address</td>
<td>203.0.113.2/24</td>
</tr>
<tr>
<td>Remote DNS</td>
<td>8.8.8.8, 8.8.4.4</td>
</tr>
</tbody>
</table>

Fig. 5: Basic SOHO Router Example

24.5.3 TNSR Configuration

Basic Connectivity

First, there is the basic interface configuration of TNSR to handle IP connectivity:
tnsr(config)# interface GigabitEthernet0/14/2
tnsr(config-interface)# ip address 172.16.1.1/24
tnsr(config-interface)# description Local
tnsr(config-interface)# enable
tnsr(config-interface)# exit

tnsr(config)# interface GigabitEthernet0/14/1
tnsr(config-interface)# ip address 203.0.113.2/24
tnsr(config-interface)# description Internet
tnsr(config-interface)# enable
tnsr(config-interface)# exit

**DHCP**

Next, configure the DHCP server and DHCP pool on TNSR:

```bash
tnsr(config)# dhcp4 server
tnsr(config-kea-dhcp4)# description LAN DHCP Server
tnsr(config-kea-dhcp4)# interface listen GigabitEthernet0/14/2
tnsr(config-kea-dhcp4)# option domain-name
tnsr(config-kea-dhcp4-opt)# data example.com
tnsr(config-kea-dhcp4-opt)# exit
tnsr(config-kea-dhcp4)# subnet 172.16.1.0/24
tnsr(config-kea-subnet4)# pool 172.16.1.100-172.16.1.245
tnsr(config-kea-subnet4-pool)# exit
tnsr(config-kea-subnet4)# interface GigabitEthernet0/14/2
tnsr(config-kea-subnet4)# option domain-name-servers
tnsr(config-kea-subnet4-opt)# data 172.16.1.1
tnsr(config-kea-subnet4-opt)# exit
tnsr(config-kea-subnet4)# option routers
tnsr(config-kea-subnet4-opt)# data 172.16.1.1
tnsr(config-kea-subnet4-opt)# exit
tnsr(config-kea-dhcp4)# exit
tnsr(config)# dhcp4 enable
```

The above example configures example.com as the domain name supplied to all clients. For the specific subnet in the example, the TNSR IP address inside the subnet is supplied by DHCP as the default gateway for clients, and DHCP will instruct clients to use the DNS Resolver daemon on TNSR at 172.16.1.1 for DNS.

**Outbound NAT**

Now configure Outbound NAT:

```bash
tnsr(config)# nat pool addresses 203.0.113.2
tnsr(config)# interface GigabitEthernet0/14/1
tnsr(config-interface)# ip nat outside
tnsr(config-interface)# exit
tnsr(config)# interface GigabitEthernet0/14/2
tnsr(config-interface)# ip nat inside
tnsr(config-interface)# exit
tnsr(config)# nat global-options nat44 forwarding true
tnsr(config)#
```
**DNS Resolver**

Finally, configure a DNS Resolver in forwarding mode:

```bash
tnsr# configure
tnsr(config)# unbound server
tnsr(config-unbound)# interface 127.0.0.1
tnsr(config-unbound)# interface 172.16.1.1
tnsr(config-unbound)# access-control 172.16.1.0/24 allow
tnsr(config-unbound)# forward-zone .
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.8.8
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.4.4
tnsr(config-unbound-fwd-zone)# exit
tnsr(config-unbound)# exit
tnsr(config)# unbound enable
```

This example enables the Unbound DNS service and configures it to listen on localhost as well as 172.16.1.1 (GigabitEthernet0/14/2, labeled LAN in the example). The example also allows clients inside that subnet, 172.16.1.0/24, to perform DNS queries and receive responses. It will send all DNS queries to the upstream DNS servers 8.8.8.8 and 8.8.4.4.

### 24.5.4 Local PC Configuration

No configuration is necessary on the Local PC, it will pull all its required settings from DHCP.

### 24.6 Using Access Control Lists (ACLs)

**Covered Topics**

- Use Case
- Example Scenario
- TNSR Configuration

#### 24.6.1 Use Case

A standard ACL works with IPv4 or IPv6 traffic at layer 3. The name of an ACL is arbitrary so it may be named in a way that makes its purpose obvious.

ACLs consist of one or more rules, defined by a sequence number that determines the order in which the rules are applied. A common practice is to start numbering at a value higher than 0 or 1, and to leave gaps in the sequence so that rules may be added later. For example, the first rule could be 10, followed by 20.

#### 24.6.2 Example Scenario

This example configures TNSR with an ACL that allows SSH, ICMP and HTTP/HTTPS connections only from a specific Remote Admin Host:
<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local PC</td>
<td>DHCP: 172.16.1.100/24</td>
</tr>
<tr>
<td>TNSR Local Interface</td>
<td>GigabitEthernet0/14/2</td>
</tr>
<tr>
<td>TNSR Local Address</td>
<td>172.16.1.1/24</td>
</tr>
<tr>
<td>TNSR Internet Interface</td>
<td>GigabitEthernet0/14/1</td>
</tr>
<tr>
<td>TNSR Internet Address</td>
<td>203.0.113.2/24</td>
</tr>
<tr>
<td>Remote Admin Host</td>
<td>208.123.73.10/24</td>
</tr>
</tbody>
</table>

Fig. 6: ACL Example Scenario
24.6.3 TNSR Configuration

```
tnsr(config)# acl WAN_protecting_acl
tnsr(config-acl)# rule 10
 tnsr(config-acl-rule)# action permit
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination address 203.0.113.2/32
 tnsr(config-acl-rule)# destination port 22
 tnsr(config-acl-rule)# source ip address 208.123.73.10/32
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# rule 20
 tnsr(config-acl-rule)# action permit
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination address 203.0.113.2/32
 tnsr(config-acl-rule)# destination port 80
 tnsr(config-acl-rule)# source ip address 208.123.73.10/32
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# rule 30
 tnsr(config-acl-rule)# action permit
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination address 203.0.113.2/32
 tnsr(config-acl-rule)# destination port 443
 tnsr(config-acl-rule)# source ip address 208.123.73.10/32
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# rule 40
 tnsr(config-acl-rule)# action deny
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination port 22
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# rule 50
 tnsr(config-acl-rule)# action deny
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination port 80
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# rule 60
 tnsr(config-acl-rule)# action deny
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# destination port 443
 tnsr(config-acl-rule)# protocol tcp
 tnsr(config-acl-rule)# exit
 tnsr(config-acl)# exit
 tnsr(config-acl)# rule 70
 tnsr(config-acl-rule)# action permit
 tnsr(config-acl-rule)# ip-version ipv4
 tnsr(config-acl-rule)# exit
 tnsr(config)# int GigabitEthernet0/14/1
 tnsr(config-interface)# access-list input acl WAN_protecting_acl sequence 10
 tnsr(config-interface)# exit
 tnsr(config)#
```

Rules 10-30 allow SSH, HTTP and HTTPS access to the WAN IP address from the Remote Admin Host. Then Rules 40-60 block SSH, HTTPS and HTTPs on the WAN IP address from all other IP addresses. Finally, rule 70 allows all other incoming traffic.
24.7 Inter-VLAN Routing

Covered Topics

- Use Case
- Example Scenario
- TNSR Configuration
  - Create Subinterfaces
  - Configure Interfaces
  - Configure DHCP
  - Configure Outbound NAT
  - Configure DNS Resolver

24.7.1 Use Case

Inter-VLAN routing is a process of forwarding network traffic from one VLAN to another VLAN using a router or layer 3 device.

24.7.2 Example Scenario

This example configures TNSR with VLANs:

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNSR Internet Interface</td>
<td>GigabitEthernet0/14/1</td>
</tr>
<tr>
<td>TNSR Internet Address</td>
<td>203.0.113.2/24</td>
</tr>
<tr>
<td>TNSR Local Interface</td>
<td>GigabitEthernet0/14/2</td>
</tr>
<tr>
<td>TNSR VLAN 10 Interface</td>
<td>GigabitEthernet0/14/2.10</td>
</tr>
<tr>
<td>TNSR VLAN 10 Address</td>
<td>172.16.10.1/24</td>
</tr>
<tr>
<td>TNSR VLAN 20 Interface</td>
<td>GigabitEthernet0/14/2.20</td>
</tr>
<tr>
<td>TNSR VLAN 20 Address</td>
<td>172.16.20.1/24</td>
</tr>
</tbody>
</table>

24.7.3 TNSR Configuration

A few pieces of information are necessary to create a VLAN subinterface (“subif”):

- The parent interface which will carry the tagged traffic, e.g. GigabitEthernet3/0/0
- The subinterface ID number, which is a positive integer that uniquely identifies this subif on the parent interface. It is commonly set to the same value as the VLAN tag
- The VLAN tag used by the subif to tag outgoing traffic, and to use for identifying incoming traffic bound for this subif. This is an integer in the range 1–4095, inclusive. This VLAN must also be tagged on the corresponding switch configuration for the port used by the parent interface.
Fig. 7: Inter-VLAN Routing Example
Create Subinterfaces

First, create subinterfaces for VLAN 10 and VLAN 20:

```
tnsr(config)# interface subif GigabitEthernet0/14/2 10
tnsr(config-subif)# dot1q 10 exact-match
tnsr(config-subif)# exit

tnsr(config)# interface subif GigabitEthernet0/14/2 20
tnsr(config-subif)# dot1q 20 exact-match
tnsr(config-subif)# exit
```

The subif interface appears with the parent interface name and the subif id, joined by a .

Configure Interfaces

At this point, subinterface behaves identically to a regular interface in that it may have an IP address, routing, and so on:

```
tnsr(config)# interface GigabitEthernet0/14/2.10
tnsr(config-interface)# ip address 172.16.10.1/24
tnsr(config-interface)# description VLAN10
tnsr(config-interface)# enable
tnsr(config-interface)# exit

tnsr(config)# interface GigabitEthernet0/14/2.20
tnsr(config-interface)# ip address 172.16.20.1/24
tnsr(config-interface)# description VLAN20
tnsr(config-interface)# enable
tnsr(config-interface)# exit
```

Configure DHCP

Next, configure the DHCP server and DHCP pool on TNSR for each VLAN.

For VLAN 10:

```
tnsr(config)# dhcp4 server
tnsr(config-kea-dhcp4)# description LAN DHCP Server
tnsr(config-kea-dhcp4)# interface listen GigabitEthernet0/14/2.10
tnsr(config-kea-dhcp4)# option domain-name
tnsr(config-kea-dhcp4-opt)# data example.com
tnsr(config-kea-dhcp4-opt)# exit
tnsr(config-kea-dhcp4)# subnet 172.16.10.0/24
tnsr(config-kea-subnet4)# pool 172.16.10.100-172.16.10.245
tnsr(config-kea-subnet4-pool)# exit
tnsr(config-kea-dhcp4)# option domain-name-servers
tnsr(config-kea-dhcp4-opt)# data 172.16.10.1
tnsr(config-kea-dhcp4-opt)# exit
```

24.7. Inter-VLAN Routing
And for VLAN 20:

```plaintext
tnsr(config)# dhcp4 server
tnsr(config-kea-dhcp4)# interface listen GigabitEthernet0/14/2.20
tnsr(config-kea-dhcp4)# subnet 172.16.20.0/24
ntsr(config-kea-subnet4)# pool 172.16.20.100-172.16.20.245
ntsr(config-kea-subnet4-pool)# exit
ntsr(config-kea-subnet4)# interface GigabitEthernet0/14/2.20
ntsr(config-kea-subnet4)# option domain-name-servers
ntsr(config-kea-subnet4-opt)# data 172.16.20.1
ntsr(config-kea-subnet4-opt)# exit
ntsr(config-kea-subnet4)# option routers
ntsr(config-kea-subnet4-opt)# data 172.16.20.1
ntsr(config-kea-subnet4-opt)# exit
ntsr(config-kea-dhcp4)# exit
ntsr(config)# dhcp4 enable
```

Configure Outbound NAT

Now configure Outbound NAT:

```plaintext
tnsr(config)# nat pool addresses 203.0.113.2
ntsr(config)# interface GigabitEthernet0/14/1
ntsr(config-interface)# ip nat outside
ntsr(config-interface)# exit
ntsr(config)# interface GigabitEthernet0/14/2.10
ntsr(config-interface)# ip nat inside
ntsr(config-interface)# exit
ntsr(config)# interface GigabitEthernet0/14/2.20
ntsr(config-interface)# ip nat inside
ntsr(config-interface)# exit
ntsr(config)# nat global-options nat44 forwarding true
ntsr(config)#
```

Configure DNS Resolver

Finally, configure a DNS Resolver in forwarding mode:

```plaintext
tnsr# configure
tnsr(config)# unbound server
tnsr(config-unbound)# interface 127.0.0.1
tnsr(config-unbound)# interface 172.16.10.1
tnsr(config-unbound)# interface 172.16.20.1
tnsr(config-unbound)# access-control 172.16.10.0/24 allow
tnsr(config-unbound)# access-control 172.16.20.0/24 allow
tnsr(config-unbound)# forward-zone .
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.8.8
tnsr(config-unbound-fwd-zone)# nameserver address 8.8.4.4
tnsr(config-unbound-fwd-zone)# exit
ntsr(config-unbound)# exit
ntsr(config)# unbound enable
```

Now there are two VLANs on the physical “LAN” port and interface GigabitEthernet0/14/2 now works as trunk port between TNSR and downstream L2/L3 switch.
This switch must be configured to match the expected VLAN tags and it must also have access ports configured for clients on each VLAN.

### 24.8 GRE ERSPAN Example Use Case

Encapsulated Remote Switched Port Analyzer (ERSPAN) is a type of GRE tunnel which allows a remote Intrusion Detection System (IDS) or similar packet inspection device to receive copies of packets from a local interface. This operates similar to a local mirror or span port on a switch, but in a remote capacity.

A typical use case for this is central packet inspection or a case where a remote site has plenty of bandwidth available, but no suitable local hardware for inspecting packets.

On TNSR, this is accomplished by configuring an ERSPAN GRE tunnel and then configuring a span to link the ERSPAN tunnel a local interface. From that point on, a copy of every packet on the interface being spanned is sent across GRE.

**Note:** The receiving end does not need to support ERSPAN, a standard GRE tunnel will suffice.

#### 24.8.1 Example Scenario

In this example, copies of packets from a local TNSR interface will be copied to a remote IDS for inspection.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Server:</td>
<td>172.29.193.47/24</td>
</tr>
<tr>
<td>TNSR Local Interface:</td>
<td>VirtualFunctionEthernet0/6/0</td>
</tr>
<tr>
<td>TNSR Local Address:</td>
<td>172.29.193.60/24</td>
</tr>
<tr>
<td>TNSR Internet Interface:</td>
<td>VirtualFunctionEthernet0/7/0</td>
</tr>
<tr>
<td>TNSR Internet Address:</td>
<td>172.29.194.142/24</td>
</tr>
<tr>
<td>IDS Address:</td>
<td>172.29.194.90/24</td>
</tr>
</tbody>
</table>

#### 24.8.2 TNSR Configuration

First, there is the basic interface configuration of TNSR to handle IP connectivity:

```bash
tnsr(config)# interface VirtualFunctionEthernet0/6/0
tnsr(config-interface)# ip address 172.29.193.160/24
tnsr(config-interface)# description Local
tnsr(config-interface)# enable
tnsr(config-interface)# exit

tnsr(config)# interface VirtualFunctionEthernet0/7/0
tnsr(config-interface)# ip address 172.29.194.142/24
tnsr(config-interface)# description Internet
tnsr(config-interface)# enable
tnsr(config-interface)# exit
```

Next, configure the GRE tunnel on TNSR:
Finally, configure a SPAN that ties the local interface to the GRE interface:

```
  tnsr(config)# span VirtualFunctionEthernet0/6/0
  tnsr(config-span)# onto gre1 hw both
  tnsr(config-span)# exit
```

### 24.8.3 Server Configuration

No configuration is necessary on the server. Any packet it sends which flows through TNSR will automatically be copied across the ERSPAN tunnel to the IDS.
24.8.4 IDS Configuration

The IDS must support GRE interfaces and also must support inspecting packets on GRE interfaces. The IDS does not need to explicitly support ERSPAN to receive copies of packets from TNSR.

At a minimum, take the following steps on the IDS:

- Configure a GRE tunnel between the IDS and TNSR, it does not need to have an address internal to the GRE tunnel.
- Configure the IDS software to inspect packets on the GRE interface
The items in this section can be used to control lower-level behavior of the dataplane and host operating system in various ways. These can help to increase performance and efficiency for large workloads.

25.1 Dataplane Configuration

For the majority of cases the default dataplane configuration is sufficient, but certain cases may require adjustments. These are often covered in more detail throughout the documentation, and relevant sections will be linked where appropriate.

These commands are all available in config mode (Configuration Mode).

**Warning:** The dataplane service requires a restart to enable configuration changes described in this section. After making changes, restart the dataplane from config mode using the following command:

```
tnsr# configure
tnsr(config)# service dataplane restart
```

25.1.1 CPU Workers and Affinity

The dataplane has a variety of commands to fine-tune how it uses available CPU resources on the host. These commands control CPU cores TNSR will use, both the number of cores and specific cores.

**Worker Configuration**

- `dataplane cpu corelist-workers <n>` Defines a specific list of CPU cores to be used by the dataplane. Run the command multiple times with different core numbers to define the list of cores to utilize. When removing items with `no`, the command accepts a specific core to remove from the list.

- `dataplane cpu coremask-workers <mask>` Similar to `corelist-workers`, but the cores are defined as a hexadecimal mask instead of a list. For example, `0x0000000000C0000C`.

- `dataplane cpu main-core <n>` Assigns the main dataplane process to a specific CPU core.

- `dataplane cpu scheduler-policy (batch|fifo|idle|other|rr)` Defines a specific scheduler policy for worker thread processor usage allocation
  - `batch` Scheduling batch processes. Uses dynamic priorities based on nice values in the host OS, but always gives the thread a small scheduling penalty so that other processes take precedence.
**fifo**  First in-first out scheduling. Will preempt other types of threads and threads with a lower priority.

**idle**  Scheduling very low priority jobs.

**other**  Default Linux time-sharing scheduling. Uses dynamic priorities based on nice values in the host OS, similar to batch but without the built-in penalty.

**rr**  Round-robin scheduling. Similar to fifo but each thread is time-limited

**dataplane cpu scheduler-priority <n>**  For the fifo and rr scheduler policies, this number sets the priority of processes for the dataplane. It can be any number between 1 (low) and 99 (high).

**dataplane cpu skip-cores <n>**  Defines the number of cores to skip when creating additional worker threads, in the range of 1 to the highest available core number. The first <n> cores will not be used by worker threads.

**Note:**  This does not affect the core used by the main thread, which is set by dataplane cpu main-core <n>.

**dataplane cpu workers <n>**  Defines the number of worker threads to create for the dataplane.

**Note:**  The number of worker threads is in addition to the main process. For example, with a worker count of 4, the dataplane will use one main process with four worker threads, for a total of five threads.

---

**Worker Example**

This example sets four additional worker threads, and instructs the dataplane to skip one core when assigning worker threads to cores:

```
  tnsr(config)# dataplane cpu workers 4
  tnsr(config)# dataplane cpu skip-cores 1
  tnsr(config)# service dataplane restart
```

---

**Worker Status**

The *show dataplane cpu threads* command displays the current dataplane process list, including the core usage and process IDs. This output corresponds to the example above:

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Type</th>
<th>PID</th>
<th>LCore</th>
<th>Core</th>
<th>Socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>vpp_main</td>
<td>2330</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>vpp_wk_0</td>
<td>workers</td>
<td>2346</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>vpp_wk_1</td>
<td>workers</td>
<td>2347</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>vpp_wk_2</td>
<td>workers</td>
<td>2348</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>vpp_wk_3</td>
<td>workers</td>
<td>2349</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

The output includes the following columns:

**id**  Dataplane thread ID.

**name**  Name of the dataplane process.

---

25.1.  Dataplane Configuration
**type**  The type of thread, which will be blank for the main process.

**pid**  The host OS process ID for each thread.

**LCore**  The logical core used by the process.

**Core**  The CPU core used by the process.

**Socket**  The CPU socket associated with the core used by the process.

### 25.1.2 DPDK Configuration

Commands in this section configure hardware settings for DPDK devices.

```
 dataplane dpdk dev <pci-id> (crypto|network) [num-rx-queues [<r>]] [num-tx-queues [<t>]]
```

Configures a specific device for use by TNSR. For network devices, see *Setup NICs in Dataplane*. For cryptographic devices, see *Setup QAT Compatible Hardware*.

```
 dataplane dpdk no-tx-checksum-offload
```

Disables transmit checksum offloading for network devices.

```
 dataplane dpdk no-multi-seg
```


```
 dataplane dpdk uio-driver [<driver-name>]
```

Configures the UIO driver for interfaces. See *Setup NICs in Dataplane*.

```
 dataplane dpdk vdev <sw-dev-type>
```

Defines a software device to be used by the dataplane, such as:

- **aesni_gcm**  AESNI GCM cryptodev
- **aesni_mb**  AESNI multibuffer cryptodev

### 25.1.3 Memory

Commands in this section configure memory allocation for the dataplane.

```
 dataplane (ip|ip6) heap-size [<size>]
```

Defines the amount of memory to be allocated for the dataplane FIB. The default is 32MB. For more information, see *Working with Large BGP Tables*.

**Note:** When tuning this value, also consider increasing the *Statistics Segment heap-size*.

```
 dataplane ip6 hash-buckets [<size>]
```

Defines the number of IPv6 forwarding table hash buckets. The default is 65536.

### 25.1.4 NAT

Commands in this section configure dataplane NAT behavior.

```
 dataplane nat dslite-ce
```

Enables DS-Lite CE mode.

```
 dataplane nat max-translations-per-user <n>
```

Defines the number of NAT translation entries to allow for each IP address. The default value is 100. The ideal value depends entirely on the environment and number of sessions per IP address involved in NAT. This includes traffic sourced from TNSR itself address as well, not only internal source IP addresses.

```
 dataplane nat mode (deterministic|endpoint-dependent|simple)
```

Configures the operating NAT mode. See *Dataplane NAT Modes*. 

---

**25.1. Dataplane Configuration**
**dataplane nat mode-options simple (out2in-dpolstatic-mapping-only)** Configures options for the NAT mode. See *Dataplane NAT Modes*.

### 25.1.5 Statistics Segment

These commands configure the statistics segment parameters for the dataplane. This feature enables local access to dataplane statistics via shared memory.

**See also:**

For more information on how to make use of this feature, see the VPP documentation for the example *stat_client*.

- **dataplane statseg heap-size <heap-size>[kKmMgG]** Size of shared memory allocation for stats segment, in bytes. This value can be suffixed with \( k \) (kilobytes), \( M \) (megabytes), or \( G \) (gigabytes) in upper or lowercase. Default value is \( 96M \).

  **Note:** This value may need to be increased to accommodate large amounts of routes in routing tables. The default value of \( 96M \) can safely accommodate approximately one million routes.

- **dataplane statseg per-node-counters enable** Enables per-graph-node performance statistics.

- **dataplane statseg socket-name <socket-name>** Absolute path to UNIX domain socket for stats segment. The default path is `/run/vpp/stats.sock`.

### 25.2 Host Memory Management Configuration

TNSR has commands to tweak a few common host OS memory management parameters.

These are:

- **sysctl vm nr_hugepages <u64>** Virtual memory, maximum number of huge pages. This controls allocations of huge areas of contiguous memory, which is used to keep TNSR in memory, rather than swapping. Each huge page is 2MB by default, and the default number of huge pages is 1024. Multiplying the values yields 2GB of RAM set aside. This value can be tweaked lower for systems with less memory or higher for systems with more available memory and larger workloads.

- **sysctl vm max_map_count <u64>** Virtual memory, maximum map count. This controls the number of memory map areas available to a given process. With workloads requiring larger amounts of memory, this may need increased to allow sufficient levels of memory allocation operations to succeed. The default value is 3096.

- **sysctl kernel shmmem <u64>** Maximum size, in bytes, of a single shared memory segment in the kernel. Default value is 2147483648 (2GB).

To view the current active values of these parameters, use `show sysctl`:

```
tnsr# show sysctl
vm/nr_hugepages = 1024
vm/max_map_count = 3096
kernel/shmmem = 2147483648
```
This section contains commonly encountered issues with TNSR and methods to resolve them.

- **Ping and traceroute do not function without host OS default route**
- **Unrecognized routes in a routing table**
- **Services do not receive traffic on an interface with NAT enabled**
- **NAT session limits / “Create NAT session failed” error**
- **ACL rules do not match NAT traffic as expected**
- **Some Traffic to the host OS management interface is dropped**
- **Locked out by NACM Rules**
- **How to gain access to the root account**
- **Console Messages Obscure Prompts**
- **Diagnosing Service Issues**
- **Debugging TNSR**

### 26.1 Ping and traceroute do not function without host OS default route

Utilities such as `ping` and `traceroute` will send traffic using the host OS routing table by default unless a specific source address is passed to the command. See *Diagnostic Routing Behavior* for details.

### 26.2 Unrecognized routes in a routing table

TNSR automatically populates routing tables with necessary entries that may not appear to directly correspond with manually configured addresses. See *Common Routes* for details.

### 26.3 Services do not receive traffic on an interface with NAT enabled

When NAT is enabled, by default TNSR will drop traffic that doesn’t match an existing NAT session or static NAT rule. This includes traffic for services on TNSR such as IPsec and BGP. To allow this traffic, see *NAT Forwarding*.
26.4 NAT session limits / “Create NAT session failed” error

By default the dataplane limits the number of NAT sessions for an IP address to a relatively low number (100) based on the configured value for `dataplane nat max-translations-per-user`. This can be changed as described in *Advanced Dataplane Configuration: NAT*.

26.5 ACL rules do not match NAT traffic as expected

When NAT is active, ACL rules are always processed before NAT on interfaces where NAT is applied, in any direction. This behavior is different from some other products, such as pfSense. See *ACL and NAT Interaction* for details.

26.6 Some Traffic to the host OS management interface is dropped

TNSR includes a default set of Netfilter rules which secure the management interface. Only certain ports are allowed by default. See *Default Allowed Traffic* for details. To allow more traffic, create host ACLs as described in *Host ACLs*.

26.7 Locked out by NACM Rules

If TNSR access is lost due to the NACM configuration, access can be regained by following the directions in *Regaining Access if Locked Out by NACM*.

26.8 How to gain access to the root account

By default, the root account has interactive login disabled, which is the best practice. This can be changed by resetting the root password using `sudo` from another administrator account, or in the ISO installer. See *Default Accounts and Passwords* for details.

26.9 Console Messages Obscure Prompts

When connected to the console of a TNSR device, such as the serial console, the kernel may output messages to the terminal which obscure prompts or other areas of the screen. This is normal and an expected effect when using the console directly.

To work around this intended behavior, use one of the following methods:

• Press Ctrl-L to clear or redraw the screen without the messages.

• Press Enter to receive a new prompt.

• Run `sudo dmesg -D` from a shell prompt or with the TNSR shell command, which will disable kernel output to all consoles.

• Connect to the TNSR device using SSH instead of the console.
### 26.10 Diagnosing Service Issues

If a service will not stay running and the logs indicate that it is crashing, additional debugging information can be obtained from core dumps.

By default, core dumps are disabled for services. These can be individually enabled as needed by the following command:

```
tnsr(config)# service (backend|bgp|dataplane|dhcp|http|ike|ntp|restconf|unbound) coredump (enable|disable)
```

The resulting core files will be written under `/var/lib/systemd/coredump/`.

### 26.11 Debugging TNSR

The following commands enable debugging information in various aspects of TNSR. These should only be used under direction of Netgate.

```
deiug cli [level <n>]  Enable debugging in clixon and cligen at the given level.
deiug tnsr (clearsetevalue) <flags> Enable debugging in TNSR. The set or clear command may be repeated multiple times to add or remove individual flag values. The value command may be used to directly set the value. The <flags> value is the logical or of all desired debugging flags.
```

The following flag values are available:

<table>
<thead>
<tr>
<th>Flag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDBG_NONE</td>
<td>0x00000000</td>
</tr>
<tr>
<td>TDBG_FRR</td>
<td>0x00000001</td>
</tr>
<tr>
<td>TDBG_HOST</td>
<td>0x00000002</td>
</tr>
<tr>
<td>TDBG_KEA</td>
<td>0x00000004</td>
</tr>
<tr>
<td>TDBG_VPP</td>
<td>0x00000008</td>
</tr>
<tr>
<td>TDBG_NTP</td>
<td>0x00000010</td>
</tr>
<tr>
<td>TDBG_STRONGSWAN</td>
<td>0x00000020</td>
</tr>
<tr>
<td>TDBG_UNBOUND</td>
<td>0x00000040</td>
</tr>
<tr>
<td>TDBG_HTTP</td>
<td>0x00000080</td>
</tr>
<tr>
<td>TDBG_DELYED_NODE</td>
<td>0x00000100</td>
</tr>
<tr>
<td>TDBG_DEP_GRAPH</td>
<td>0x00000200</td>
</tr>
<tr>
<td>TDBG_TRANSACTION</td>
<td>0x00000400</td>
</tr>
<tr>
<td>TDBG_ACL</td>
<td>0x00010000</td>
</tr>
<tr>
<td>TDBG_BGP</td>
<td>0x00020000</td>
</tr>
<tr>
<td>TDBG_BRIDGE</td>
<td>0x00040000</td>
</tr>
<tr>
<td>TDBG_INTF</td>
<td>0x00080000</td>
</tr>
<tr>
<td>TDBG_NEIGHBOR</td>
<td>0x00100000</td>
</tr>
<tr>
<td>TDBG_SUBIF</td>
<td>0x00200000</td>
</tr>
<tr>
<td>TDBG_SYSCTL</td>
<td>0x00400000</td>
</tr>
<tr>
<td>TDBG_GRE</td>
<td>0x00800000</td>
</tr>
<tr>
<td>TDBG_LOOPBACK</td>
<td>0x01000000</td>
</tr>
<tr>
<td>TDBG_ROUTE</td>
<td>0x02000000</td>
</tr>
<tr>
<td>TDBG_SPAN</td>
<td>0x04000000</td>
</tr>
<tr>
<td>TDBG_MAP</td>
<td>0x08000000</td>
</tr>
</tbody>
</table>
debug vmgmt (clear|set|value) <flags>  Enable VPP Mgmt library debug. The set or clear command may be repeated multiple times to add or remove individual flag values. The value command may be used to directly set the value. The <flags> value is the logical or of all desired debugging flags.

The following flag values are available:

<table>
<thead>
<tr>
<th>Flag</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDBG_NONE</td>
<td>0x0000</td>
</tr>
<tr>
<td>VDBG_API_SETUP</td>
<td>0x0001</td>
</tr>
<tr>
<td>VDBG_API_MSG</td>
<td>0x0002</td>
</tr>
<tr>
<td>VDBG_ACL</td>
<td>0x0004</td>
</tr>
<tr>
<td>VDBG_BRIDGE</td>
<td>0x0008</td>
</tr>
<tr>
<td>VDBG_INTF</td>
<td>0x0010</td>
</tr>
<tr>
<td>VDBG_NAT</td>
<td>0x0020</td>
</tr>
<tr>
<td>VDBG_TAP</td>
<td>0x0040</td>
</tr>
<tr>
<td>VDBG_MEMIF</td>
<td>0x0080</td>
</tr>
<tr>
<td>VDBG_LLDP</td>
<td>0x0100</td>
</tr>
<tr>
<td>VDBG_GRE</td>
<td>0x0200</td>
</tr>
<tr>
<td>VDBG_MAP</td>
<td>0x0400</td>
</tr>
<tr>
<td>VDBGROUTE</td>
<td>0x0800</td>
</tr>
</tbody>
</table>

no debug (cli|tsr|vmgmt)  Removes all debugging.
• Mode List
• Master Mode Commands
• Config Mode Commands
• Show Commands in Both Master and Config Modes
• Access Control List Modes
• MACIP ACL Mode
• GRE Mode
• HTTP mode
• Interface Mode
• Loopback Mode
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• NAT Reassembly Mode
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• IKE Peer Authentication Mode
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• IKE Child SA Proposal Mode
• IKE Peer Identity Mode
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• Map Mode
• Map Parameters Mode
• memif Mode
• Dynamic Routing Access List Mode
• Dynamic Routing Prefix List Mode
• Dynamic Routing Route Map Rule Mode
• Dynamic Routing BGP Mode
• Dynamic Routing BGP Server Mode
• Dynamic Routing BGP Neighbor Mode
• Dynamic Routing BGP Address Family Mode
• Dynamic Routing BGP Address Family Neighbor Mode
• Dynamic Routing BGP Community List Mode
• Dynamic Routing BGP AS Path Mode
• Dynamic Routing Manager Mode
• IPv4 Route Table Mode
• IPv6 Route Table Mode
• IPv4 or IPv6 Next Hop Mode
• SPAN Mode
• VXLAN Mode
• User Authentication Configuration Mode
• NTP Configuration Mode
• NTP Restrict Mode
• NTP Upstream Server Mode
• NACM Group Mode
• NACM Rule-list Mode
• NACM Rule Mode
• DHCP IPv4 Server Config Mode
• DHCP4 Subnet4 Mode
• DHCP4 Subnet4 Pool Mode
• DHCP4 Subnet4 Reservation Mode
• Kea DHCP4, Subnet4, Pool, or Reservation Option Mode
• Unbound Server Mode
• Unbound Forward-Zone Mode
• Subif Mode
• Bond Mode
27.1 Mode List

<table>
<thead>
<tr>
<th>Internal Name</th>
<th>Prompt</th>
<th>Mode Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>access_list</td>
<td>config-access-list</td>
<td>Dynamic Routing Accesss List</td>
</tr>
<tr>
<td>acl</td>
<td>config-acl</td>
<td>Access Control List</td>
</tr>
<tr>
<td>acl_rule</td>
<td>config-acl-rule</td>
<td>ACL Rule</td>
</tr>
<tr>
<td>aspath</td>
<td>config-aspath</td>
<td>AS Path ordered rule</td>
</tr>
<tr>
<td>auth</td>
<td>config-user</td>
<td>User Authentication</td>
</tr>
<tr>
<td>bfd</td>
<td>config-bfd</td>
<td>Bidirectional Forwarding Detection</td>
</tr>
<tr>
<td>bfd_key</td>
<td>config-bfd-key</td>
<td>BFD key</td>
</tr>
<tr>
<td>bgp</td>
<td>config-bgp</td>
<td>BGP server</td>
</tr>
<tr>
<td>bgp_ip4multi</td>
<td>config-bgp-ip4multi</td>
<td>BGP IPv4 Multicast Address Family</td>
</tr>
<tr>
<td>bgp_ip4multi_nbr</td>
<td>config-bgp-ip4multi-nbr</td>
<td>BGP IPv4 Multicast Address Family Neighbor</td>
</tr>
<tr>
<td>bgp_ip4uni</td>
<td>config-bgp-ip4uni</td>
<td>BGP IPv4 Unicast Address Family</td>
</tr>
<tr>
<td>bgp_ip4uni_nbr</td>
<td>config-bgp-ip4uni-nbr</td>
<td>BGP IPv4 Unicast Address Family Neighbor</td>
</tr>
<tr>
<td>bgp_ip6multi</td>
<td>config-bgp-ip6multi</td>
<td>BGP IPv6 Multicast Address Family</td>
</tr>
<tr>
<td>bgp_ip6multi_nbr</td>
<td>config-bgp-ip6multi-nbr</td>
<td>BGP IPv6 Multicast Address Family Neighbor</td>
</tr>
<tr>
<td>bgp_ip6uni</td>
<td>config-bgp-ip6uni</td>
<td>BGP IPv6 Unicast Address Family</td>
</tr>
<tr>
<td>bgp_ip6uni_nbr</td>
<td>config-bgp-ip6uni-nbr</td>
<td>BGP IPv6 Unicast Address Family Neighbor</td>
</tr>
<tr>
<td>bgp_neighbor</td>
<td>config-bgp-neighbor</td>
<td>BGP Neighbor</td>
</tr>
<tr>
<td>bond</td>
<td>config-bond</td>
<td>Interface bonding</td>
</tr>
<tr>
<td>bridge</td>
<td>config-bridge</td>
<td>Bridge</td>
</tr>
<tr>
<td>community_list</td>
<td>config-community</td>
<td>BGP community list</td>
</tr>
<tr>
<td>config</td>
<td>config</td>
<td>Configuration</td>
</tr>
<tr>
<td>frr_bgp</td>
<td>config-frr-bgp</td>
<td>Dynamic Routing BGP</td>
</tr>
<tr>
<td>gre</td>
<td>config-gre</td>
<td>Generic Route Encapsulation</td>
</tr>
<tr>
<td>host_acl</td>
<td>config-host-acl</td>
<td>Host Access List</td>
</tr>
<tr>
<td>host_acl_rule</td>
<td>config-host-acl-rule</td>
<td>Host Access List Rule</td>
</tr>
<tr>
<td>host_if</td>
<td>config-host-if</td>
<td>Host interface</td>
</tr>
<tr>
<td>http</td>
<td>config-http</td>
<td>HTTP server</td>
</tr>
<tr>
<td>ike_authentication</td>
<td>config-ike-auth</td>
<td>IKE peer authentication</td>
</tr>
<tr>
<td>ike_authentication_round</td>
<td>config-ike-auth-round</td>
<td>IKE peer authentication round</td>
</tr>
<tr>
<td>ike_child</td>
<td>config-ike-child</td>
<td>IKE child SA</td>
</tr>
<tr>
<td>ike_child_proposal</td>
<td>config-ike-child-proposal</td>
<td>IKE child SA proposal</td>
</tr>
<tr>
<td>ike_identity</td>
<td>config-ike-identity</td>
<td>IKE peer identity</td>
</tr>
<tr>
<td>ike_proposal</td>
<td>config-ike-proposal</td>
<td>IKE proposal</td>
</tr>
<tr>
<td>interface</td>
<td>config-interface</td>
<td>Interface</td>
</tr>
<tr>
<td>ipsec_crypto_ike</td>
<td>config-ipsec-crypto-ike</td>
<td>IKE</td>
</tr>
<tr>
<td>ipsec_crypto_manual</td>
<td>config-crypto-manual</td>
<td>IPsec static keying</td>
</tr>
<tr>
<td>ipsec_tunnel</td>
<td>config-ipsec-tun</td>
<td>IPsec tunnel</td>
</tr>
<tr>
<td>kea_dhcp4</td>
<td>config-kea-dhcp4</td>
<td>DHCP4 Server</td>
</tr>
<tr>
<td>kea_dhcp4_log</td>
<td>config-kea-dhcp4-log</td>
<td>DHCP4 Log</td>
</tr>
<tr>
<td>kea_dhcp4_log_out</td>
<td>config-kea-dhcp4-log-out</td>
<td>DHCP4 Log output</td>
</tr>
<tr>
<td>kea_dhcp4_opt</td>
<td>config-kea-dhcp4-opt</td>
<td>DHCP4 option</td>
</tr>
<tr>
<td>kea_subnet4</td>
<td>config-kea-dhcp4-subnet4</td>
<td>DHCP4 subnet4</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 1 – continued from previous page

<table>
<thead>
<tr>
<th>Internal Name</th>
<th>Prompt</th>
<th>Mode Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>kea_subnet4_opt</td>
<td>config-kea-subnet4-opt</td>
<td>DHCP4 subnet4 option</td>
</tr>
<tr>
<td>kea_subnet4_pool</td>
<td>config-kea-subnet4-pool</td>
<td>DHCP4 subnet4 pool</td>
</tr>
<tr>
<td>kea_subnet4_pool_opt</td>
<td>config-kea-subnet4-pool-opt</td>
<td>DHCP4 subnet4 pool option</td>
</tr>
<tr>
<td>kea_subnet4_reservation</td>
<td>config-kea-subnet4-reservation</td>
<td>DHCP4 subnet4 host reservation</td>
</tr>
<tr>
<td>kea_subnet4_reservation_opt</td>
<td>config-kea-subnet4-reservation-opt</td>
<td>DHCP4 subnet4 host res option</td>
</tr>
<tr>
<td>loopback</td>
<td>config-loopback</td>
<td>Loopback interface</td>
</tr>
<tr>
<td>macip</td>
<td>config-macip</td>
<td>MAC/IP access control list</td>
</tr>
<tr>
<td>macip_rule</td>
<td>config-macip-rule</td>
<td>MACIP Rule</td>
</tr>
<tr>
<td>map</td>
<td>config-map</td>
<td>MAP-E/MAP-T</td>
</tr>
<tr>
<td>map_param</td>
<td>config-map-param</td>
<td>MAP-E/MAP-T global parameter</td>
</tr>
<tr>
<td>master</td>
<td>config-memif</td>
<td>Memif interface</td>
</tr>
<tr>
<td>nacm_group</td>
<td>config-nacm-group</td>
<td>NACM group</td>
</tr>
<tr>
<td>nacm_rule</td>
<td>config-nacm-rule</td>
<td>NACM rule</td>
</tr>
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<td>nacm_rule_list</td>
<td>config-nacm-rule-list</td>
<td>NACM rule list</td>
</tr>
<tr>
<td>nat_reassembly</td>
<td>config-nat-reassembly</td>
<td>NAT reassembly</td>
</tr>
<tr>
<td>ntp</td>
<td>config-ntp</td>
<td>NTP</td>
</tr>
<tr>
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<td>config-ntp-restrict</td>
<td>NTP restriction</td>
</tr>
<tr>
<td>ntp_server</td>
<td>config-ntp-server</td>
<td>NTP server</td>
</tr>
<tr>
<td>prefix_list</td>
<td>config-prefix-list</td>
<td>Dynamic routing prefix list</td>
</tr>
<tr>
<td>route_dynamic_manager</td>
<td>config-route-dynamic-manager</td>
<td>Dynamic routing manager</td>
</tr>
<tr>
<td>route_map</td>
<td>config-route-map</td>
<td>Route Map</td>
</tr>
<tr>
<td>route_table_v4</td>
<td>config-route-table-v4</td>
<td>IPv4 Static Route Table</td>
</tr>
<tr>
<td>route_table_v6</td>
<td>config-route-table-v6</td>
<td>IPv6 Static Route Table</td>
</tr>
<tr>
<td>rttbl4_next_hop</td>
<td>config-rttbl4-next-hop</td>
<td>IPv4 Next Hop</td>
</tr>
<tr>
<td>rttbl6_next_hop</td>
<td>config-rttbl6-next-hop</td>
<td>IPv6 Next Hop</td>
</tr>
<tr>
<td>span</td>
<td>config-span</td>
<td>SPAN</td>
</tr>
<tr>
<td>subif</td>
<td>config-subif</td>
<td>Sub-interface VLAN</td>
</tr>
<tr>
<td>tap</td>
<td>config-tap</td>
<td>Tap</td>
</tr>
<tr>
<td>unbound</td>
<td>config-unbound</td>
<td>Unbound DNS Server</td>
</tr>
<tr>
<td>unbound_fwd_zone</td>
<td>config-unbound-fwd-zone</td>
<td>Unbound forward-zone</td>
</tr>
<tr>
<td>unbound_local_host</td>
<td>config-unbound-local-host</td>
<td>Unbound local host override</td>
</tr>
<tr>
<td>unbound_local_zone</td>
<td>config-unbound-local-zone</td>
<td>Unbound local zone override</td>
</tr>
<tr>
<td>vxlan</td>
<td>config-vxlan</td>
<td>VXLAN</td>
</tr>
</tbody>
</table>

### 27.2 Master Mode Commands

```bash
tnsr# configure [terminal]
tnsr# debug cli [level <n>]
tnsr# debug tnsr (clear|set|value) <flags>
tnsr# debug vmgmt (clear|set|value) <flags>
tnsr# no debug (cli|tnsr|vmgmt)
tnsr# exit
tnsr# ls [-l]
tnsr# ping (<dest-host>|<dest-ip>) [ipv4|ipv6] [interface <if-name>] [source <src-addr>] [count <count>] [packet-size <bytes>] [ttl <ttl-hops>] [timeout <wait-sec>

(continues on next page)
```
[source <src-addr>] [packet-size <bytes>] [no-dns] [timeout <seconds>]
    [ttl <ttl-hos>] [waittime <wait-sec>]

tnsr# whoami

### 27.2.1 Package Management Commands

```
  tnsr# package (info|list) [available|installed|updates] [<pkg-name>]
  tnsr# package install <pkg-glob>
  tnsr# package remove <pkg-glob>
  tnsr# package search <term>
  tnsr# package upgrade <pkg-glob>
```

### 27.2.2 Public Key Infrastructure Commands

```
  tnsr# pki ca list
  tnsr# pki ca <name> (append <source-name>|delete|enter|get|import <file>)
  tnsr# pki certificate list
  tnsr# pki certificate <name> (delete|enter|get|import <file>)
  tnsr# pki private-key list
  tnsr# pki private-key <name> (delete|enter|get|import <file>)
  tnsr# pki private-key <name> generate [key-length (2048|3072|4096)]
  tnsr# pki signing-request list
  tnsr# pki signing-request <name> (delete|generate|get|sign (ca-name <ca>|self))
  tnsr# pki signing-request set (city|common-name|country|org|org-unit|state) <text>
  tnsr# pki signing-request set digest (md5|sha1|sha224|sha256|sha384|sha512)
  tnsr# pki signing-request settings (clear|show)
```

### 27.3 Config Mode Commands

```
  tnsr(config)# [no] acl <acl-name>
  tnsr(config)# [no] auth user <user-name>
  tnsr(config)# [no] bfd conf-key-id <conf-key-id>
  tnsr(config)# [no] bfd session <bfd-session>
  tnsr(config)# [no] cli option auto-discard
  tnsr(config)# configuration candidate clear
  tnsr(config)# configuration candidate discard
  tnsr(config)# configuration candidate load <filename> [(replace|merge)]
  tnsr(config)# configuration candidate validate
  tnsr(config)# configuration copy candidate startup
  tnsr(config)# configuration copy running (candidate|startup)
  tnsr(config)# configuration copy startup candidate
  tnsr(config)# configuration save (candidate|running) <filename>
  tnsr(config)# [no] dataplane cpu corelist-workers [<corelist-workers>]
  tnsr(config)# [no] dataplane cpu coremask-workers <coremask-workers>
  tnsr(config)# [no] dataplane cpu main-core <main-core>
  tnsr(config)# [no] dataplane cpu scheduler-policy (batch|fifo|idle|other|rr)
  tnsr(config)# [no] dataplane cpu scheduler-priority <scheduler-priority>
  tnsr(config)# [no] dataplane cpu skip-cores <skip-cores>
  tnsr(config)# [no] dataplane cpu workers <workers>
```

(continues on next page)
tnsr(config)# dataplane dpdk dev <pci-id> (crypto|network)
    [num-rx-queues [<num-rxqs>]] [num-tx-queues [<num-txqs>]]
    [vlan-strip-offload (off|on)]

tnsr(config)# dataplane dpdk dev <pci-id> network name <name>

tnsr(config)# no dataplane dpdk dev <pci-id> [name] [num-rx-queues] [num-tx-queues]
    [vlan-strip-offload]

tnsr(config)# no dataplane dpdk no-multi-seg

tnsr(config)# no dataplane dpdk no-tx-checksum-offload

tnsr(config)# no dataplane dpdk uio-driver [uio-driver]

tnsr(config)# no dataplane dpdk vdev <sw-dev-type>

tnsr(config)# no dataplane ip heap-size [<size>]

tnsr(config)# no dataplane ip6 heap-size [<size>]

tnsr(config)# no dataplane ip6 hash-buckets [<size>]

tnsr(config)# no dataplane nat dslite-ce

tnsr(config)# no dataplane nat max-translations-per-user <n>

tnsr(config)# no dataplane nat mode (deterministic|endpoint-dependent|simple)

tnsr(config)# no dataplane nat mode-options simple (out2in-dpo|static-mapping-only)

tnsr(config)# no dataplane nat statseg heap-size <heap-size>[kKmMgG]

tnsr(config)# no dataplane nat statseg per-node-counters enable

tnsr(config)# no dataplane nat statseg socket-name <socket-name>

tnsr(config)# debug cli [level <n>]

tnsr(config)# debug tnsr (clear|set|value) <flags>

tnsr(config)# debug vmgmt (clear|set|value) <flags>

tnsr(config)# no debug (cli|tnsr|vmgmt)

tnsr(config)# dhcp4 (enable|disable)

tnsr(config)# dhcp4 server

tnsr(config)# dslite aftr endpoint <ip6-address>

tnsr(config)# dslite b4 endpoint <ip6-address>

tnsr(config)# dslite pool address <ipv4-addr-first> [- <ipv4-addr-last>]

tnsr(config)# no dslite [pool address]

tnsr(config)# exit

tnsr(config)# no gre <gre-name>

tnsr(config)# no host acl <acl-name>

tnsr(config)# no host interface <host-if-name>

tnsr(config)# http (enable|disable)

tnsr(config)# no http server

tnsr(config)# no interface <if-name>

tnsr(config)# interface clear counters [<interface>]

tnsr(config)# no interface bond <instance>

tnsr(config)# no interface bridge domain <domain-id>

tnsr(config)# no interface loopback <name>

tnsr(config)# no interface memif interface <id>

tnsr(config)# no interface memif socket id <id> filename <file>

tnsr(config)# no interface subif <interface> <subid>

tnsr(config)# no interface tap <host-name>

tnsr(config)# no ipsec tunnel <tunnel-num>

tnsr(config)# no lldp system-name <system-name>

tnsr(config)# no lldp tx-hold <transmit-hold>

tnsr(config)# no lldp tx-interval <transmit-interval>

tnsr(config)# no macip <macip-name>

tnsr(config)# nacm (enable|disable)

tnsr(config)# no nacm enable

tnsr(config)# no nacm exec-default (deny|permit)

tnsr(config)# no nacm group <group-name>

tnsr(config)# no nacm read-default (deny|permit)

tnsr(config)# no nacm rule-list (rule-list-name)

tnsr(config)# no nacm write-default (deny|permit)

(continues on next page)
27.4 Show Commands in Both Master and Config Modes

```plaintext
tnsr# show acl [<acl-name>]
tnsr# show bfd
tnsr# show bfd keys [conf-key-id <conf-key-id>]
tnsr# show bfd sessions [conf-key-id <conf-key-id> | peer-ip-addr <peer-addr>]
tnsr# show cli
```

(continues on next page)
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr# show clock</td>
<td>Show the system clock.</td>
</tr>
<tr>
<td>tnsr# show configuration (candidate</td>
<td>running</td>
</tr>
<tr>
<td>tnsr# show counters [&lt;interface&gt;]</td>
<td>Show counters for a specific interface.</td>
</tr>
<tr>
<td>tnsr# show dataplane cpu threads</td>
<td>Show the CPU threads information.</td>
</tr>
<tr>
<td>tnsr# show dslite</td>
<td>Show the DSLite information.</td>
</tr>
<tr>
<td>tnsr# show gre [&lt;tunnel-name&gt;]</td>
<td>Show GRE information for a specific tunnel.</td>
</tr>
<tr>
<td>tnsr# show host interface (acl</td>
<td>bonding</td>
</tr>
<tr>
<td>tnsr# show http [&lt;config-file&gt;]</td>
<td>Show HTTP configuration.</td>
</tr>
<tr>
<td>tnsr# show interface [&lt;if-name&gt;] [(acl</td>
<td>bonding</td>
</tr>
<tr>
<td>tnsr# show interface bridge domain [&lt;bdi&gt;]</td>
<td>Show bridge domain information for a specific bridge domain.</td>
</tr>
<tr>
<td>tnsr# show interface memif [&lt;id&gt;]</td>
<td>Show memif information for a specific memif.</td>
</tr>
<tr>
<td>tnsr# show interface bond [&lt;id&gt;]</td>
<td>Show bond interface information for a specific bond.</td>
</tr>
<tr>
<td>tnsr# show interface lacp [&lt;if-name&gt;]</td>
<td>Show lacp interface information for a specific lacp.</td>
</tr>
<tr>
<td>tnsr# show interface tap</td>
<td>Show tap interface information.</td>
</tr>
<tr>
<td>tnsr# show ipsec tunnel [&lt;tunnel_number&gt; [child</td>
<td>ike</td>
</tr>
<tr>
<td>tnsr# show kea [keactrl</td>
<td>dhcp4] [config-file]</td>
</tr>
<tr>
<td>tnsr# show macip [&lt;macip-name&gt;]</td>
<td>Show macip information for a specific macip.</td>
</tr>
<tr>
<td>tnsr# show map [&lt;map-domain-name&gt;]</td>
<td>Show map information for a specific map domain.</td>
</tr>
<tr>
<td>tnsr# show nacm [group [&lt;group-name&gt;]</td>
<td>Show NACM group information.</td>
</tr>
<tr>
<td>tnsr# show nat [config</td>
<td>deterministic-mappings</td>
</tr>
<tr>
<td>tnsr# show nat dynamic (addresses</td>
<td>interfaces)</td>
</tr>
<tr>
<td>tnsr# show nat sessions [verbose]</td>
<td>Show NAT sessions.</td>
</tr>
<tr>
<td>tnsr# show neighbor [interface &lt;if-name&gt;]</td>
<td>Show neighbor information for a specific interface.</td>
</tr>
<tr>
<td>tnsr# show ntp [(associations</td>
<td>peers) [associd &lt;id&gt;]]</td>
</tr>
<tr>
<td>tnsr# show ntp config-file</td>
<td>Show NTP configuration file.</td>
</tr>
<tr>
<td>tnsr# show packet-counters</td>
<td>Show packet counters information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic access-list [&lt;access-list-name&gt;]</td>
<td>Show route access-list information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp as-path [&lt;as-path-name&gt;]</td>
<td>Show route BGP as-path information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp community-list [&lt;community-list-name&gt;]</td>
<td>Show route BGP community-list information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp config [&lt;as-number&gt;]</td>
<td>Show route BGP configuration.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp neighbors [[&lt;peer&gt;] [advertised-routes</td>
<td>dampened-routes</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp network &lt;prefix&gt;</td>
<td>Show route BGP network information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp nexthop [detail]</td>
<td>Show route BGP nexthop information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp peer-group &lt;peer-group-name&gt;</td>
<td>Show route BGP peer-group information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic bgp summary</td>
<td>Show route BGP summary information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic manager</td>
<td>Show route dynamic manager information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic prefix-list [&lt;prefix-list-name&gt;]</td>
<td>Show route BGP prefix-list information.</td>
</tr>
<tr>
<td>tnsr# show route dynamic route-map [&lt;route-map-name&gt;]</td>
<td>Show route BGP route-map information.</td>
</tr>
<tr>
<td>tnsr# show route [table &lt;route-table-name&gt;]</td>
<td>Show route table information.</td>
</tr>
<tr>
<td>tnsr# show span</td>
<td>Show span information.</td>
</tr>
<tr>
<td>tnsr# show sysct1</td>
<td>Show sysctl information.</td>
</tr>
<tr>
<td>tnsr# show system</td>
<td>Show system information.</td>
</tr>
<tr>
<td>tnsr# show unbound [config-file]</td>
<td>Show unbound configuration.</td>
</tr>
<tr>
<td>tnsr# show version</td>
<td>Show system version.</td>
</tr>
<tr>
<td>tnsr# show vxlan [&lt;vxlan-name&gt;]</td>
<td>Show VXLAN information for a specific VXLAN.</td>
</tr>
</tbody>
</table>
27.5 Access Control List Modes

27.5.1 Enter Access Control List Mode

tnsr(config)# acl <acl-name>
tnsr(config-acl)#

27.5.2 Access Control List Mode Commands

tnsr(config-acl)# rule <seq-number>

27.5.3 Remove Access Control List

tnsr(config)# no acl <acl-name>

27.5.4 Enter ACL Rule Mode

tnsr(config-acl)# rule <seq-number>
tnsr(config-acl-rule)#

27.5.5 ACL Rule Mode Commands

tnsr(config-acl-rule)# action (deny|permit|reflect)
tnsr(config-acl-rule)# ip-version (ipv4|ipv6)
tnsr(config-acl-rule)# no action [deny|permit|reflect]
tnsr(config-acl-rule)# destination address <ip-prefix>
tnsr(config-acl-rule)# no destination address [<ip-prefix>]
tnsr(config-acl-rule)# [no] destination port (any|<first> [- <last>])
tnsr(config-acl-rule)# [no] icmp type (any|<type-first> [- <type-last>])
tnsr(config-acl-rule)# [no] icmp code (any|<code-first> [- <code-last>])
tnsr(config-acl-rule)# [no] protocol (icmp|udp|tcp)
tnsr(config-acl-rule)# source address <ip-prefix>
tnsr(config-acl-rule)# no source address [<ip-prefix>]
tnsr(config-acl-rule)# [no] source port (any|<first> [- <last>])
tnsr(config-acl-rule)# [no] tcp flags mask <mask> value <value>
tnsr(config-acl-rule)# [no] tcp flags value <value> mask <mask>

27.5.6 Remove ACL Rule

tnsr(config-acl)# no rule <seq>
27.6 MACIP ACL Mode

27.6.1 Enter MACIP ACL Mode

```
tnsr(config)# macip <macip-name>
tnsr(config-macip)#
```

27.6.2 MACIP ACL Mode Commands

```
tnsr(config-macip)# rule <seq>
```

27.6.3 Remove MACIP ACL

```
tnsr(config-macip)# no macip <macip-name>
```

27.6.4 Enter MACIP ACL Rule Mode

```
tnsr(config-macip)# rule <seq-number>
tnsr(config-macip-rule)#
```

27.6.5 MACIP Rule Mode Commands

```
tnsr(config-macip-rule)# action (deny|permit)
tnsr(config-macip-rule)# no action [deny|permit]
tnsr(config-macip-rule)# ip-version (ipv4|ipv6)
tnsr(config-macip-rule)# address <ip-prefix>
tnsr(config-macip-rule)# no address [<ip-prefix>]
tnsr(config-macip-rule)# mac address <mac-address> [mask <mac-mask>]
tnsr(config-macip-rule)# mac mask <mac-mask> [address <mac-address>]
tnsr(config-macip-rule)# no mac
tnsr(config-macip-rule)# no mac address [<mac-address>] [mask [<mac-mask>]]
tnsr(config-macip-rule)# no mac mask [<mac-mask>] [address [<mac-address>]]
```

27.6.6 Remove MACIP ACL Rule

```
tnsr(config-macip)# no rule <seq-number>
```

27.7 GRE Mode

27.7.1 Enter GRE Mode

```
tnsr(config)# gre <gre-name>
tnsr(config-gre)#
```
27.7.2 GRE Mode Commands

```
tnsr(config-gre)# encapsulation route-table <rt-table-name>
tnsr(config-gre)# instance <id>
tnsr(config-gre)# destination <ip-address>
tnsr(config-gre)# source <ip-address>
tnsr(config-gre)# tunnel-type erspan session-id <session-id>
tnsr(config-gre)# tunnel-type (l3|teb)
```

27.7.3 Remove GRE Instance

```
tnsr(config)# no gre <gre-name>
```

27.8 HTTP mode

27.8.1 Enter HTTP mode

```
tnsr(config)# http server
tnsr(config-http)#
```

27.8.2 HTTP Mode Commands

```
tnsr(config-http)# authentication client-certificate-ca <cert-name>
tnsr(config-http)# authentication type (client-certificate|password|none)
tnsr(config-http)# enable restconf
tnsr(config-http)# disable restconf
tnsr(config-http)# server certificate <cert-name>
```

27.8.3 Remove http Configuration

```
tnsr(config)# no http server
```

27.9 Interface Mode

27.9.1 Enter Interface mode

```
tnsr(config)# interface <if-name>
tnsr(config-interface)#
```

27.9.2 Interface Mode Commands
27.9.3 Remove Interface

tnsr(config)# no interface <if-name>

27.10 Loopback Mode

27.10.1 Enter Loopback Mode

tnsr(config)# interface loopback <loopback-name>
tnsr(config-loopback)#

27.10.2 Loopback Mode Commands
27.10.3 Remove Loopback interface

```
tnsr(config)# no interface <loop<n>>
tnsr(config)# no interface loopback <loopback-name>
```

27.11 Bridge Mode

27.11.1 Enter Bridge Mode

```
tnsr(config)# interface bridge <bdi>
tnsr(config-bridge)#
```

27.11.2 Bridge Mode commands

```
tnsr(config-bridge)# [no] arp entry ip <ip-addr> mac <mac-addr>
tnsr(config-bridge)# [no] arp term
nsr(config-bridge)# [no] flood
tnsr(config-bridge)# [no] forward
tnsr(config-bridge)# [no] learn
tnsr(config-bridge)# [no] mac-age <mins>
tnsr(config-bridge)# [no] rewrite
nsr(config-bridge)# [no] uu-flood
```

27.11.3 Remove Bridge

```
tnsr(config)# no interface bridge <bdi>
```

27.12 NAT Commands in Configure Mode

```
tnsr(config)# [no] nat static mapping (icmp|udp|tcp)
  local <ip> [<port>]
exernal (<ip>|<if-name>) [<port>]
[twice-nat] [out-to-in-only]
[route-table <rt-tbl-name>]
tnsr(config)# [no] nat ipfix logging [domain <domain-id>] [src-port <port>]
tnsr(config)# [no] nat pool address <ip-first> [- <ip-last>] [twice-nat]
tnsr(config)# [no] nat pool interface <if-name> [twice-nat]
```
27.13 NAT Reassembly Mode

27.13.1 Enter NAT Reassembly Mode

```
tnsr(config)# nat reassembly (ipv4|ipv6)
tnsr(config-nat-reassembly)#
```

27.13.2 NAT Reassembly Mode Commands

```
tnsr(config-nat-reassembly)# concurrent-reassemblies <max-reassemblies>
tnsr(config-nat-reassembly)# disable
tnsr(config-nat-reassembly)# enable
tnsr(config-nat-reassembly)# fragments <max-fragments>
tnsr(config-nat-reassembly)# timeout <seconds>
```

27.14 DS-Lite Commands in Configure Mode

```
tnsr(config)# dslite aftr endpoint <ip6-address>
tnsr(config)# dslite b4 endpoint <ip6-address>
tnsr(config)# dslite pool address <ipv4-addr-first> [- <ipv4-addr-last>]
```

27.15 Tap Mode

27.15.1 Enter Tap Mode

```
tnsr(config)# interface tap <tap-name>
tnsr(config-tap)#
```

27.15.2 Tap Mode commands

```
tnsr(config-tap)# [no] host bridge <bridge-name>
tnsr(config-tap)# [no] host ipv4 gateway <ipv4-addr>
tnsr(config-tap)# [no] host ipv4 prefix <ipv4-prefix>
tnsr(config-tap)# [no] host ipv6 gateway <ipv6-addr>
tnsr(config-tap)# [no] host ipv6 prefix <ipv6-prefix>
tnsr(config-tap)# [no] host mac-address <host-mac-address>
tnsr(config-tap)# [no] instance <instance>
tnsr(config-tap)# [no] mac-address <mac-address>
tnsr(config-tap)# [no] rx-ring-size <size>
tnsr(config-tap)# [no] tx-ring-size <size>
```
27.15.3 Remove Tap

```plaintext
tnsr(config)# no interface tap <tap-name>
```

27.16 BFD Key Mode

27.16.1 Enter BFD Key Mode

```plaintext
tnsr(config)# bfd conf-key-id <conf-key-id>
tnsr(config-bfdkey)#
```

27.16.2 BFD Key Mode Commands

```plaintext
tnsr(config-bfdkey)# authentication type (keyed-sha1|meticulous-keyed-sha1)
tnsr(config-bfdkey)# secret < (<hex-pair>)[1-20] >
```

27.16.3 Remove BFD Key Configuration

```plaintext
tnsr(config)# no bfd conf-key-id <conf-key-id>
```

27.17 BFD Mode

27.17.1 Enter BFD Mode

```plaintext
tnsr(config)# bfd session <bfd-session>
tnsr(config-bfd)#
```

27.17.2 BFD Mode Commands

```plaintext
tnsr(config-bfd)# [no] bfd-key-id <bfd-key-id>
tnsr(config-bfd)# [no] conf-key-id <conf-key-id>
tnsr(config-bfd)# delayed (true|false)
tnsr(config-bfd)# desired-min-tx <microseconds>
tnsr(config-bfd)# detect-multiplier <n-packets>
tnsr(config-bfd)# disable
tnsr(config-bfd)# [no] enable
tnsr(config-bfd)# interface <if-name>
tnsr(config-bfd)# local address <ip-address>
tnsr(config-bfd)# peer address <ip-address>
tnsr(config-bfd)# remote address <ip-address>
tnsr(config-bfd)# required-min-rx <microseconds>
```
27.17.3 Remove BFD Configuration

```text
tnsr(config)# no bfd session <bfd-session>
```

27.17.4 Change BFD Admin State

```text
tnsr# bfd session <bfd-session>
tnsr(config-bfd)# disable
tnsr(config-bfd)# [no] enable
tnsr(config-bfd)#
```

27.17.5 Change BFD Authentication

```text
tnsr(config)# bfd session <bfd-session>
tnsr(config-bfd)# bfd-key-id <bfd-key-id>
tnsr(config-bfd)# conf-key-id <conf-key-id>
tnsr(config-bfd)# delayed (true|false)
```

27.18 Host Interface Mode

27.18.1 Enter Host Interface Mode

```text
tnsr(config)# host interface <if-name>
tnsr(config-host-if)#
```

27.18.2 Host Interface Mode Commands

```text
tnsr(config-host-if)# [no] description <rest>
tnsr(config-host-if)# disable
tnsr(config-host-if)# [no] enable
tnsr(config-host-if)# [no] ip address <ipv4-prefix>
tnsr(config-host-if)# [no] ipv6 address <ipv6-prefix>
tnsr(config-host-if)# mtu <mtu-value>
```

27.18.3 Remove Host Interface

```text
tnsr(config)# no host interface <if-name>
```
27.19 IPsec Tunnel Mode

27.19.1 Enter IPsec Tunnel Mode

```bash
tnsr(config)# ipsec tunnel <tunnel-num>
tnsr(config-ipsec-tun)#
```

27.19.2 IPsec Tunnel Mode Commands

```bash
tnsr(config-ipsec-tun)# crypto config-type (ike|manual)
tnsr(config-ipsec-tun)# crypto (ike|manual)
tnsr(config-ipsec-tun)# [no] local-address <ip-address>
tnsr(config-ipsec-tun)# [no] remote-address (<ip-address>|<hostname>)
```

27.19.3 Remove IPsec Tunnel

```bash
tnsr(config)# no ipsec tunnel <tunnel-num>
```

27.20 IKE mode

27.20.1 Enter IKE mode

```bash
tnsr(config-ipsec-tun)# crypto ike
tnsr(config-ipsec-crypto-ike)#
```

27.20.2 IKE Mode Commands

```bash
tnsr(config-ipsec-crypto-ike)# [no] authentication (local|remote)
tnsr(config-ipsec-crypto-ike)# [no] child <name>
tnsr(config-ipsec-crypto-ike)# [no] identity (local|remote)
tnsr(config-ipsec-crypto-ike)# lifetime <seconds>
tnsr(config-ipsec-crypto-ike)# no lifetime
nsr(config-ipsec-crypto-ike)# [no] proposal <number>
tnsr(config-ipsec-crypto-ike)# version (0|1|2)
tnsr(config-ipsec-crypto-ike)# no version
```

27.20.3 Remove IKE configuration

```bash
tnsr(config-ipsec-tun)# no crypto ike
```
27.21 IKE Peer Authentication Mode

27.21.1 Enter IKE Peer Authentication Mode

```bash
tnsr(config-ipsec-crypto-ike)# authentication (local|remote)
tnsr(config-ike-auth)#
```

27.21.2 IKE Peer Authentication Mode Commands

```bash
tnsr(config-ike-auth)# [no] round (1|2)
```

27.21.3 Remove IKE Peer Authentication Configuration

```bash
tnsr(config-ipsec-crypto-ike)# no authentication (local|remote)
```

27.22 IKE Peer Authentication Round Mode

27.22.1 Enter IKE Peer Authentication Round Mode

```bash
tnsr(config-ike-auth)# round (1|2)
tnsr(config-ike-auth-round)#
```

27.22.2 IKE Peer Authentication Round Mode Commands

```bash
tnsr(config-ike-auth-round)# type psk
tnsr(config-ike-auth-round)# no type
tnsr(config-ike-auth-round)# psk <pre-shared-key>
tnsr(config-ike-auth-round)# no psk
```

27.22.3 Remove IKE Peer Authentication Round Configuration

```bash
tnsr(config-ike-auth)# no round (1|2)
```

27.23 IKE Child SA Mode

27.23.1 Enter IKE Child SA Mode

```bash
tnsr(config-ipsec-crypto-ike)# child <name>
tnsr(config-ike-child)#
```
27.23.2 IKE Child SA Mode Commands

```
tnsr(config-ike-child)# lifetime <seconds>
tnsr(config-ike-child)# no lifetime
tnsr(config-ike-child)# [no] proposal <number>
```

27.23.3 Remove IKE Child SA

```
tnsr(config-ipsec-crypto-ike)# no child <name>
```

27.24 IKE Child SA Proposal Mode

27.24.1 Enter IKE Child SA Proposal Mode

```
tnsr(config-ike-child)# proposal <number>
tnsr(config-ike-child-proposal)#
```

27.24.2 IKE Child SA Proposal Mode Commands

```
tnsr(config-ike-child-proposal)# encryption <crypto-algorithm>
tnsr(config-ike-child-proposal)# no encryption
tnsr(config-ike-child-proposal)# integrity <integrity-algorithm>
tnsr(config-ike-child-proposal)# no integrity
tnsr(config-ike-child-proposal)# group <pfs-group>
tnsr(config-ike-child-proposal)# no group
tnsr(config-ike-child-proposal)# sequence-number (esn|noesn)
tnsr(config-ike-child-proposal)# no sequence-number
```

27.24.3 Remove IKE Child SA Proposal

```
tnsr(config-ike-child)# no proposal <number>
```

27.25 IKE Peer Identity Mode

27.25.1 Enter IKE Peer Identity Mode

```
tnsr(config-ipsec-crypto-ike)# identity (local|remote)
tnsr(config-ike-identity)#
```

27.25.2 IKE Peer Identity Mode Commands
27.25.3 Remove IKE Peer Identity Configuration

tnsr(config-ike-identity)# no type

27.26 IKE Proposal Mode

27.26.1 Enter IKE Proposal Mode

tnsr(config-ipsec-crypto-ike)# proposal <number>
tnsr(config-ike-proposal)#

27.26.2 IKE Proposal Mode Commands

tnsr(config-ike-proposal)# encryption <crypto-algorithm>
tnsr(config-ike-proposal)# no encryption
tnsr(config-ike-proposal)# integrity <integrity-algorithm>
tnsr(config-ike-proposal)# no integrity
tnsr(config-ike-proposal)# prf <prf-algorithm>
tnsr(config-ike-proposal)# no prf
tnsr(config-ike-proposal)# group <diffie-hellman-group>
tnsr(config-ike-proposal)# no group

27.26.3 Remove IKE Proposal Configuration

tnsr(config-ipsec-crypto-ike)# no proposal <number>

27.27 Map Mode

27.27.1 Enter Map Mode

tnsr(config)# nat nat64 map <domain-name>

27.27.2 Map Mode Commands
27.27.3 Remove Map Entry

tnsr(config)# [no] nat nat64 map <domain-name>

27.28 Map Parameters Mode

27.28.1 Enter Map Parameters Mode

tnsr(config)# nat nat64 map parameters

27.28.2 Map Parameters Mode Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr(config-map-param)# [no] fragment (inner</td>
<td>outer)</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] fragment ignore-df</td>
<td>Ignore DF option</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] icmp source-address &lt;ipv4-address&gt;</td>
<td>ICMP source address option</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] icmp6 unreachable-msgs (disable</td>
<td>enable)</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] pre-resolve (ipv4</td>
<td>ipv6) next-hop &lt;ip46-address&gt;</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] reassembly (ipv4</td>
<td>ipv6) (buffers</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] security-check (disable</td>
<td>enable)</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] security-check fragments (disable</td>
<td>enable)</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] traffic-class copy (disable</td>
<td>enable)</td>
</tr>
<tr>
<td>tnsr(config-map-param)# [no] traffic-class tc &lt;tc-value&gt;</td>
<td>Traffic class TC option</td>
</tr>
</tbody>
</table>

27.29 memif Mode

27.29.1 Enter memif Mode

tnsr(config)# interface memif interface <id>

27.29.2 memif mode Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tnsr(config-memif)#</td>
<td>Command for memif interface</td>
</tr>
</tbody>
</table>
27.29.3 Remove memif Interface

```
  tnsr(config)# no interface memif interface <id>
```

27.30 Dynamic Routing Access List Mode

27.30.1 Enter Dynamic Routing Access List Mode

```
  tnsr(config)# route dynamic access-list <access-list-name>
  tnsr(config-access-list)#
```

27.30.2 Dynamic Routing Access List Mode Commands

```
  tnsr(config-access-list)# [no] remark <rest>
  tnsr(config-access-list)# rule <seq#> (permit|deny) <ip-prefix>
  tnsr(config-access-list)# no rule <seq#> [(permit|deny) [<ip-prefix>]]
```

27.30.3 Remove Dynamic Routing Access List

```
  tnsr(config)# no route dynamic access-list <access-list-name>
```

27.31 Dynamic Routing Prefix List Mode

27.31.1 Enter Dynamic Routing Prefix List Mode

```
  tnsr(config)# route dynamic prefix-list <pl-name>
  tnsr(config-pref-list)#
```

27.31.2 Dynamic Routing Prefix List Mode Commands

```
  tnsr(config-pref-list)# [no] sequence <seq#> [(permit|deny) [le <upper-bound>] [ge <lower-bound>]]
  tnsr(config-pref-list)# description <desc...>
```
27.31.3 Remove Dynamic Routing Prefix List

```
tnsr(config)# no route dynamic prefix-list <pl-name>
```
27.32.3 Remove Dynamic Routing Route Map

```bash
tnsr(config-rt-map)# no route dynamic route-map <route-map-name>
```

27.32.4 Remove Dynamic Routing Route Map Rule

```bash
tnsr(config-rt-map)# no route dynamic route-map <route-map-name> [permit|deny]
```

27.32.5 Dynamic Routing Route Map Notes

- `<src-protocol>` is one of:
  - bgp - BGP protocol
  - connected - Routes from directly connected peer
  - kernel - Routes from kernel
  - static - Statically configured routes
  - system - Routes from system configuration

27.33 Dynamic Routing BGP Mode

27.33.1 Enter Dynamic Routing BGP Mode

```bash
tnsr(config)# route dynamic bgp
tnsr(config-frr-bgp)#
```
27.33.2 Dynamic Routing BGP Mode Commands

```plaintext
tenr(config-frr-bgp)# [no] as-path <as-path-name>
tenr(config-frr-bgp)# [no] community-list <comm-list-name> (standard|expanded)
[extended|large]
tenr(config-frr-bgp)# disable
tenr(config-frr-bgp)# [no] enable
tenr(config-frr-bgp)# [no] option debug (allow-martians|nht|update-groups)
tenr(config-frr-bgp)# [no] option debug as4 [segment]
tenr(config-frr-bgp)# [no] option debug bestpath <ipv6-prefix>
tenr(config-frr-bgp)# [no] option debug keepalive [<peer>]
tenr(config-frr-bgp)# [no] option debug neighbor-events [<peer>]
tenr(config-frr-bgp)# [no] option debug updates
[in <peer>|out <peer>|prefix (<ipv4-prefix>|<ipv6-prefix>)]
tenr(config-frr-bgp)# [no] option debug zebra [prefix (<ipv4-prefix>|<ipv6-prefix>)]
tenr(config-frr-bgp)# [no] server <asn>
tenr(config-frr-bgp)# [no] route-map delay-timer <interval-sec>
tenr(config-frr-bgp)# neighbor <if-name> <ip-address> <mac-address>
[no-adj-route-table-entry]
tenr(config-frr-bgp)# no neighbor <if-name> [<ip-address>
[<mac-address> [no-adj-route-table-entry]]
```

27.34 Dynamic Routing BGP Server Mode

27.34.1 Enter Dynamic Routing BGP Server Mode

```plaintext
tenr(config-frr-bgp)# server <asn>
tenr(config-bgp)#
```

27.34.2 Dynamic Routing BGP Server Mode Commands

```plaintext
tenr(config-bgp)# [no] address-family (ipv4|ipv6) (unicast|multicast|vpn|labeled-unicast)
tenr(config-bgp)# [no] address-family (vpnv4|vpnv6) unicast
ntenr(config-bgp)# [no] address-family <l2vpn evpn>
tenr(config-bgp)# [no] always-compare-med
tenr(config-bgp)# [no] bestpath as-path (confed|ignore|multipath-relax [as-set|no-as-set])
tenr(config-bgp)# [no] bestpath compare-routerid
tenr(config-bgp)# [no] bestpath med [confed|missing-as-worst]
tenr(config-bgp)# [no] client-to-client reflection
tenr(config-bgp)# [no] coalesce-time <uint32>
tenr(config-bgp)# [no] cluster-id (<ipv4>|<1..4294967295>)
tenr(config-bgp)# [no] confederation identifier <ASN>
tenr(config-bgp)# [no] confederation peer <ASN>
tenr(config-bgp)# [no] deterministic-med
tenr(config-bgp)# [no] disable-ebgp-connected-route-check
tenr(config-bgp)# [no] enforce-first-as
tenr(config-bgp)# [no] listen limit <1-5000>
tenr(config-bgp)# [no] listen range (<ipv4-prefix>|<ipv6-prefix>) peer-group <peer-group-name>
```

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```
tnsr(config-bgp)# [no] max-med administrative [med-value]
tnsr(config-bgp)# [no] max-med on-startup period <secs-(5-86400)> [med-value]
tnsr(config-bgp)# [no] neighbor <peer>
tnsr(config-bgp)# [no] network import-check
tnsr(config-bgp)# [no] route-reflector allow-outbound-policy
tnsr(config-bgp)# [no] router-id <A.B.C.D>
tnsr(config-bgp)# [no] timers keep-alive <interval> hold-time <hold-time>
tnsr(config-bgp)# [no] update-delay <delay>
tnsr(config-bgp)# [no] write-quanta <num-of-packets>
```

### 27.34.3 Remove Dynamic Routing BGP Server

```
tnsr(config-frr-bgp)# no server <asn>
```

### 27.35 Dynamic Routing BGP Neighbor Mode

#### 27.35.1 Enter Dynamic Routing BGP Neighbor Mode

```
tnsr(config-bgp)# neighbor <peer>
tnsr(config-bgp-neighbor)#
```

#### 27.35.2 Dynamic Routing BGP Neighbor Mode Commands

```
tnsr(config-bgp-neighbor)# [no] advertisement-interval <interval-sec-0-600>
tnsr(config-bgp-neighbor)# [no] capability (dynamic|extended-nexthop)
tnsr(config-bgp-neighbor)# [no] disable-connected-check
tnsr(config-bgp-neighbor)# [no] description <string>
tnsr(config-bgp-neighbor)# disable
tnsr(config-bgp-neighbor)# [no] dont-capability-negotiate
tnsr(config-bgp-neighbor)# [no] ebgp-multihop [hop-maximum <max-hop-count-1-255>]
tnsr(config-bgp-neighbor)# [no] enable
tnsr(config-bgp-neighbor)# [no] enforce-multihop
tnsr(config-bgp-neighbor)# [no] local-as <asn> [no-prepend [replace-as]]
tnsr(config-bgp-neighbor)# [no] override-capability
tnsr(config-bgp-neighbor)# [no] passive
tnsr(config-bgp-neighbor)# [no] password <line>
tnsr(config-bgp-neighbor)# [no] peer-group [<peer-group-name>]
tnsr(config-bgp-neighbor)# [no] port <port>
tnsr(config-bgp-neighbor)# [no] remote-as <asn>
tnsr(config-bgp-neighbor)# [no] solo
tnsr(config-bgp-neighbor)# [no] strict-capability-match
tnsr(config-bgp-neighbor)# [no] timers keepalive <interval-0-65535> holdtime <hold-0-65535>
tnsr(config-bgp-neighbor)# [no] timers connect <bgp-connect-1-65535>
tnsr(config-bgp-neighbor)# [no] ttl-security hops <n-hops>
tnsr(config-bgp-neighbor)# [no] update-source (<ifname>|<ip-address>)
```
27.35.3 Remove Dynamic Routing BGP Neighbor

tnsr(config-bgp)# no neighbor <peer>

27.36 Dynamic Routing BGP Address Family Mode

27.36.1 Enter Dynamic Routing BGP Address Family Mode

tnsr(config-bgp)# address-family ipv4 unicast
tnsr(config-bgp-ip4uni)#

tnsr(config-bgp)# address-family ipv4 multicast
tnsr(config-bgp-ip4multi)#

tnsr(config-bgp)# address-family ipv6 unicast
tnsr(config-bgp-ip6uni)#

tnsr(config-bgp)# address-family ipv6 multicast
tnsr(config-bgp-ip6multi)#

27.36.2 Dynamic Routing BGP IPv4 Unicast Address Family Mode Commands

tnsr(config-bgp-ip4uni)# [no] aggregate-address <ipv4-prefix> [as-set] [summary-only]
tnsr(config-bgp-ip4uni)# [no] distance external <extern> internal <intern> local
    →<local>
tnsr(config-bgp-ip4uni)# [no] distance administrative <dist> prefix <ipv4-prefix>
    access-list <access-list-name>
tnsr(config-bgp-ip4uni)# [no] maximum-paths <non-ibgp-paths> [igbp <ibgp-paths>
    →[equal-cluster-length]]
tnsr(config-bgp-ip4uni)# [no] neighbor <existing-neighbor>
tnsr(config-bgp-ip4uni)# [no] network <ipv4-prefix> [route-map <route-map>]
    →[label-index <index>]
tnsr(config-bgp-ip4uni)# [no] redistribute <route-source> [metric <val>]
    →[route-map <route-map-name>]
tnsr(config-bgp-ip4uni)# [no] redistribute table id <kernel-table-id> [metric <val>]
    →[route-map <route-map-name>]

27.36.3 Dynamic Routing BGP IPv4 Multicast Address Family Mode Commands

tnsr(config-bgp-ip4multi)# [no] aggregate-address <ipv4-prefix> [as-set] [summary-only]
tnsr(config-bgp-ip4multi)# [no] distance external <extern> internal <intern> local
    →<local>
tnsr(config-bgp-ip4multi)# [no] distance administrative <dist> prefix <ipv4-prefix>
    access-list <access-list-name>
tnsr(config-bgp-ip4multi)# [no] neighbor <existing-neighbor>

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27.36.4 Dynamic Routing BGP IPv6 Unicast Address Family Mode Commands

```
tnsr(config-bgp-ip6uni)# [no] aggregate-address <ipv4-prefix> [as-set] [summary-only]
tnsr(config-bgp-ip6uni)# [no] distance external <extern> internal <intern> local <local>
tnsr(config-bgp-ip6uni)# [no] distance administrative <dist> prefix <ipv4-prefix>
  access-list <access-list-name>
tnsr(config-bgp-ip6uni)# [no] maximum-paths <non-ibgp-paths> [igbp <ibgp-paths>
  [equal-cluster-length]]
tnsr(config-bgp-ip6uni)# [no] neighbor <existing-neighbor>
tnsr(config-bgp-ip6uni)# [no] network <ipv4-prefix> [route-map <route-map>]
  [label-index <index>]
tnsr(config-bgp-ip6uni)# [no] redistribute <route-source> [metric <val>|route-map <route-map>]
tnsr(config-bgp-ip6uni)# [no] redistribute table id <kernel-table-id> [metric <val>
  |route-map <route-map-name>]
tnsr(config-bgp-ip6uni)# [no] table-map <route-map-name>
```
27.37 Dynamic Routing BGP Address Family Neighbor Mode

**Note:** Though the samples below indicate IPv4 unicast, the same syntax is used for all address families.

### 27.37.1 Enter Dynamic Routing BGP Address Family Neighbor Mode

```plaintext
tnsr(config-bgp-ip4uni)# neighbor <existing-neighbor>
tnsr(config-bgp-ip4uni-nbr)#
```

### 27.37.2 Dynamic Routing BGP Address Family Neighbor Mode Commands

```plaintext
tnsr(config-bgp-ip4uni-nbr)# [no] activate
tnsr(config-bgp-ip4uni-nbr)# [no] addpath-tx-all-paths
tnsr(config-bgp-ip4uni-nbr)# [no] addpath-tx-bestpath-per-as
tnsr(config-bgp-ip4uni-nbr)# [no] allowas-in [occurrence-1-10]|<origin>
tnsr(config-bgp-ip4uni-nbr)# [no] as-override
tnsr(config-bgp-ip4uni-nbr)# [no] attribute-unchanged [as-path|next-hop|med]
tnsr(config-bgp-ip4uni-nbr)# [no] capability orf prefix-list (send|receive|both)
tnsr(config-bgp-ip4uni-nbr)# [no] default-originate [route-map <route-map>]
tnsr(config-bgp-ip4uni-nbr)# [no] distribute-list <access-list-name> (in|out)
tnsr(config-bgp-ip4uni-nbr)# [no] filter-list <access-list-name> (in|out)
tnsr(config-bgp-ip4uni-nbr)# [no] maximum-prefix limit <val-1-4294967295>
tnsr(config-bgp-ip4uni-nbr)# [no] maximum-prefix restart <val-1-65535>
tnsr(config-bgp-ip4uni-nbr)# [no] maximum-prefix threshold <val-1-100>
tnsr(config-bgp-ip4uni-nbr)# [no] maximum-prefix warning-only
tnsr(config-bgp-ip4uni-nbr)# [no] next-hop-self [force]
tnsr(config-bgp-ip4uni-nbr)# [no] prefix-list <prefix-list-name> (in|out)
tnsr(config-bgp-ip4uni-nbr)# [no] remove-private-AS [all] [replace-AS]
tnsr(config-bgp-ip4uni-nbr)# [no] route-map <name> (in|out)
tnsr(config-bgp-ip4uni-nbr)# [no] route-reflector-client
```

### 27.37.3 Remove Dynamic Routing BGP Address Family Neighbor

```plaintext
tnsr(config-bgp-ip4uni)# no neighbor <existing-neighbor>
```

27.38 Dynamic Routing BGP Community List Mode

### 27.38.1 Enter Dynamic Routing BGP Community List Mode

```plaintext
tnsr(config-frr-bgp)# community-list <cl-name> (standard|expanded) [extended|large]
tnsr(config-community)#
```
27.38.2 Dynamic Routing BGP Community List Mode Commands

- `tnsr(config-community)# description <desc...>`
- `tnsr(config-community)# sequence <seq> (permit|deny) <community-value>`
- `tnsr(config-community)# no description [<desc...>]
- `tnsr(config-community)# no sequence <seq> [(permit|deny) <community-value>]

27.38.3 Remove Dynamic Routing BGP Community List

- `tnsr(config-frr-bgp)# no community-list <cl-name> (standard|expanded) [extended|large]

27.39 Dynamic Routing BGP AS Path Mode

27.39.1 Enter Dynamic Routing BGP AS Path Mode

- `tnsr(config-frr-bgp)# as-path <as-path-name>
- `tnsr(config-aspath)#`

27.39.2 Dynamic Routing BGP AS Path Mode Commands

- `tnsr(config-aspath)# [no] rule <seq> (permit|deny) <pattern>

27.39.3 Remove Dynamic Routing BGP AS Path

- `tnsr(config-frr-bgp)# no as-path <as-path-name>

27.40 Dynamic Routing Manager Mode

27.40.1 Enter Dynamic Routing Manager Mode

- `tnsr(config)# route dynamic manager
- `tnsr(config-route-dynamic-manager)#`

27.40.2 Dynamic Routing Manager Mode Commands

- `tnsr(config-route-dynamic-manager)# [no] debug (events|fpm|nht)
- `tnsr(config-route-dynamic-manager)# [no] debug kernel [msgdump [send|receive]]
- `tnsr(config-route-dynamic-manager)# [no] debug packet [send|receive] [detailed]
- `tnsr(config-route-dynamic-manager)# [no] debug rib [detailed]
- `tnsr(config-route-dynamic-manager)# [no] log file <filename> [<level>]
- `tnsr(config-route-dynamic-manager)# [no] log syslog [<level>]`
27.41 IPv4 Route Table Mode

27.41.1 Enter IPv4 Route Table Mode

```
tnsr(config)# route ipv4 table <route-table-name>
tnsr(config-route-table-v4)#
```

27.41.2 IPv4 Route Table Mode Commands

```
tnsr(config-route-table-v4)# description <rest-of-line>
tnsr(config-route-table-v4)# [no] route <destination-prefix>
```

27.41.3 Remove IPv4 Route Table

```
tnsr(config-route-table-v4)# no route ipv4 table <route-table-name>
```

27.42 IPv6 Route Table Mode

27.42.1 Enter IPv6 Route Table Mode

```
tnsr(config)# route ipv6 table <route-table-name>
tnsr(config-route-table-v6)#
```

27.42.2 IPv6 Route Table Mode Commands

```
tnsr(config-route-table-v6)# description <rest-of-line>
tnsr(config-route-table-v6)# [no] route <destination-prefix>
```

27.42.3 Remove IPv6 Route Table

```
tnsr(config-route-table-v6)# no route ipv6 table <route-table-name>
```

27.43 IPv4 or IPv6 Next Hop Mode

27.43.1 Enter IPv4 or IPv6 Next Hop Mode

```
tnsr(config-route-table-v46)# route <destination-prefix>
tnsr(config-rttbl46-next-hop)#
```

27.41. IPv4 Route Table Mode
27.43.2 IPv4 or IPv6 Next Hop Mode Commands

```
tnsr(config-rttbl46-next-hop)# [no] description <rest-of-line>
tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> via <ip46-addr>
    [<if-name>|<next-hop-table <route-table-name>>]
    [weight <multi-path-weight>]
    [preference <admin-preference>]
    [resolve-via-host] [resolve-via-attached]

tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> via drop

tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> via local

tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> via null-send-unreach

tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> via null-send-prohibit

tnsr(config-rttbl46-next-hop)# [no] next-hop <hop-id> classify <classify-table-name>

```

27.43.3 Remove IPv4 or IPv6 Next Hop

```
tnsr(config-rttbl46-next-hop)# no next-hop <hop-id>
```

27.44 SPAN Mode

27.44.1 Enter SPAN Mode

```
tnsr(config)# span <if-name-src>
tnsr(config-span)#
```

27.44.2 SPAN Mode Commands

```
tnsr(config-span)# onto <if-name-dst> (hw|l2) (rx|tx|both|disabled)
```

27.44.3 Remove Single SPAN Destination

```
tnsr(config-span)# no onto <if-name-dst> [(hw|l2)]
```

27.44.4 Remove SPAN

```
tnsr(config)# no span <if-name-src>
```
27.45 VXLAN Mode

27.45.1 Enter VXLAN Mode

```bash
tnsr(config)# vxlan <tunnel-name>
tnsr(config-vxlan)#
```

27.45.2 VXLAN Mode Commands

```bash
tnsr(config-vxlan)# [no] destination <ip-addr>
tnsr(config-vxlan)# [no] encapsulation (ipv4|ipv6) route-table <rt-table-name>
tnsr(config-vxlan)# [no] instance <id>
tnsr(config-vxlan)# [no] multicast interface <if-name>
tnsr(config-vxlan)# [no] source <ip-addr>
tnsr(config-vxlan)# [no] vni <u24>
```

27.45.3 Remove VXLAN Tunnel

```bash
tnsr(config)# no vxlan [<tunnel-name>]
```

27.46 User Authentication Configuration Mode

27.46.1 Enter User Authentication Configuration Mode

```bash
tnsr(config)# auth user <user-name>
tnsr(config-user)#
```

27.46.2 User Authentication Mode Commands

```bash
tnsr(config-user)# [no] password <user-password>
tnsr(config-user)# [no] user-keys <key-name>
```

27.46.3 Remove User

```bash
tnsr(config)# no auth user <user-name>
```

27.47 NTP Configuration Mode

27.47.1 Enter NTP Configuration Mode

```bash
tnsr(config)# ntp server
tnsr(config-ntp)#
```
27.47.2 NTP Mode Commands

```bash
tnsr(config-ntp)# disable monitor
tnsr(config-ntp)# enable monitor
tnsr(config-ntp)# driftfile <file-path>
tnsr(config-ntp)# interface sequence <seq> (drop|ignore|listen)
   (all|interface <if-name>|prefix <ip-prefix>)
tnsr(config-ntp)# logconfig sequence <seq> (add|delete|set)
   (all|clock|peer|sync|sys) (all|events|info|statistics|status)
tnsr(config-ntp)# restrict (default|host <fqdn>|prefix <ip-prefix>|source)
tnsr(config-ntp)# server (address <ip-address>|host <fqdn>)
tnsr(config-ntp)# statsdir <directory-path>
tnsr(config-ntp)# tinker panic <n-secs>
tnsr(config-ntp)# tos orphan <stratum>
```

27.47.3 Remove NTP Server

```bash
tnsr(config)# no ntp server
```

27.48 NTP Restrict Mode

27.48.1 Enter NTP Restrict Mode

```bash
tnsr(config-ntp)# restrict (default|host <fqdn>|prefix <ip-prefix>|source)
```

27.48.2 NTP Restrict Mode Commands

```bash
tnsr(config-ntp-restrict)# kod
tnsr(config-ntp-restrict)# limited
tnsr(config-ntp-restrict)# nomodify
tnsr(config-ntp-restrict)# nopeer
tnsr(config-ntp-restrict)# noquery
tnsr(config-ntp-restrict)# noserve
tnsr(config-ntp-restrict)# notrap
```

27.48.3 Remove NTP Restriction

```bash
tnsr(config-ntp)# no restrict (default|host <fqdn>|prefix <ip-prefix>|source)
```

27.49 NTP Upstream Server Mode

27.49.1 Enter NTP Upstream Server Mode

```bash
tnsr(config-ntp)# server (address <ip-address>|host <fqdn>)
```
27.49.2 NTP Upstream Server Mode Commands

```
tnsr(config-ntp-server)# iburst
 tnsr(config-ntp-server)# maxpoll <power-of-2-sec>
 tnsr(config-ntp-server)# noselect
 tnsr(config-ntp-server)# operational-mode (pool|server)
 tnsr(config-ntp-server)# prefer
```

27.49.3 Remove NTP Upstream Server

```
tnsr(config-ntp)# no server (address <ip-address>|host <fqdn>)
```

27.50 NACM Group Mode

27.50.1 Enter NACM Group Mode

```
tnsr(config)# nacm group <group-name>
 tnsr(config-nacm-group)#
```

27.50.2 NACM Group Mode Commands

```
tnsr(config-nacm-group)# [no] member <user-name>
```

27.50.3 Remove NACM Group

```
tnsr(config)# no nacm group <group-name>
```

27.51 NACM Rule-list Mode

27.51.1 Enter NACM Rule-list Mode

```
tnsr(config)# nacm rule-list <rule-list-name>
 tnsr(config-nacm-rule-list)#
```

27.51.2 NACM Rule-list Mode Commands

```
tnsr(config-nacm-rule-list)# [no] group (>*</group-name>)
 tnsr(config-nacm-rule-list)# [no] rule <rule-name>
```
27.51.3 Remove NACM Rule-list

```bash
tnsr(config)# no nacm rule-list <rule-list-name>
```

27.52 NACM Rule Mode

27.52.1 Enter NACM Rule Mode

```bash
tnsr(config-nacm-rule-list)# rule <rule-name>
tnsr(config-nacm-rule)#
```

27.52.2 NACM Rule Mode Commands

```bash
tnsr(config-nacm-rule)# [no] access-operations (*|create|read|update|delete|exec)
tnsr(config-nacm-rule)# [no] action (deny|permit)
tnsr(config-nacm-rule)# [no] module (*|<module-name>)
tnsr(config-nacm-rule)# [no] comment <rest>
tnsr(config-nacm-rule)# [no] rpc (*|<rpc-name>)
tnsr(config-nacm-rule)# [no] notification (*|<notification-name>)
tnsr(config-nacm-rule)# [no] path <node-id>
```

27.52.3 Remove NACM Rule

```bash
tnsr(config-nacm-rule-list)# no rule <rule-name>
```

27.53 DHCP IPv4 Server Config Mode

27.53.1 Enter DHCP IPv4 Server Mode

```bash
tnsr(config)# [no] dhcp4 server
tnsr(config)# dhcp4 {disable|enable}
tnsr(config)# no dhcp4 enable
tnsr(config-kea-dhcp4)#
```

27.53.2 DHCP IPv4 Server Mode Commands

```bash
tnsr(config-kea-dhcp4)# [no] decline-probation-period <seconds>
tnsr(config-kea-dhcp4)# [no] description <desc>
tnsr(config-kea-dhcp4)# [no] echo-client-id <boolean>
tnsr(config-kea-dhcp4)# [no] interface listen <if-name>
tnsr(config-kea-dhcp4)# [no] interface listen *
tnsr(config-kea-dhcp4)# [no] interface socket (raw|udp)
tnsr(config-kea-dhcp4)# [no] lease filename <filename>
tnsr(config-kea-dhcp4)# [no] lease lifc-interval <seconds>
```

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27.53.3 Remove DHCP IPv4 Server Configuration

```bash
tnsr(config)# no dhcp4 server
```

27.54 DHCP4 Subnet4 Mode

27.54.1 Enter DHCP4 Subnet4 Mode

```bash
tnsr(config-kea-dhcp4)# subnet <ipv4-prefix>
tnsr(config-kea-subnet4)#
```

27.54.2 DHCP4 Subnet4 Mode Commands

```bash
tnsr(config-kea-subnet4)# [no] id <uint32>
tnsr(config-kea-subnet4)# [no] option <dhcp4-option>
tnsr(config-kea-subnet4)# [no] pool <ipv4-prefix>|<ipv4-range>
tnsr(config-kea-subnet4)# [no] interface <if-name>
```

27.54.3 Remove DHCP4 IPv4 Subnet4 Configuration

```bash
tnsr(config-kea-dhcp4)# no subnet <ipv4-prefix>|<ipv4-range>
```

27.55 DHCP4 Subnet4 Pool Mode

27.55.1 Enter DHCP4 Subnet4 Pool Mode

```bash
tnsr(config-kea-subnet4)# pool <ipv4-prefix>|<ipv4-range>
tnsr(config-kea-subnet4-pool)#
```

27.55.2 DHCP4 Subnet4 Pool Mode Commands

```bash
tnsr(config-kea-subnet4-pool)# [no] option <dhcp4-option>
```
27.55.3 Remove DHCP4 IPv4 Subnet4 Pool

```
tnsr(config-kea-subnet4)# no pool <ipv4-prefix>|<ipv4-range>
```

27.56 DHCP4 Subnet4 Reservation Mode

27.56.1 Enter DHCP4 Subnet4 Reservation Mode

```
tnsr(config-kea-subnet4)# reservation <ipv4-address>
tnsr(config-kea-subnet4-reservation)#
```

27.56.2 DHCP4 Subnet4 Reservation Mode Commands

```
tnsr(config-kea-subnet4-reservation)# [no] hostname <hostname>
tnsr(config-kea-subnet4-reservation)# [no] mac-address <mac-address>
tnsr(config-kea-subnet4-reservation)# [no] option <dhcp4-option>
```

27.56.3 Remove DHCP4 IPv4 Subnet4 Reservation

```
tnsr(config-kea-subnet4)# no reservation <ipv4-address>
```

27.57 Kea DHCP4, Subnet4, Pool, or Reservation Option Mode

27.57.1 Enter DHCP4 Option Mode

```
tnsr(config-kea-*)# option <dhcp4-option>
tnsr(config-kea-*>*opt)#
```

27.57.2 DHCP4 Option Mode Commands

```
tnsr(config-kea-*>*opt)# [no] always-send <boolean>
tnsr(config-kea-*>*opt)# [no] csv-format <boolean>
tnsr(config-kea-*>*opt)# [no] data <option-data>
tnsr(config-kea-*>*opt)# [no] space <space-name>
```

27.57.3 Remove DHCP4 Option Configuration

```
tnsr(config-kea-*)# no option <dhcp4-option>
```
27.58 Unbound Server Mode

27.58.1 Enter Unbound Server Mode

```bash
tnsr(config)# unbound server
tnsr(config-unbound)#
```

27.58.2 Unbound Server Mode Commands

```bash
tnsr(config-unbound)# disable (caps-for-id | harden (dnssec-stripped|glue) | hide (version|identity) | ip4 | ip6 | message prefetch | serve-expired | tcp | udp)

tnsr(config-unbound)# edns reassembly size <s>

tnsr(config-unbound)# enable (caps-for-id | harden (dnssec-stripped|glue) | hide (version|identity) | ip4 | ip6 | message prefetch | serve-expired | tcp | udp)

tnsr(config-unbound)# forward-zone <zone-name>

tnsr(config-unbound)# host cache (num-hosts <num> | slabs <s> | ttl <t>)

tnsr(config-unbound)# interface <ip4-address>

tnsr(config-unbound)# jostle timeout <t>

tnsr(config-unbound)# key cache slabs <s>

tnsr(config-unbound)# message cache (size <s> | slabs <s>)

tnsr(config-unbound)# port outgoing range <n>

tnsr(config-unbound)# rrsset cache (size <s> | slabs <s>)

tnsr(config-unbound)# rrsset-message cache ttl (minimum <min> | maximum <max>)

tnsr(config-unbound)# socket receive-buffer size <s>

tnsr(config-unbound)# tcp buffers (incoming <n> | outgoing <n>)

tnsr(config-unbound)# thread (num-queries <n> | num-threads <n> | unwanted-reply-threshold <threshold>)

tnsr(config-unbound)# verbosity <level-0..5>
```

27.58.3 Remove Unbound Server

```bash
tnsr(config)# no unbound server
```

27.59 Unbound Forward-Zone Mode

27.59.1 Enter Unbound Forward-Zone Mode

```bash
tnsr(config-unbound)# forward-zone <zone-name>

tnsr(config-unbound-fwd-zone)#
```

27.59.2 Unbound Forward-Zone Mode Commands

```bash
tnsr(config-unbound-fwd-zone)# disable (forward-first | forward-tls-upstream)

tnsr(config-unbound-fwd-zone)# enable (forward-first | forward-tls-upstream)
```

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27.59.3 Remove Unbound Forward-Zone Zone

```bash
tnsr(config-unbound)# no forward-zone <zone-name>
```

27.60 Subif Mode

27.60.1 Enter Subif Mode

```bash
tnsr(config)# interface subif <if-name> <subid>
tnsr(config-subif)#
```

27.60.2 Subif Mode Commands

```bash
tnsr(config-subif)# default
tnsr(config-subif)# dot1q (<outer-vlan-id>|any)
tnsr(config-subif)# exact-match
nsr(config-subif)# inner-dot1q (inner-vlan-id>|any)
tnsr(config-subif)# outer-dot1ad (<outer-vlan-id>|any)
tnsr(config-subif)# outer-dot1q (<outer-vlan-id>|any)
```

27.60.3 Remove Subif

```bash
tnsr(config)# no interface subif <if-name> <subid>
```

27.61 Bond Mode

27.61.1 Enter Bond Mode

```bash
tnsr(config)# interface bond <instance>
tnsr(config-bond)#
```

27.61.2 Bond Mode Commands

```bash
tnsr(config-bond)# [no] load-balance {l2|l23|l34}
tnsr(config-bond)# [no] mode {round-robin|active-backup|xor|broadcast|lACP}
tnsr(config-bond)# [no] mac-address <mac-address>
```
27.61.3 Remove Bond

```
tnsr(config)# no interface bond <instance>
```

27.62 Host ACL Mode

27.62.1 Enter Host ACL Mode

```
tnsr(config)# host acl <acl-name>
tnsr(config-host-acl)#
```

27.62.2 Host ACL Mode Commands

```
tnsr(config-host-acl)# [no] description <text>
tnsr(config-host-acl)# [no] rule <rule-seq>
tnsr(config-host-acl)# [no] sequence <acl-seq>
```

27.62.3 Remove Host ACL

```
tnsr(config)# no host acl <acl-name>
```

27.63 Host ACL Rule Mode

27.63.1 Enter Host ACL Rule Mode

```
tnsr(config-host-acl)# rule <rule-seq>
tnsr(config-host-acl-rule)#
```

27.63.2 Host ACL Rule Mode Commands

```
tnsr(config-host-acl-rule)# [no] action (deny|permit)
tnsr(config-host-acl-rule)# [no] description <text>
tnsr(config-host-acl-rule)# [no] match input-interface <host-interface>
tnsr(config-host-acl-rule)# [no] match ip address (source|destination) <ip-addr>
tnsr(config-host-acl-rule)# [no] match ip icmp type
  (address-mask-reply|address-mask-request|destination-unreachable|
   echo-reply|echo-request|info-reply|info-request|parameter-problem|
   redirect|router-advertisement|router-solicitation|source-quench|
   time-exceeded|timestamp-reply|timestamp-request) [code <code>]
tnsr(config-host-acl-rule)# [no] match ip icmpv6 type
```

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| (destination-unreachable|echo-reply|echo-request|        
| mld-listener-query|mld-listener-reduction|mld-listener-        
| →report|        
| nd-neighbor-advert|nd-neighbor-solicit|nd-redirect|        
| nd-router-advert|nd-router-solicit|packet-too-big|        
| parameter-problem|router-renumbering|time-exceeded)|        

→[code <code>]

tnsr(config-host-acl-rule)# [no] match ip port (source|destination) <port-num>

| tnsr(config-host-acl-rule)# [no] match ip port (source|destination) range start <low-        
| →port-num>        
| [end <high-port-num>]        

| tnsr(config-host-acl-rule)# [no] match ip protocol (icmp|tcp|udp)        
| tnsr(config-host-acl-rule)# [no] match ip tcp flag (ack|cwr|ece|fin|psh|rst|syn|urg)        
| tnsr(config-host-acl-rule)# [no] match ip version (4|6)        
| tnsr(config-host-acl-rule)# [no] match mac address (source|destination) <mac>        

27.63.3 Remove Host ACL Rule

tnsr(config-host-acl)# no rule <rule-seq>
In addition to the CLI, there are a variety of ways to configure TNSR, including a RESTful API.

### 28.1 YANG Data Models

The sets of functions and procedures used to manipulate the TNSR configuration are generated from the RFC 7950 data models defined in the TNSR YANG models.

### 28.2 RESTCONF API

TNSR can be controlled via a RESTCONF API. Reference material, code examples, and more on the RESTCONF API may be found in the TNSR API Documentation.
29.1 TNSR 19.05 Release Notes

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29.1.1 About This Release

General

- Added support for QAT C62x crypto devices [1718]
- Added service management RPCs to data model [1715]

ACL

- Fixed creating an ACL using only a description [1558]
- Fixed creating an empty ACL [1735]
- Fixed creating an ACL rule with a destination port [1796]

BGP

- IPv6 BGP neighbors get entered as peer-groups only in bgpd.conf [1190]
- Removed deprecated neighbor <peer> interface <if> BGP command [2113]
- Restructured BGP address family configuration to accommodate IPv4 and IPv6 [2049]
- Removed option to create a new neighbor inside address family mode [2194]
- Removed route-map set metric options for +/- rtt and +/- metric as they were not supported as users expected in FRR [2191]

CLI

- [no] shutdown style syntax has been removed. Use enable and disable, or no enable [1652]
- Fixed paging issues in output that could lead to incorrect or missing output after certain actions taken with multi-page output (e.g. pressing q or Enter at a More prompt) [1774, 1773]
• The CLI now stores command history between sessions *(Command History)* [514, 1949]
• Standardized commands to enabled coredumps for services, and added support for coredumps from ike, unbound, http, and ntp *(Diagnosing Service Issues)* [1831]
• Fixed ping so it can work with IPv6 source addresses [2004]
• Improved CLI performance when working with large lists [2127]
• Increased timeout for package commands to allow longer processes to finish completely, such as upgrades [1768]

Dataplane

• Fixed writing default values to the dataplane configuration when no dataplane options are set in the configuration [1982]
• Fixed dataplane crashes when using NAT with forwarding enabled with certain packet combinations when the protocol is not ICMP, TCP, or UDP [1998]
• Mellanox support: Added option to disable multi-segment buffers in the dataplane [2022]
• Fixed an error when configuring a dataplane crypto device without first configuring the UIO driver [1812]
• Added worker thread and core affinity options [1675]
• Added an option to set custom interface names for dataplane interfaces [2062]
• Added commands to configure dataplane statistics segment options [2199]

DHCP

• The DHCP server can now function when an interface is configured as a DHCP client [1801]
• DHCP server no longer uses link-local interface IP addresses (169.254.0.x) as a source address for DHCP packets or as a DHCP Server Identifier [1222]
• Removed incorrect references to the netgate-interface module from the DHCP server CLI specification API paths [1810]
• Removed redundant ipv4 forms of DHCP-related commands [1557]

Host ACLs

• Added support for Host ACLs to control traffic to host OS interfaces using nftables [1651]

HTTP Server / RESTCONF

• nginx now behaves as expected with authentication type none and TLS [1086]

Warning: This mode is intended only for testing, not production use.

• Fixed RESTCONF get of /restconf/data/ so it properly returns state data [1534]
Installer

- Improved consistency in post-install login procedures across all TNSR platforms [2013]
- Fixed installation issues on hardware that has an eMMC device, such as the SG-5100 [2048]
- Fixed the default NACM configuration when installing from ISO [2133]
- Added Infiniband/rdma packages to the default installation [2201]

Interfaces

- An interface can now be deleted if it had an ACL or MACIP applied [1177, 1178]
- MACIP ACLs no longer remain in the interface configuration after being removed [1179]
- Bond interfaces in LACP mode no longer send LACPDUs when configured for passive mode [1614]
- VLAN tag rewrite settings have been relocated to interfaces, as they do not require a subinterface [1344]
- VXLAN validation now properly reflects that a VXLAN entry requires a VNI [1821]
- GRE and VXLAN now create interfaces on the host [1999]
- Fixed display of link speeds for 40G and 100G interfaces [1867]
- Removed unused “Admin status” field from state information for host interfaces [1864]
- Fixed interface counters for Mellanox interfaces [2039]
- Fixed interface counters for IPsec interfaces [2075]
- VLAN tag-rewrite attributes are now included in show interface output [1654]
- Changed show interfaces to output interfaces in a consistent order [2046]
- Fixed a problem with neighbor location (ARP/NA) when VLAN tags are present [1326]
- Fixed default handling of VMXNET3 interfaces [1703]

IPsec

- Added support for the 3DES encryption algorithm in IPsec proposals [1444]

NACM

- NACM now supports all access operations and module restrictions (NACM Rule Lists) [1809]
- The method to manually disable NACM has changed. Regaining Access if Locked Out by NACM has been updated to reflect the new method [1750, 1752]

NAT

- DS-Lite B4 endpoint is now shown in the output of show dslite [1625]
- NAT sessions may now be queried with show nat sessions [verbose] (View NAT Sessions) [975, 1456]
- Fixed issues with NAT and multiple worker threads [1844]
- NAT mode deletion is now properly respected in VPP startup configuration after TNSR services restart [1017]
• Fixed incorrect NAT static mappings being added when a new rule differed from an existing rule only by the port-local value [1100]

29.1.2 Known Limitations

Updates

• The UIO drivers may not be present in the correct directory after a kernel upgrade. Since the UIO drivers are kernel-specific, they must be rebuilt after any change in the kernel [2216]

To work around this issue, force a reinstall of the DPDK package which will rebuild the UIO drivers and place them in the appropriate location for the updated kernel:

$ sudo yum -y reinstall dpdk

ACLs

• ACLs used with access-list output do not work on traffic sent to directly connected hosts [2057]

BFD

• Attempting to change a BFD local/peer address fails [1549]
• BFD cannot be administratively disabled via CLI [1883]
• The BFD delayed option does not work [1885]
• An unused BFD conf-key cannot be modified [1891]
• BFD does not integrate with BGP [2106]

BGP

• TNSR does not send BGP updates without restarting service with redistribute from connected option [746]
• Route with aggregate-address via next-hop 0.0.0.0 does not appear in TNSR route table [832]
• BGP sessions may fail to establish or rapidly reconnect when receiving more prefixes than defined by maximum-prefix limit [858]
• The maximum-prefix restart command does not work [859]
• TNSR installs multiple paths for received routes even though support for multiple paths is not enabled [885]
  Workaround: Run systemctl reset-failed frr from the shell to clear the error which will allow the BGP service to start again.
• Changing update-source from an IP address to loop1 allows a session to establish but remote prefixes do not appear in the FIB until reboot [1104]
• BGP import-check feature does not work [781]
• Logs may include spurious BGP message binary API client 'route_daemon' died which do not affect BGP routing [1714]
CLI

- `show route table` causes the backend to die with large numbers of routes in the table [506]
  For example, this crash happens with a full BGP feed.
- Using `service dataplane restart` can cause clixon_backend to lose its configuration [1383]
- Large lists (e.g. 10,000+ ACLs) can cause significant delays in related CLI operations [2139]

DHCP

- Adding a DHCP reservation without a MAC address causes Kea to fail and the entry cannot be removed [1530]
  Workaround: A MAC address is required for DHCP reservations, so always enter a MAC address when creating an entry.
- Configuring Kea to log all names with `*` does not work [1307]
  Workaround: Configure each name separately instead of using a wildcard.

DNS

- Local zone FQDN handling for forward (A) and reverse (PTR) data is inconsistent, only allowing one or the other to work as expected for a given FQDN [1384]
- Using the `allow_setrd` attribute for access-control entries causes unbound to fail [1747]
- Unbound requires a default route in the host OS to resolve [1884]

Host ACLs

- Host ACL entries are duplicated after a dataplane restart [2207]

HTTP Server / RESTCONF

- HTTP server runs even though it’s not configured to run after TNSR services restart [1153]
  Workaround: Manually stop the `nginx` service using `systemctl`.
- RESTCONF query replies may contain CDATA tags in JSON [1463]
- Adding an ACL rule entry via RESTCONF may appear to add a duplicate ACL [1238]

Interfaces

- Loopback interface responds to ICMP echo from an outside host even when in a Down state [850]
- Non-LACP bond interfaces may experience packet drops when a bond member interface is down [1603]
- MAC address changes on dataplane interfaces are not reflected on the host tap interface until the dataplane is restarted [1502] Workaround: Restart the dataplane after changing an interface MAC address.
- Bond interface MAC addresses do not match their host tap interface unless a MAC address is explicitly set at creation [1502]
  Workaround: Set the MAC address when creating the bond interface.
• Packets do not pass through a subinterface after the subinterface configuration has been modified [1612]
• QinQ VLAN termination is not working [1550]
• Chelsio interfaces crash the dataplane [1896]
• VLAN subinterfaces may not work under KVM using virtio drivers [2189]

IPsec

• An IPsec tunnel which was removed and then added back in may take longer than expected to establish [1313]

MAP

• MAP-T BR cannot translate IPv4 ICMP echo reply to IPv6 [1749]
• MAP security check configuration differs between the dataplane and CLI [1777]
• MAP behavior cannot be changed from translate to encapsulate without restarting the dataplane [1779]
• TCP MSS value is not applied to encapsulated packets when MAP-E mode is used [1816]
• Fragmentation of IPv4 packets is performed regardless of configured MAP fragmentation behavior when MAT-T mode is used [1826]
• MAP BR does not send ICMPv6 unreachable messages when a packet fails to match a MAP domain [1869]
• Pre-resolve does not work when MAP-T mode is used [1871]
• MAP BR encapsulates/translations only last fragment when receiving fragmented packets from IPv4 network [1887]

NACM

• Permitted default read and write operations cannot be executed if default exec policy is set to deny [1158]

NAT

• twice-nat does not work [1023]
• NAT forwarding is not working for in2out direction [1039]
• NAT static mapping with defined ports leads to clixon-backend crash after restart [1103]
• DS-Lite is not functional; B4 router sends encapsulated IPv4-in-IPv6 packets, but AFTR replies with an error [1626]
• NAT forwarding fails with more than one worker thread [2031]
  Note: This also affects connectivity to services on TNSR, such as RESTCONF, when the client is not on a directly connected network.
• Deterministic NAT crashes the dataplane [1856]
• Connections to and from the TNSR host are included in NAT sessions when connecting through an interface with ip nat outside [1892] [1979]
Neighbors

- IPv6 static neighbors entries do not work [2005]

NTP

- NTP restrictions for prefixes do not work [1705]

RESTCONF

- A malformed request may cause the API to return unexpected errors for a few seconds while it restarts [2079]

Routing

- Deleting a non-empty route table fails with an error and the table remains in the configuration, but it cannot be changed afterward [1241]

  Workaround: Remove all routes from the table before deleting. Alternately, copy the running configuration to startup and restart TNSR, which will make the route table appear again so the routes and then the table can be removed.

User Management

- When deleting a user key from the running configuration it is not removed from the user’s authorized_keys file [1162]

  Workaround: Manually edit the authorized_keys file for the user and remove the key.

VXLAN

- Changes to a VXLAN interface do not apply until the dataplane is restarted [1778]
- Alternate VXLAN encapsulation routing tables cannot be configured [1872]

29.1.3 Reporting Issues

For issues, please contact the Netgate Support staff.

- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)

29.2 TNSR 19.02.1 Release Notes

- About This Release
  - General
  - NAT
• **Known Limitations**
  - ACL
  - BFD
  - BGP
  - CLI
  - DHCP
  - DNS
  - HTTP Server / RESTCONF
  - Interfaces
  - IPsec
  - NACM
  - NAT
  - Routing
  - User Management

• **Reporting Issues**

**29.2.1 About This Release**

This is a maintenance release for TNSR software version 19.02 with bug fixes and Azure support.

**See also:**

For more information on changes in TNSR version 19.02, see *TNSR 19.02 Release Notes*.

**General**

- TNSR is now supported on Azure [974]

**NAT**

- Fixed a problem with removing MAP entries after restarting TNSR [1653]

**29.2.2 Known Limitations**

**ACL**

- Attempting to create an ACL containing only a description fails [1558]

  **Workaround:** Define one or more rules on the ACL.

**BFD**

- Attempting to change a BFD local/peer address fails [1549]
BGP

- TNSR does not send BGP updates without restarting service with `redistribute from connected` option [746]
- Route with `aggregate-address via next-hop 0.0.0.0` does not appear in TNSR route table [832]
- BGP sessions may fail to establish or rapidly reconnect when receiving more prefixes than defined by `maximum-prefix limit` [858]
- The `maximum-prefix restart` command does not work [859]
- TNSR installs multiple paths for received routes even though support for multiple paths is not enabled [885]
  Workaround: Run `systemctl reset-failed frr` from the shell to clear the error which will allow the BGP service to start again.
- Changing `update-source` from an IP address to `loop1` allows a session to establish but remote prefixes do not appear in the FIB until reboot [1104]
- IPv6 BGP neighbors get entered as `peer-groups only in bgpd.conf` [1190]
- BGP `import-check` feature does not work [781]

CLI

- `show route table` causes the backend to die with large numbers of routes in the table [506]
  For example, this crash happens with a full BGP feed.
- Using `service dataplane restart` can cause `clixon_backend` to lose its configuration [1383]

DHCP

- The DHCP server does not function if an interface is configured as a DHCP client [1801]
  Corrected in the next release under development (19.05).
- DHCP server uses default VPP interface IP address (169.254.0.x) as a source address for DHCP packets and as a DHCP Server Identifier [1222]
- Adding a DHCP reservation without a MAC address causes Kea to fail and the entry cannot be removed [1530]
  Workaround: A MAC address is required for DHCP reservations, so always enter a MAC address when creating an entry.
- Configuring Kea to log all names with `*` does not work [1307]
  Workaround: Configure each name separately instead of using a wildcard.

DNS

- Local zone FQDN handling for forward (A) and reverse (PTR) data is inconsistent, only allowing one or the other to work as expected for a given FQDN [1384]
HTTP Server / RESTCONF

- **nginx** does not behave as expected with authentication type `none` and TLS [1086]
  
  This mode is primarily for testing and not production use.
  
  Workaround: Use password or certificate-based authentication for RESTCONF.

- HTTP server runs even though it's not configured to run after TNSR services restart [1153]
  
  Workaround: Manually stop the **nginx** service using `systemctl`.

- RESTCONF get of `/restconf/data/` does not properly return state data [1534]

- RESTCONF query replies may contain CDATA tags in JSON [1463]

- Adding an ACL rule entry via RESTCONF may appear to add a duplicate ACL [1238]

Interfaces

- Loopback interface responds to ICMP echo from an outside host even when in a *Done* state [850]

- Unable to delete an interface if has had an ACL or MACIP applied [1177, 1178]
  
  Workaround: Remove the entire ACL or MACIP entry. Then, the interface may be removed.

- MACIP ACL remains in the interface configuration after being removed [1179]

- Bond interfaces in LACP mode will send LACPDUs even when configured for passive mode [1614]

- Non-LACP bond interfaces may experience packet drops when a bond member interface is down [1603]

- MAC address change on tap interfaces may not be reflected in the dataplane until the dataplane is restarted [1502]
  
  Workaround: Restart the dataplane after changing an interface MAC address.

- MAC address change on bond interfaces may not be reflected in the dataplane until the dataplane is restarted [1502]
  
  Workaround: Set the MAC address when creating the bond interface.

- VLAN tag rewrite settings are only available in subinterfaces [1344]

- Packets do not pass through a subinterface after the subinterface configuration has been modified [1612]

- QinQ VLAN termination is not working [1550]

- ARP replies received from another host on a VLAN subinterface are not processed correctly [1326]

IPsec

- An IPsec tunnel which was removed and then added back in may take longer than expected to establish [1313]

NACM

- Permitted default read and write operations cannot be executed if default exec policy is set to `deny` [1158]
NAT

- **twice-nat** does not work [1023]
- NAT mode is not deleted from VPP startup configuration after TNSR services restart [1017]
- NAT forwarding is not working for in2out direction [1039]
- NAT static mappings are not added as expected when only the `port-local` value differs [1100]
- NAT static mapping with defined ports leads to `clixon-backend` crash after restart [1103]
- DS-Lite is not functional; B4 router sends encapsulated IPv4-in-IPv6 packets, but AFTR replies with an error [1626]
- DS-Lite B4 endpoint is not shown by `show dslite` command [1625]
- Unable to view a list of NAT sessions [975, 1456]

Routing

- Deleting a non-empty route table fails with an error and the table remains in the configuration, but it cannot be changed afterward [1241]
  
  Workaround: Remove all routes from the table before deleting. Alternately, copy the running configuration to startup and restart TNSR, which will make the route table appear again so the routes and then the table can be removed.

User Management

- When deleting a user key from the running configuration it is not removed from the user’s *authorized_keys* file [1162]
  
  Workaround: Manually edit the *authorized_keys* file for the user and remove the key.

29.2.3 Reporting Issues

For issues, please contact the Netgate Support staff.

- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)

29.3 TNSR 19.02 Release Notes

- *About This Release*
  - General
  - BGP
  - CLI
  - Dataplane
  - DHCP Server
29.3.1 About This Release

**Warning:** A number of commands were reorganized with this release, more information will be noted below in individual sections. If a command that worked in a previous release is no longer present, it has most likely been changed to a more logical and consistent location.

**Warning:** RESTCONF queries now require a namespace in the format of `module:name` where only the `name` was required in previous versions. To locate the correct `module:name` combination, see *API Endpoints*.

**General**

- The data models have been updated with more consistent naming and locations
- Introduced a YANG `id` type for `name` fields [1318]
- Miscellaneous code cleanup and refactoring for stability and performance improvements [1516] [1571]
- Updated to CentOS 7.6 [1335]
• Updated build to use gcc 7 [1147]
• Fixed a potential crash when listing packages [1312]
• Improved handling of package versions to better handle situations where a dependency update requires reinstalling related packages [950]

BGP

• BGP commands reorganized under route dynamic for configuration and show route dynamic for status. See Commands and Border Gateway Protocol. [1369]
• FRR updated to 6.0.x

CLI

• The configuration database commands have been reorganized under configuration for making changes, such as copy, and under show configuration for viewing the contents of a configuration. See Commands and Configuration Database. [1347]
• Fixed system location text handling when the value contains whitespace [1584]

Dataplane

• Updated DPDK igb_uio module to v19.02 [842]

DHCP Server

• Updated Kea to 1.4.0-P1 [1239]

DNS

• Fixed removal of access-control entries in the CLI [1417]

Host

• Fixed inconsistent behavior of host interface commands [1611]
• Added a default set of nftables rules to limit inbound traffic to the host [476]

Interfaces

• Several interface-related configuration commands have been moved under the interface command for better consistency. These include: bridge, loopback, memif, subif, and tap. See Commands and Types of Interfaces [1336]
• Added support for Bonding Interfaces for link aggregation and redundancy, including support for LACP [1025]
• Fixed display of a single TAP interface [1554]
• Fixed state data returned from a GET request for /netgate-interface:interfaces-state/interface [1553]
• Corrected validation of memif socket ID to exclude 0 which is reserved, and enforce a maximum of 4294967294 [1527]
• Corrected validation of bridge domain ID to exclude 0 which is reserved, and enforce a maximum of 16777215 [1526]
• Fixed handling of non-default routing tables assigned to interfaces at startup [1518]
• Removed unused container /interfaces-config/interface/tunnel from data model [1427]
• Fixed subif commands outer-dot1q any and outer-dot1ad any [1552] [1352]
• Fixed subinterfaces failing after changing configuration [1346]
• Removed the untagged command from subif as it was non-functional and unnecessary (use the parent interface for untagged traffic) [1345]

NAT

• Added support for MAP-T and MAP-E BR [1399]

RESTCONF

Warning: RESTCONF queries now require a namespace in the format of module:name where only the name was required in previous versions. To locate the correct module:name combination, see API Endpoints.

• Fixed RESTCONF calls for RPCs returning error 400 despite succeeding [1511]

Routing

• Fixed removing a route table reporting failure when the operation succeeded [1515]

29.3.2 Known Limitations

ACL

• Attempting to create an ACL containing only a description fails [1558]
  Workaround: Define one or more rules on the ACL.

BFD

• Attempting to change a BFD local/peer address fails [1549]

BGP

• TNSR does not send BGP updates without restarting service with redistribute from connected option [746]
• Route with aggregate-address via next-hop 0.0.0.0 does not appear in TNSR route table [832]
• BGP sessions may fail to establish or rapidly reconnect when receiving more prefixes than defined by maximum-prefix limit [858]
• The maximum-prefix restart command does not work [859]
• TNSR installs multiple paths for received routes even though support for multiple paths is not enabled [885]
  Workaround: Run systemctl reset-failed frr from the shell to clear the error which will allow the BGP service to start again.
• Changing update-source from an IP address to loop1 allows a session to establish but remote prefixes do not appear in the FIB until reboot [1104]
• IPv6 BGP neighbors get entered as peer-groups only in bgpd.conf [1190]
• BGP import-check feature does not work [781]

CLI
• show route table causes the backend to die with large numbers of routes in the table [506]
  For example, this crash happens with a full BGP feed.
• Using service dataplane restart can cause clixon_backend to lose its configuration [1383]

DHCP
• DHCP server uses default VPP interface IP address (169.254.0.x) as a source address for DHCP packets and as a DHCP Server Identifier [1222]
• Adding a DHCP reservation without a MAC address causes Kea to fail and the entry cannot be removed [1530]
  Workaround: A MAC address is required for DHCP reservations, so always enter a MAC address when creating an entry.
• Configuring Kea to log all names with * does not work [1307]
  Workaround: Configure each name separately instead of using a wildcard.

DNS
• Local zone FQDN handling for forward (A) and reverse (PTR) data is inconsistent, only allowing one or the other to work as expected for a given FQDN [1384]

HTTP Server / RESTCONF
• nginx does not behave as expected with authentication type none and TLS [1086]
  This mode is primarily for testing and not production use.
  Workaround: Use password or certificate-based authentication for RESTCONF.
• HTTP server runs even though it’s not configured to run after TNSR services restart [1153]
  Workaround: Manually stop the nginx service using systemctl.
• RESTCONF get of /restconf/data/ does not properly return state data [1534]
• RESTCONF query replies may contain CDATA tags in JSON [1463]
• Adding an ACL rule entry via RESTCONF may appear to add a duplicate ACL [1238]
Interfaces

- Loopback interface responds to ICMP echo from an outside host even when in a *Down* state [850]
- Unable to delete an interface if has had an ACL or MACIP applied [1177, 1178]
  Workaround: Remove the entire ACL or MACIP entry. Then, the interface may be removed.
- MACIP ACL remains in the interface configuration after being removed [1179]
- Bond interfaces in LACP mode will send LACPDUs even when configured for passive mode [1614]
- Non-LACP bond interfaces may experience packet drops when a bond member interface is down [1603]
- MAC address change on tap interfaces may not be reflected in the dataplane until the dataplane is restarted [1502]
  Workaround: Restart the dataplane after changing an interface MAC address.
- MAC address change on bond interfaces may not be reflected in the dataplane until the dataplane is restarted [1502]
  Workaround: Set the MAC address when creating the bond interface.
- VLAN tag rewrite settings are only available in subinterfaces [1344]
- Packets do not pass through a subinterface after the subinterface configuration has been modified [1612]
- QinQ VLAN termination is not working [1550]
- ARP replies received from another host on a VLAN subinterface are not processed correctly [1326]

IPsec

- An IPsec tunnel which was removed and then added back in may take longer than expected to establish [1313]

NACM

- Permitted default read and write operations cannot be executed if default exec policy is set to *deny* [1158]

NAT

- *twice-nat* does not work [1023]
- NAT mode is not deleted from VPP startup configuration after TNSR services restart [1017]
- NAT forwarding is not working for *in2out* direction [1039]
- NAT static mappings are not added as expected when only the *port-local* value differs [1100]
- NAT static mapping with defined ports leads to *clixon-backend* crash after restart [1103]
- DS-Lite is not functional; B4 router sends encapsulated IPv4-in-IPv6 packets, but AFTR replies with an error [1626]
- DS-Lite B4 endpoint is not shown by *show dslite* command [1625]
- Unable to view a list of NAT sessions [975, 1456]
Routing

- Deleting a non-empty route table fails with an error and the table remains in the configuration, but it cannot be changed afterward [1241]

Workaround: Remove all routes from the table before deleting. Alternately, copy the running configuration to startup and restart TNSR, which will make the route table appear again so the routes and then the table can be removed.

User Management

- When deleting a user key from the running configuration it is not removed from the user's `authorized_keys` file [1162]

Workaround: Manually edit the `authorized_keys` file for the user and remove the key.

### 29.3.3 Reporting Issues

For issues, please contact the Netgate Support staff.

- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)

### 29.4 TNSR 18.11 Release Notes

- **About This Release**
  - Access Lists (ACLs)
  - Authentication & Access Control
  - BGP
  - Bridge
  - CLI
  - Hardware & Installation
  - Interfaces
  - Host
  - IPsec
  - NAT
  - NTP
  - RESTCONF
  - VLAN/Subinterfaces
- **Known Limitations**
  - Authentication & Access Control
29.4.1 About This Release

Access Lists (ACLs)

• Added a description field to ACL rule entries [1195]
• Fixed issues with numerical sorting of ACL entries in `show` output [1255]
• Fixed issues with order of installed ACL rules in the dataplane with large sequence numbers [1270]

Authentication & Access Control

• Removed users from the TNSR configuration so they are stored/managed directly in the host operating system, which eliminates any chance to be out of sync [1067]
• Fixed issues with deleting NACM rule lists [1137]

BGP

• Fixed an issue where the BGP service could not restart more that three times in a row [902]
• Added `bgp clear` command to clear active BGP sessions [923]

Bridge

• Fixed a problem where the TNSR CLI incorrectly allowed multiple bridge interfaces to have `bvi set` [984]

CLI

• Fixed a problem where applied `dataplane` commands were not immediately present in the running configuration database until another change was made [1099]
• Fixed a problem where the candidate configuration database could not be emptied with the `clear` command [1066]
Hardware & Installation

- Added an ISO image to install TNSR on supported hardware [1364]
- Added support for VMware installations [1026]
- Added support for Mellanox network adapters [1268]

Interfaces

- Fixed interface link speed displaying incorrectly in CLI and RESTCONF [672]
- Fixed issues with duplicate entries being generated in the dataplane interface configuration [1243]

Host

- Added the ability to configure host OS management interfaces in the CLI [260, 261, 262]
- Fixed issues with ping command parameter parsing [1133]
- Fixed issues specifying a source address with ping [1134]

IPsec

- Fixed issues with IPsec tunnels failing to establish after a dataplane restart [1138]

NAT

- Changed the default NAT mode to endpoint-dependent [1079]
- Fixed creating a twice-nat pool [972]
- Fixed creating out-to-in-only static mappings [976]
- Fixed NAT reassembly for ICMP packets [990]
- Fixed fragment limitations for NAT reassembly [1065]
- Added support for deterministic NAT [360]

NTP

- Fixed issues with the ntp restrict command [1163]

RESTCONF

- Fixed validation when submitting invalid MAC addresses via RESTCONF [1197]
- Fixed validation when submitting invalid IP addresses via RESTCONF [1199]
VLAN/Subinterfaces

- Fixed issues where daemons such as Kea and ntpd did not correctly form configuration file references to subinterface names [1150]
- Fixed issues with clients on subinterface networks from receiving return traffic that passes through TNSR [1152]

The upstream VPP issue causing this has been fixed, but an additional source of problems in this area is that the dot1q setting for a subinterface must use exact-match to communicate properly with hosts on the VLAN. Ensure subinterfaces are configured to use this property.

29.4.2 Known Limitations

Authentication & Access Control

BGP

- TNSR does not send BGP updates without restarting service with redistribute from connected option [746]
- Route with aggregate-address via next-hop 0.0.0.0 does not appear in TNSR route table [832]
- BGP sessions may fail to establish or rapidly reconnect when receiving more prefixes than defined by maximum-prefix limit [858]
- The maximum-prefix restart command does not work [859]
- TNSR installs multiple paths for received routes even though support for multiple paths is not enabled [885]

  Workaround: Run systemctl reset-failed frr from the shell to clear the error which will allow the BGP service to start again.

- Changing update-source from an IP address to loop1 allows a session to establish but remote prefixes do not appear in the FIB until reboot [1104]
- IPv6 BGP neighbors get entered as peer-groups only in bgpd.conf [1190]
- peer-group attribute remote-as does not get into FRR bgpd.conf [1272]

CLI

- show route table causes the backend to die with large numbers of routes in the table [506]

  For example, this crash happens with a full BGP feed.

DHCP

- A single IP address can be set in a pool range, but the DHCP daemon requires a start/end IP address or a prefix [1208]

  Workaround: Configure a pool with a start and end address or prefix.

- DHCP server uses default VPP interface IP address (169.254.0.x) as a source address for DHCP packets and as a DHCP Server Identifier [1222]
- Unable to delete DHCPv4 options specified within the pool configuration [1267]
HTTP Server / RESTCONF

- **nginx** does not behave as expected with authentication type none and TLS [1086]
  
  This mode is primarily for testing and not production use.
  
  Workaround: Use password or certificate-based authentication for RESTCONF.
  
- HTTP server runs even though it's not configured to run after TNSR services restart [1153]
  
  Workaround: Manually stop the **nginx** service using `systemctl`.

Interfaces

- Loopback interface responds to ICMP echo from an outside host even when in a Down state [850]
  
- Unable to delete an interface if has had an ACL or MACIP applied [1177, 1178]
  
  Workaround: Remove the entire ACL or MACIP entry. Then, the interface may be removed.
  
- MACIP ACL remains in the interface configuration after being removed [1179]

NAT

- **twice-nat** does not work [1023]
  
- NAT mode is not deleted from VPP startup configuration after TNSR services restart [1017]
  
- NAT forwarding is not working for in2out direction [1039]
  
- NAT static mappings are not added as expected when only the port-local value differs [1100]
  
- NAT static mapping with defined ports leads to clixon-backend crash after restart [1103]
  
- PAT dynamic sessions limited to 100 entries per address [1303]
  
  This is the default limit per user in VPP and will be configurable in the next release.

Routing

- Deleting a non-empty route table fails with an error and the table remains in the configuration, but it cannot be changed afterward [1241]
  
  Workaround: Remove all routes from the table before deleting. Alternately, copy the running configuration to startup and restart TNSR, which will make the route table appear again so the routes and then the table can be removed.

User Management

- When deleting a user key from the running configuration it is not removed from the user’s `authorized_keys` file [1162]
  
  Workaround: Manually edit the `authorized_keys` file for the user and remove the key.
29.4.3 Reporting Issues

For issues, please contact the Netgate Support staff.

- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)

29.5 TNSR 18.08 Release Notes

- About This Release
  - Authentication & Access Control
  - BGP
  - CLI
  - DHCP
  - DNS Resolver
  - Hardware & Installation
  - IPsec
  - NAT
  - NTP
  - PKI (Certificates)
  - RESTCONF
- Known Limitations
  - Authentication & Access Control
  - BGP
  - Bridge
  - CLI
  - RESTCONF
  - Interfaces
  - NAT
  - VLAN/Subinterfaces
- Reporting Issues

29.5.1 About This Release

Authentication & Access Control

- Added support for NETCONF Access Control Model (NACM) management.
NACM provides group-based controls to selectively allow command access for users. Users are authenticated by other means (e.g. RESTCONF certificates or users, CLI user) and then mapped to groups based on username.

- Added default configurations for NACM for different platforms [891]
  These default rules allow members of group admin to have unlimited access and sets the default values to deny. It includes the users tnsr and root in the group admin.

  **Warning:** TNSR Does not prevent a user from changing the rules in a way that would cut off all access.

- Changed password management to allow changing passwords for users in the host OS as well as for TNSR users [1091]

**BGP**

- Added explicit sequence numbering to BGP AS Path statements to support multiple patterns in a single AS Path [898]
- Added `show bgp network A.B.C.D` command to display detailed information about BGP routes [922]

**CLI**

- Added `enable` and `disable` commands to be used in favor of `no shutdown/shutdown` [938]
- Fixed CLI issues with data encoding that could lead to XML Parsing errors [887]

**DHCP**

- Improved support and control for DHCP server (Kea) management [490, 738, 1037, 1045]
- Added explicit `enable/disable` for DHCP Server daemon [1053]
- Added logging support to the DHCP Server [907]

**DNS Resolver**

- Added support for management of a DNS Resolver (Unbound) [492, 1072, 1093, 1094]

**Hardware & Installation**

- Added support for installation on Xeon D, C3000 SoCs [961]
- Added configuration packages for Netgate hardware that can run TNSR [1056]
- Fixed a Layer 2 connectivity issue with certain Intel 10G fiber configurations due to a timeout waiting for link [509]
IPsec

- Added QAT cryptographic acceleration enabled for IPsec [912, 940]
  This acceleration works with QAT CPIC cards as well as C62X, C3XXX, and D15XX QAT devices.
- Fixed an issue where an IPsec Child SA would disappear after an IKEv1 Security Association re-authenticates [628]

NAT

- Fixed creating a NAT pool for custom route tables in the CLI [1055]
- Fixed handling of the NAT reassembly timeout value [1000]
- Added support for output feature NAT [867, 897]
- Fixed an error when changing static NAT command boolean properties [703]
- Addressed NAT issues which prevent the TNSR host OS network services from working on nat outside interfaces [616]

  This can only work in endpoint-dependent NAT mode, which can be enabled as follows:

  ```
  dataplane nat endpoint-dependent
  service dataplane restart
  ```

  This may become the default NAT mode in future TNSR releases [1079]

NTP

- Added support for NTP server (ntp.org) management [847, 939, 948, 952]

PKI (Certificates)

- Added support to the PKI CLI for managing certificate authority (CA) entries as well as certificate signing [930]

RESTCONF

- Added commands for RESTCONF management and authentication (HTTP server, nginx) [933]
- Added support to RESTCONF for certificate-based authentication [937]

  When using certificates to authenticate, the common name (CN) part of the subject is used as the username.
- Added PAM support for HTTP authentication to the HTTP server [934]

29.5.2 Known Limitations

Authentication & Access Control

- Unable to delete a user from the CLI after TNSR services restart [1067]
BGP

• TNSR does not send BGP updates without restarting service with `redistribute from connected` option [746]

• Route with `aggregate-address` via `next-hop 0.0.0.0` does not appear in TNSR route table [832]

• BGP sessions may fail to establish or rapidly reconnect when receiving more prefixes than defined by `maximum-prefix limit` [858]

• The `maximum-prefix restart` command does not work [859]

• TNSR installs multiple paths for received routes even though support for multiple paths is not enabled [885]

• Unable to restart BGP service more than three times in a row [902]
  
  Workaround: Run `systemctl reset-failed frr` from the shell to clear the error which will allow the BGP service to start again.

• Changing `update-source` from an IP address to `loop1` allows a session to establish but remote prefixes do not appear in the FIB until reboot [1104]

Bridge

• TNSR CLI allows multiple bridge interfaces to have `bvi` set [984]
  
  Only the first interface set with `bvi` will work properly.

  Workaround: Only set `bvi` on a single interface.

CLI

• Applied `dataplane` commands are not immediately present in the running configuration database until another change is made [1099]

• The candidate configuration database cannot be emptied with the `clear` command [1066]

• `show route table` causes the backend to die with large numbers of routes in the table [506]
  
  For example, this crash happens with a full BGP feed.

RESTCONF

• `nginx` does not behave as expected with `authentication type none` [1086]
  
  This mode is primarily for testing and not production use.

  Workaround: Use password or certificate-based authentication for RESTCONF.

Interfaces

• Interface link speed displayed incorrectly in CLI and RESTCONF [672]

• Loopback interface responds to ICMP echo from an outside host even when in a `Down` state [850]
NAT

• Unable to create a twice-nat pool [972] or twice-nat not working [1023]
  twice-nat can only work in endpoint-dependent NAT mode, which can be enabled as follows:
  ```
  dataplane nat endpoint-dependent
  service dataplane restart
  ```

• Unable to create out-to-in-only static mapping [976]
  out-to-in-only can only work in endpoint-dependent NAT mode, which can be enabled as follows:
  ```
  dataplane nat endpoint-dependent
  service dataplane restart
  ```

• NAT Reassembly is not working for ICMP packets [990]
• Fragment limitation for NAT reassembly is not working [1065]
• NAT mode is not deleted from VPP startup configuration after TNSR services restart [1017]
• NAT forwarding is not working for in2out direction [1039]
• NAT static mappings are not added as expected when only the port-local value differs [1100]
• NAT static mapping with defined ports leads to clixon-backend crash after restart [1103]

VLAN/Subinterfaces

• Daemons such as Kea and ntpd do not correctly form configuration file references to subinterface names [1150]
• A VPP issue is preventing clients on subinterface networks from receiving return traffic that passes through TNSR [1152]
  – These clients can communicate to TNSR, but not to hosts on other interfaces or subinterfaces.
  – Other interface types work properly

29.5.3 Reporting Issues

For issues, please contact the Netgate Support staff.

• Send email to support@netgate.com
• Phone: 512.646.4100 (Support is Option 2)

29.6 TNSR 18.05 Release Notes

29.6.1 About This Release

This is the first public release of Netgate’s TNSR product.

Please see the TNSR Product Manual for details on the features of TNSR. https://docs.netgate.com/tnsr/en/latest
29.6.2 Known Limitations

[295] Loopback with IPv6 address will not respond to IPv6 pings.
Workaround: none.

[477] Linux route rules for the router-plugin/tap-inject are not cleaned up
If the dataplane crashes, route rules added to the host system network stack are not cleaned up when it restarts.
Workaround: none.

[483] Deleting in-use prefix-list fails
If you attempt to delete an in-use prefix list, the command will fail, but the configuration is left in an inconsistent state.
Workaround: remove the use of the prefix list prior to deleting it.

[490][739] DHCP Server Issues
There are multiple issues with the DHCP Server, it’s use is not recommended at this time.
Workaround: none.

[506] The command “show route table” causes backend crash
A large route table (> 50k routes) can cause the “show route table” command to crash the backend process.
Workaround: Use “vppctl show ip fib” from a shell or vtysh to view route tables when a large number of routes have been added.

[612] RPC error when input includes “<” character
Using the “<” character as input to the CLI can cause an RPC error. The error is properly detected, reported, and handled in the known cases. This affects all cases where there is free-form input.
Workaround: Do not use the “<” character.

[616] Enabling NAT on an outside interface disables services on that interface
If you configure NAT on an outside interface, then that interface cannot provide services (like DHCP, ssh, etc.).
Workaround: none

[618] SLAAC is not supported in dataplane, but host stack interfaces have it enabled.
Workaround: none.

[628] Child SAs can disappear after an IKEv1 SA reauth.
Workaround: none.

[672] Interface speed and duplex show as unknown
The link speed and duplex indicators (visible with the “show interface” command) can display as “unknown”.
Workaround: Use the “vppctl show interface” command from an OS shell.

[706] Unable to change DHCP client hostname option
The DHCP Client hostname can not be changed.
Workaround: none.

[741] Data plane restart breaks RESTCONF
If you restart the data plane, the RESTCONF service loses it’s connection and does not reestablish it.
Workaround: Restart the data plane via the CLI, which does not have the same issue.
[745] RESTCONF RPC output is invalid JSON
Some RPCs return multiple line output and the new line characters are not handled properly resulting in the inability of a JSON parser to process the output.
Workaround: none.

[746] BGP updates not being sent when “redistribute from connected” option specified
Routes from connected routers are not propagated when the redistribute from connected option is set
Workaround: none. You can temporarily resolve the problem by resetting the BGP service.

[781] BGP import-check feature does not work
If the import-check option is set and then BGP is configured to advertise an unreachable network then the network is still advertised.
Workaround: none.

[824] unable to create a default route when more than one loopback interface exists
Workaround: none.

[831] Unable to create a second static NAT translation on a loopback interface
Workaround: none.

[832] Route with aggregate-address via next-hop 0.0.0.0 doesn’t appear in routing table
Workaround: none.

[850] Loopback interface can be ping from an outside host even when marked down
Workaround: none.

[858] BGP session constantly flapping when receiving more prefixes than defined in maximum-prefix limit command
Workaround: none.

[859] BGP “maximum-prefix restart” option doesn’t work
Workaround: none.

[860] No warning message in CLI when BGP “maximum-prefix” option is configured
If the maximum number of prefixes is exceeded, there is no indication to a user that this has occurred.
Workaround: none.

[861] Unable to set BGP warning-only option for maximum-prefix option.
Workaround: none.

29.6.3 Reporting Issues

For issues, please contact the Netgate Support staff.
- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)
29.7 TNSR 0.1.0 Release Notes

29.7.1 About This Release

The TNSR 0.1.0 Release is the first release of the Netgate TNSR product. As there is no previous release of the TNSR products, there can be no changes relative to a previous version. Everything is new!

This release constitutes an early, evaluation version of the product.

29.7.2 Known Limitations

BGP Routes

While BGP may be configured, started, and run, reports of it not recording and displaying the learned BGP routes using the TNSR command “show routes” have been reported.

A possible work-around appears to be to stop, and then restart the BGP daemon using:

```
tenst# service bgp stop
tenst# service bgp start
```

BGP route-map and prefix-list Entries

TNSR route-maps and prefix-lists may be configured, and subsequently passed along to the underlying FRR configuration. TNSR will also allow removal of route-maps or prefix-lists from its configuration. However, they are not removed from the underlying FRR configuration.

A possible work-around is to manually remove them from the underlying FRR configuration using `vtysh` directly.

DHCP Server

The DHCP server does not support any form of Options yet.

The “server dhcp stop dhcp4” will not effectively terminate the Kea IPv4 DHCP server. A work-around is to run some form of “sudo killall kea-dhcp4” from a shell prompt.

29.7.3 Reporting Issues

For issues, please contact the Netgate Support staff.

- Send email to support@netgate.com
- Phone: 512.646.4100 (Support is Option 2)
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The following list shows each Open Source component along with its license.

<table>
<thead>
<tr>
<th>Software</th>
<th>License</th>
</tr>
</thead>
<tbody>
<tr>
<td>CentOS 7</td>
<td>CentOS EULA</td>
</tr>
<tr>
<td>Linux kernel and modules</td>
<td>GPLv2</td>
</tr>
<tr>
<td>cligen</td>
<td>Apache 2.0</td>
</tr>
<tr>
<td>clixon</td>
<td>Apache 2.0</td>
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<tr>
<td>curl</td>
<td>MIT</td>
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<tr>
<td>davici</td>
<td>LGPLv2.1</td>
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<td>libnl</td>
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<td>net-snmp</td>
<td>Net SNMP</td>
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<tr>
<td>strongswan</td>
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<td>unbound</td>
<td>BSD 3-clause</td>
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<tr>
<td>VPP</td>
<td>Apache 2.0</td>
</tr>
</tbody>
</table>

GPL-licensed code modified for use in TNSR is available in source form:

<table>
<thead>
<tr>
<th>Package</th>
<th>Repository Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>frr</td>
<td><a href="http://github.com/netgate/frr">http://github.com/netgate/frr</a></td>
</tr>
<tr>
<td>strongswan</td>
<td><a href="http://github.com/netgate/strongswan">http://github.com/netgate/strongswan</a></td>
</tr>
<tr>
<td>Hyper-V Linux kernel modules</td>
<td><a href="https://github.com/netgate/uio_hv_generic">https://github.com/netgate/uio_hv_generic</a></td>
</tr>
</tbody>
</table>

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