Application Hosting Configuration Guide for Cisco ASR 9000 Series Routers, Cisco IOS XR Releases

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Changes to This Document

This table lists the technical changes made to this document since it was first released.

Table 1: Changes to This Document

Date	Summary
September 2024	Republished for Cisco IOS XR Release 24.3.1
June 2024	Republished for Cisco IOS XR Release 24.2.1
April 2022	Republished for Cisco IOS XR Release 7.5.2
July 2021	Republished for Cisco IOS XR Release 7.4.1
August 2019	Republished for Cisco IOS XR Release 7.0.1
March 2018	Republished for Cisco IOS XR Releases 6.4.1 and 6.3.2.
September 2017	Republished for Cisco IOS XR Release 6.3.1.
July 2017	Republished for Cisco IOS XR Release 6.2.2.
November 2016	Republished for Cisco IOS XR Release 6.1.2.
December 2015	First release for Cisco IOS XR Release 6.0.0.

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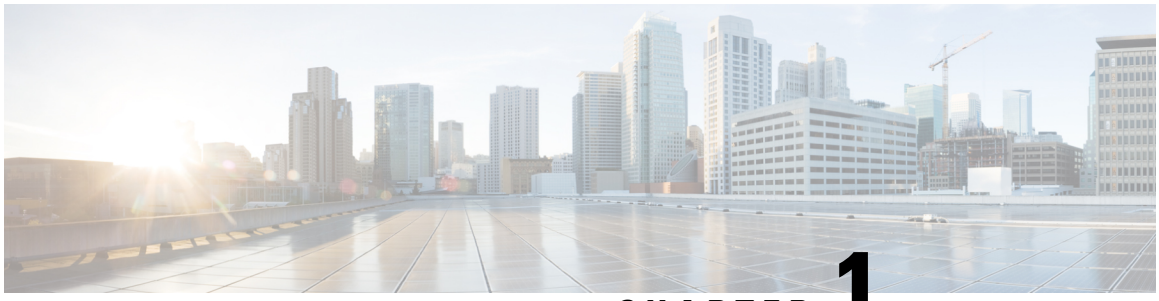


CHAPTER 1

New and Changed Feature Information

This section lists all the new and changed features for the Application Hosting Configuration Guide.

New and Changed Application Hosting Features

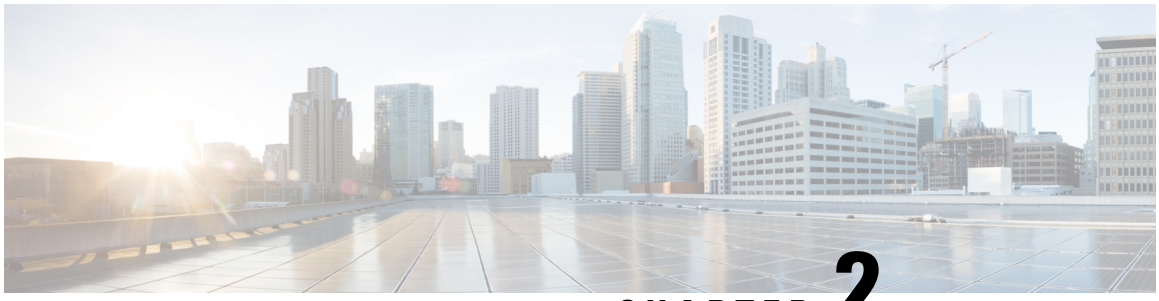
This section describes the new and changed application hosting features for Cisco IOS XR.

Application Hosting Features Added or Modified

Table 3: New and Changed Features

Feature	Description	Introduced/Changed in Release	Where Documented
Cisco Secure DDoS Edge Protection	This feature was introduced.	Release 24.3.1	Cisco Secure DDoS Edge Protection
Telemetry Data Export from Line Card Port via User Defined VRF	This feature was introduced.	Release 24.1.1	Telemetry Data Export from Line Card Port via User Defined VRF
MPLS Explicit Null for IPv6 Data packets	This feature was introduced.	Release 24.1.1	MPLS Explicit Null for IPv6 Data packets
Customize Docker Run Options using Application Manager	This feature was introduced.	Release 24.1.1	Customize Docker Run Options using Application Manager
No new features were added.	None	Release 7.4.1	NA
No new features were added.	None	Release 7.0.1	NA
No new features were added.	None	Release 6.6.2	NA

Feature	Description	Introduced/Changed in Release	Where Documented
No new features were added.	None	Release 6.5.2	NA



CHAPTER 2

Getting Started with Application Hosting

This section introduces application hosting and the Linux environment used for hosting applications on the Cisco IOS XR Operating System.

Need for Application Hosting

Over the last decade, there has been a need for a network operating system that supports operational agility and efficiency through seamless integration with existing tool chains. Service providers have been looking for shorter product cycles, agile workflows, and modular software delivery; all of these can be automated efficiently. The 64-bit Cisco IOS XR that replaces the older 32-bit QNX version meets these requirements. It does that by providing an environment that simplifies the integration of applications, configuration management tools, and industry-standard zero touch provisioning mechanisms. The 64-bit IOS XR matches the DevOps style workflows for service providers, and it has an open internal data storage system that can be used to automate the configuration and operation of the device hosting an application.

While we are rapidly moving to virtual environments, there is an increasing need to build applications that are reusable, portable, and scalable. Application hosting gives administrators a platform for leveraging their own tools and utilities. Cisco IOS XR 6.0 supports third-party off-the-shelf applications built using Linux tool chains. Users can run custom applications cross-compiled with the software development kit that Cisco provides. Cisco routers support third-party off-the-shelf applications An application hosted on a network device can serve a variety of purposes. This ranges from automation, configuration management monitoring, and integration with existing tool chains.

Before an application can be hosted on a device, the following requirements must be met:

- Suitable build environment to build your application
- A mechanism to interact with the device and the network outside the device

When network devices are managed by configuration management applications, such as Chef and Puppet, network administrators are freed of the task of focusing only on the CLI. Because of the abstraction provided by the application, while the application does its job, administrators can now focus on the design, and other higher level tasks.

Deep Dive Into Application Hosting

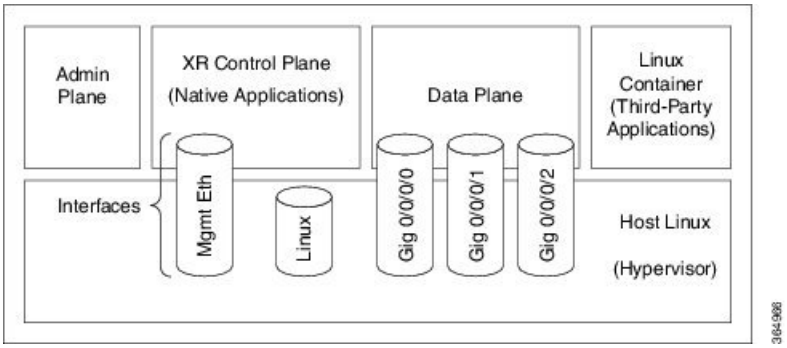
This section describes the architecture of the 64-bit IOS XR and the architecture used for application hosting.

64-bit IOS XR Architecture

IOS XR provides Linux containers for application hosting through a hypervisor. Each container provides a unique functionality. The 64-bit host Linux (hypervisor) works well with embedded systems. The various containers that are offered on the host Linux, are explained in this section.

The following figure illustrates the 64-bit IOS XR architecture.

Figure 1: 64-bit IOS XR Architecture



- **Admin Plane**: The admin plane is the first Linux container to be launched on booting IOS XR. The admin plane is responsible for managing the life cycle of the IOS XR control plane container.
- **XR Control Plane**: Applications are hosted natively in the 64-bit IOS XR control plane. You can access the IOS XR Linux bash shell through the control plane.
- **Data Plane**: The data plane substitutes and provides all the features of a line card in a modular router chassis.
- **Third-Party Container**: You can create your own Linux container (LXC) for hosting third-party applications and use the LC interfaces that are provided.

Apart from the Linux containers, several interfaces are offered on the host Linux.

Application Hosting Architecture

The 64-bit IOS XR introduces the concept of using containers on the 64-bit host Linux (hypervisor) for hosting applications in the XR control plane LXC (native) and in the third-party LXC. The host Linux is based on the Windriver Linux 7 distribution.

The application hosting architecture is designed to offer the following containers for both native and third-party applications:

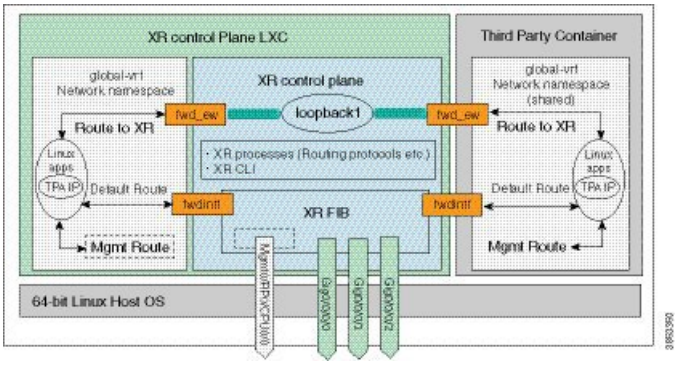
- **XR Control Plane LXC (native applications reside here)**: The XR control plane LXC contains the `global-vrf` network namespace and the XR control plane. The LXC provides the XR Linux shell to access `global-vrf` and the XR router console (CLI) to access the XR control plane. The LXC is also based on the WRL7 distribution. For more information on the XR control plane LXC.

- **Third-Party Container (third-party applications reside here)**: The 64-bit IOS XR provides you an option to create and launch your own Linux container, known as the third-party container. You can install applications within the container that shares the network namespace with XR. You can access the namespace through the XR Linux shell.

The network namespace on XR is shared across all applications and is known as `global-vrf`.

The Third-Party Application (TPA) IP is configured so that applications can communicate outside XR through the `fwdintf` interface, which is bound to the Loopback0 interface of XR. All applications communicate with XR through the `fwd_ew` interface, which is bound to the Loopback1 interface of XR.

Figure 2: Application Hosting Architecture



Application Hosting on the Cisco IOS XR Linux Shell

Linux supports an entire ecosystem of applications and tools that have been created, tested, and deployed by system administrators, developers, and network engineers over the last few decades. Linux is well suited for hosting servers with or without applications, because of its stability, security, scalability, reduced cost for licensing, and the flexibility it offers to customize applications for specific infrastructure needs.

With a growing focus on DevOps style workflows that focus on automation and ease of integration, network devices need to evolve and support standard tools and applications that make the automation process easier. A standardized and shared tool chain can boost speed, efficiency, and collaboration. IOS XR is developed from a Yocto-based Wind River Linux 7 distribution. The OS is RPM based and well suited for embedded systems.

IOS XR enables hosting of 64-bit Linux applications on the box, and has the following advantages:

- Seamless integration with configuration management applications
- Easy access to file systems
- Ease of operation

To host a Linux application on IOS XR, you must be familiar with the Linux shell on XR.

A typical Linux OS provides a single set of network interfaces and routing table entries that are shared across the OS. With the introduction of network namespaces, Linux provides multiple instances of network interfaces and routing tables that operate independently.

Note Support for network namespaces varies across different distributions of the Linux OS. Ensure that the distribution you are planning to use for application hosting supports network namespaces.

Network Namespaces on IOS XR

There are two ways of accessing the IOS XR Linux shell, depending on the version of Cisco IOS XR that you are using in your network.

- If you are using **Cisco IOS XR Version 6.0.0**, then you must use the procedure in Accessing the Third-Party Network Namespace on Cisco IOS XR Linux Shell, on page 6. Accessing the XR Linux shell takes you to the default network namespace, XRNNS. You must navigate from this namespace to access the third-party network namespace (TPNNS), where all the third-party application interfaces reside. There is a difference between what you can access and view at the XR router prompt, and what you can access and view at the XR Linux Shell.
- If you are using **Cisco IOS XR Version 6.0.2** and higher, then you must use the procedure in Accessing Global VRF on the Cisco IOS XR Linux Shell, on page 12. Accessing the XR Linux shell takes you directly to the third-party network namespace, renamed as global VRF. You can run bash commands at the XR router prompt itself to view the interfaces and IP addresses stored in global VRF. Navigation is faster and more intuitive in this version of IOS XR.

Accessing the Third-Party Network Namespace on Cisco IOS XR Linux Shell

The Cisco IOS XR Linux shell provides a Third-Party Network Namespace (TPNNS) that provides the required isolation between third-party applications and internal XR processes, while providing the necessary access to XR interfaces for the applications. You can use the steps mentioned in this section to access the IOS XR Linux shell and navigate through the XRNNS (default XR Network Namespace) and the TPNNS.

Note This procedure is applicable only on Cisco IOS XR Versions 5.3.2 and 6.0.0. For accessing this namespace on other versions of Cisco IOS XR, see Accessing Global VRF on the Cisco IOS XR Linux Shell, on page 12.

Use these steps to navigate through the XR Linux shell.

1. From your Linux box, access the IOS XR console through SSH, and log in.

```
cisco@host:~$ ssh root@192.168.122.188
root@192.168.122.188's password:
RP/0/RP0/CPU0:ios#
```

   You have reached the IOS XR router prompt.

2. View the ethernet interfaces on IOS XR.

```
RP/0/0/CPU0:ios# show ipv4 interface brief
...

Interface                      IP-Address      Status                Protocol
Loopback0                      1.1.1.1/32      Up                    Up
GigabitEthernet0/0/0/0         10.1.1.1/24     Up                    Up
...
```

```
RP/0/RP0/CPU0:ios# show interfaces gigabitEthernet 0/0/0/0
...

GigabitEthernet0/0/0/0 is up, line protocol is up
Interface state transitions: 4
Hardware is GigabitEthernet, address is 5246.e8a3.3754 (bia
5246.e8a3.3754)
Internet address is 10.1.1.1/24
MTU 1514 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
reliability 255/255, txload 0/255, rxload 0/255
Encapsulation ARPA,
Duplex unknown, 1000Mb/s, link type is force-up
output flow control is off, input flow control is off
loopback not set,
Last link flapped 01:03:50
ARP type ARPA, ARP timeout 04:00:00
Last input 00:38:45, output 00:38:45
Last clearing of "show interface" counters never
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
12 packets input, 1260 bytes, 0 total input drops
0 drops for unrecognized upper-level protocol
Received 2 broadcast packets, 0 multicast packets
0 runts, 0 giants, 0 throttles, 0 parity
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
12 packets output, 1224 bytes, 0 total output drops
Output 1 broadcast packets, 0 multicast packets
```

The output displays the IP and MAC addresses of the `GigabitEthernet0/0/0/0` interface.

3. Enter the **run** command to launch the IOS XR Linux bash shell.

   You can also check the version of IOS XR when you are at the bash prompt.

```
RP/0/RP0/CPU0:ios# run
Wed Oct 28 18:45:56.168 IST

[xr-vm_node0_RP0_CPU0:~]$ uname -a
Linux xr-vm_node0_RP0_CPU0 3.10.19-WR7.0.0.2_standard #1 SMP Mon Jul 6
13:38:23 PDT 2015 x86_64 GNU/Linux
[xr-vm_node0_RP0_CPU0:~]$
```

Note To exit the Linux bash shell and launch the IOS XR console, enter the **exit** command:

```
[xr-vm_node0_RP0_CPU0:~]$ exit
exit
RP/0/RP0/CPU0:ios#
```

4. Locate the network interfaces by running the **ifconfig** command.

```
[xr-vm_node0_RP0_CPU0:~]$ ifconfig
eth0      Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:8996  Metric:1
          RX packets:280 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:31235 (30.5 KiB)  TX bytes:20005 (19.5 KiB)

eth-vf0   Link encap:Ethernet  HWaddr 52:54:00:34:29:44
```

```
          inet addr:10.11.12.14  Bcast:10.11.12.255  Mask:255.255.255.0
          inet6 addr: fe80::5054:ff:fe34:2944/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:9000  Metric:1
          RX packets:19 errors:0 dropped:0 overruns:0 frame:0
          TX packets:13 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1566 (1.5 KiB)  TX bytes:1086 (1.0 KiB)

eth-vf1   Link encap:Ethernet  HWaddr 52:54:00:ee:f7:68
          inet6 addr: fe80::5054:ff:feee:f768/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:9000  Metric:1
          RX packets:326483 errors:0 dropped:3 overruns:0 frame:0
          TX packets:290174 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:24155455 (23.0 MiB)  TX bytes:215862857 (205.8 MiB)

eth-vf1.1794 Link encap:Ethernet  HWaddr 52:54:01:5c:55:8e
          inet6 addr: fe80::5054:1ff:fe5c:558e/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:8996  Metric:1
          RX packets:10 errors:0 dropped:0 overruns:0 frame:0
          TX packets:13 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:728 (728.0 B)  TX bytes:1234 (1.2 KiB)

eth-vf1.3073 Link encap:Ethernet  HWaddr e2:3a:dd:0a:8c:06
          inet addr:192.0.0.4  Bcast:192.255.255.255  Mask:255.0.0.0
          inet6 addr: fe80::e03a:ddff:fe0a:8c06/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:8996  Metric:1
          RX packets:317735 errors:0 dropped:3560 overruns:0 frame:0
          TX packets:257881 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:18856325 (17.9 MiB)  TX bytes:204552163 (195.0 MiB)

eth-vf1.3074 Link encap:Ethernet  HWaddr 4e:41:50:00:10:01
          inet addr:172.0.16.1  Bcast:172.255.255.255  Mask:255.0.0.0
          inet6 addr: fe80::4c41:50ff:fe00:1001/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:8996  Metric:1
          RX packets:8712 errors:0 dropped:0 overruns:0 frame:0
          TX packets:32267 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:723388 (706.4 KiB)  TX bytes:11308374 (10.7 MiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:1635360 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1635360 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:182532711 (174.0 MiB)  TX bytes:182532711 (174.0 MiB)

tap123    Link encap:Ethernet  HWaddr c6:13:74:4b:dc:e3
          inet6 addr: fe80::c413:74ff:fe4b:dce3/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:13 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:500
          RX bytes:0 (0.0 B)  TX bytes:998 (998.0 B)
```

The output displays the internal interfaces (`eth0` through `eth-vf1.3074`) used by IOS XR. These interfaces exist in XR Network Namespace (XRNNS) and do not interact with the network outside IOS XR. Interfaces that interact with the network outside IOS XR are found in the Third Party Network Namespace (TPNNS).

5. Enter the TPNNS on the IOS XR bash shell.

```
[XR-vm_node0_RP0_CPU0:~]$ ip netns exec tpnns bash
```

6. View the TPNNS interfaces.

```
[XR-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

The interfaces displayed in the output are replicas of the IOS XR interfaces in the Linux environment. (They have the same MAC and IP addresses.)

- `Gi0_0_0_0` is the IOS XR GigabitEthernet 0/0/0/0 interface.
- `Mg0_RP0_CPU0_0` is the IOS XR management interface, used for administrative operations on XR.
- `fwd_ew` is the interface used for communication (east to west) between third-party applications and IOS XR.

- `fwdintf` is the interface used for communication between third-party applications and the network outside IOS XR.
- `lo:0` is the IOS XR loopback0 interface used for communication between third-party applications and the outside network through the `fwdintf` interface. The loopback0 interface must be configured for applications to communicate outside XR. Alternatively, applications can also configure a GigE interface for external communication, as explained in the Communication Outside Cisco IOS XR, on page 45 section.

All interfaces that are enabled (with the **no shut** command) are added to TPNNS on IOS XR.

7. (Optional) View the IP routes used by the `fwd_ew` and `fwdintf` interfaces.

```
[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 1.1.1.1
8.8.8.8 dev fwd_ew  scope link
192.168.122.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 192.168.122.213
```

Note The `fwdintf` and `fwd_ew` interfaces is not support from IOS XR software release 7.9.1.

Alternative Method of Entering the Third Party Network Namespace on IOS XR

To directly enter the TPNNS on logging to IOS XR, without entering the **ip netns exec tpnns bash** command, you can use the `sshd_tpnns` service, as explained in the steps that follow. The procedure involves the creation of a non-root user in order to access the service. (Root users cannot access this service.)

Note On IOS XR, prior to starting a service that binds to an interface, ensure that the interface is configured, up, and operational.

To ensure that a service starts only after an interface is configured, include the following function in the service script:

```
. /etc/init.d/tpnns-functions
tpnns_wait_until_ready
```

The addition of the **tpnns_wait_until_ready** function ensures that the service script waits for one or more interfaces to be configured before starting the service.

1. (Optional) If you want the TPNNS service to start automatically on reload, add the `sshd_tpnns` service and verify its presence.

```
bash-4.3# chkconfig --add sshd_tpnns
bash-4.3# chkconfig --list sshd_tpnns
sshd_tpnns      0:off   1:off   2:off   3:on    4:on    5:on    6:off
bash-4.3#
```

2. Start the `sshd_tpnns` service.

```
bash-4.3# service sshd_tpnns start
Generating SSH1 RSA host key: [  OK  ]
Generating SSH2 RSA host key: [  OK  ]
Generating SSH2 DSA host key: [  OK  ]
  generating ssh ECDSA key...
Starting sshd: [  OK  ]
```

```
bash-4.3# service sshd_tpnns status
sshd (pid  6224) is running...
```

3. Log into the `sshd_tpnns` session as the non-root user created in Step 1.

```
host@fe-ucs36:~$ ssh devops@192.168.122.222 -p 57722
devops@192.168.122.222's password:
Last login: Tue Sep  8 20:14:11 2015 from 192.168.122.1
XR-vm_node0_RP0_CPU0:~$
```

4. Verify whether you are in TPNNS by viewing the interfaces.

```
[XR-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

You are ready to use the IOS XR Linux shell for hosting applications.

Accessing Global VRF on the Cisco IOS XR Linux Shell

The Third-Party Network Namespace (TPNNS) is renamed as Global VRF (global-vrf) in Cisco IOS XR Version 6.0.2 and higher. When you access the Cisco IOS XR Linux shell, you directly enter global VRF. This is described in the following procedure.

1. From your Linux box, access the IOS XR console through SSH, and log in.

```
cisco@host:~$ ssh root@192.168.122.188
root@192.168.122.188's password:
RP/0/RP0/CPU0:ios#
```

   You have reached the IOS XR router prompt.

2. View the ethernet interfaces on IOS XR.

```
RP/0/0/CPU0:ios# show ipv4 interface brief
...

Interface                      IP-Address      Status                Protocol
Loopback0                      1.1.1.1/32      Up                    Up
GigabitEthernet0/0/0/0         10.1.1.1/24     Up                    Up
...


RP/0/RP0/CPU0:ios# show interfaces gigabitEthernet 0/0/0/0
...

GigabitEthernet0/0/0/0 is up, line protocol is up
Interface state transitions: 4
Hardware is GigabitEthernet, address is 5246.e8a3.3754 (bia
5246.e8a3.3754)
Internet address is 10.1.1.1/24
MTU 1514 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
reliability 255/255, txload 0/255, rxload 0/255
Encapsulation ARPA,
Duplex unknown, 1000Mb/s, link type is force-up
output flow control is off, input flow control is off
loopback not set,
Last link flapped 01:03:50
ARP type ARPA, ARP timeout 04:00:00
Last input 00:38:45, output 00:38:45
Last clearing of "show interface" counters never
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
12 packets input, 1260 bytes, 0 total input drops
0 drops for unrecognized upper-level protocol
Received 2 broadcast packets, 0 multicast packets
0 runts, 0 giants, 0 throttles, 0 parity
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
12 packets output, 1224 bytes, 0 total output drops
Output 1 broadcast packets, 0 multicast packets
```

   The output displays the IP and MAC addresses of the `GigabitEthernet0/0/0/0` interface.

3. Verify whether the bash command runs in global VRF by running the **bash -c ifconfig** command to view the network interfaces.

```
RP/0/RP0/CPU0:ios# bash -c ifconfig
...
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
```

```
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

The presence of the following two interfaces confirms that you are in Global VRF:

`fwd_ew` is the interface used for communication (east to west) between third-party applications and IOS XR.

`fwdintf` is the interface used for communication between third-party applications and the network outside IOS XR.

4. Access the Linux shell by running the **bash** command.

```
RP/0/RP0/CPU0:ios# bash
Tue Aug 02 13:44:07.627 UTC
[xr-vm_node0_RP0_CPU0:~]$
```

5. (Optional) View the IP routes used by the `fwd_ew` and `fwdintf` interfaces.

```
[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 1.1.1.1
```

```
8.8.8.8 dev fwd_ew  scope link
192.168.122.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 192.168.122.213
```

Alternative Method of Entering Global VRF on IOS XR

To directly enter global VRF on logging to IOS XR, without entering the **bash** command, you can use the `sshd_operns` service, as explained in the steps that follow. The procedure involves the creation of a non-root user in order to access the service. (Root users cannot access this service.)

Note On IOS XR, prior to starting a service that binds to an interface, ensure that the interface is configured, up, and operational.

To ensure that a service starts only after an interface is configured, include the following function in the service script:

```
. /etc/init.d/operns-functions
operns_wait_until_ready
```

The addition of the **operns_wait_until_ready** function ensures that the service script waits for one or more interfaces to be configured before starting the service.

1. (Optional) If you want the operns service to start automatically on reload, add the `sshd_operns` service and verify its presence.

```
bash-4.3# chkconfig --add sshd_operns
bash-4.3# chkconfig --list sshd_operns
sshd_operns      0:off   1:off   2:off   3:on    4:on    5:on    6:off
bash-4.3#
```

2. Start the `sshd_operns` service.

```
bash-4.3# service sshd_operns start
Generating SSH1 RSA host key: [  OK  ]
Generating SSH2 RSA host key: [  OK  ]
Generating SSH2 DSA host key: [  OK  ]
  generating ssh ECDSA key...
Starting sshd: [  OK  ]

bash-4.3# service sshd_operns status
sshd (pid  6224) is running...
```

3. Log into the `sshd_operns` session as the non-root user created in Step 1.

```
host@fe-ucs36:~$ ssh devops@192.168.122.222 -p 57722
devops@192.168.122.222's password:
Last login: Tue Sep  8 20:14:11 2015 from 192.168.122.1
XR-vm_node0_RP0_CPU0:~$
```

4. Verify whether you are in global VRF by viewing the network interfaces.

```
[XR-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)
```

```
Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

You are ready to use the IOS XR Linux shell for hosting applications.

Support for Docker Run Options via AppMgr Commands

Table 4: Feature History Table

Feature Name	Release Information	Description
Support for Docker Run Options via AppMgr Commands	Release 24.1.1	You can now leverage Application Manager to efficiently overwrite default docker runtime configurations, tailoring them to specific parameters like CPU usage, security settings, and health checks.You can thus optimize application performance, maintain fair resource allocation among multiple dockers, and establish non-default network security settings to meet specific security requirements. Additionally, you can accurately monitor and reflect the health of individual applications. This feature modifies the **docker-run-opts** option command.

With this feature, runtime options for docker containerized applications on IOS-XR can be configured during launch using the "appmgr activate" command. AppMgr, which oversees docker containerized applications, ensures that these runtime options can effectively override default configurations, covering aspects like CPU, security, and health checks during the container launch.

This feature introduces multiple runtime options that allow users to customize different parameters of docker containers. The configuration of these runtime options is flexible, as users can use either command or Netconf for the configuration process. Regardless of the chosen method, runtime options must be added to **docker-run-opts** as needed.

The following are the docker run option commands introduced in IOS-XR software release 24.1.1.

Table 5: Docker Run Options

Docker Run Option	Description
--cpus	Number of CPUs
--cpuset-cpus	CPUs in which to allow execution (0-3, 0,1)
--cap-drop	Drop Linux capabilities
--user, -u	Sets the username or UID
--group-add	Add additional groups to run
--health-cmd	Run to check health

Docker Run Option	Description
--health-interval	Time between running the check
--health-retries	Consecutive failures needed to report unhealthy
--health-start-period	Start period for the container to initialize before starting health-retries countdown
--health-timeout	Maximum time to allow one check to run
--no-healthcheck	Disable any container-specified HEALTHCHECK
--add-host	Add a custom host-to-IP mapping (host:ip)
--dns	Set custom DNS servers
--dns-opt	Set DNS options
--dns-search	Set custom DNS search domains
--domainname	Container NIS domain name
--oom-score-adj	Tune host's OOM preferences (-1000 to 1000)
--shm-size	Size of /dev/shm
--init	Run an init inside the container that forwards signals and reaps processes
--label, -l	Set meta data on a container
--label-file	Read in a line delimited file of labels
--pids-limit	Tune container pids limit (set -1 for unlimited)
--work-dir	Working directory inside the container
--ulimit	Ulimit options
--read-only	Mount the container's root filesystem as read only
--volumes-from	Mount volumes from the specified container(s)
--stop-signal	Signal to stop the container
--stop-timeout	Timeout (in seconds) to stop a container

Prior to IOS-XR software release 24.1.1, only the below mentioned docker run option commands were supported.

Table 6: Docker Run Options

Docker Run Option	Description
--publish	Publish a container's port(s) to the host

Docker Run Option	Description
--entrypoint	Overwrite the default ENTRYPOINT of the image
--expose	Expose a port or a range of ports
--link	Add link to another container
--env	Set environment variables
--env-file	Read in a file of environment variables
--network	Connect a container to a network
--hostname	Container host name
--interactive	Keep STDIN open even if not attached
--tty	Allocate a pseudo-TTY
--publish-all	Publish all exposed ports to random ports
--volume	Bind mount a volume
--mount	Attach a filesystem mount to the container
--restart	Restart policy to apply when a container exits
--cap-add	Add Linux capabilities
--log-driver	Logging driver for the container
--log-opt	Log driver options
--detach	Run container in background and print container ID
--memory	Memory limit
--memory-reservation	Memory soft limit
--cpu-shares	CPU shares (relative weight)
--sysctl	Sysctl options

The below section provides the information on how to configure the docker run time options. In this example we configure the docker run time option using appmgr and Netconf.

Step 1 Use the pids-limit command to limit the number of process IDs in the docker run command, as shown below:

Example:

```
appmgr application alpine_app activate type docker source alpine docker-run-opts "-it -pids-limit
90" docker-run-cmd "sh"
Router#
```

Step 2 This step shows example for Netconf request for enabling pids-limit:

Example:

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <edit-config>
    <target>
      <candidate/>
    </target>
    <config>
      <appmgr xmlns=http://cisco.com/ns/yang/Cisco-IOS-XR-um-appmgr-cfg>
        <applications>
          <application>
            <application-name>alpine_app</application-name>
            <activate>
              <type>docker</type>
                                          <source-name>alpine_pids_limit</source-name>
                                          <docker-run-cmd>/bin/sh</docker-run-cmd>
                                          <docker-run-opts>-it --pids-limit=10</docker-run-opts>
            </activate>
          </application>
        </applications>
      </appmgr>
    </config>
  </edit-config>
```

Verification

Procedure

	Command or Action	Purpose

Step 1	Verify the configuration - To confirm the configuration, run the following command on the router.
	Example:
	`Router# show running-config appmgr`
	`Thu Mar 23 08:22:47.014 UTC`
	`appmgr`
	` application alpine_app`
	`  activate type docker source alpine`
	`docker-run-opts "-it -pids-limit 90" docker-run-cmd`
	` "sh"`
	` !`
	`!`	

Getting Started with Using Vagrant for Application Hosting

You can use vagrant as a tool for design, development, and testing of applications that can be hosted on Cisco IOS XR. You can use vagrant on a host device of your choice, for completing the steps described in the following sections.

Pre-requisites for Using Vagrant

Before you can start using vagrant, ensure that you have fulfilled the following requirements on your host device.

- Latest version of Vagrant for your operating system. We recommend Version 1.8.6.
- Latest version of a virtual box for your operating system. We recommend Version 5.1+.
- Minimum of 5 GB of RAM with two cores.
- (Optional) If you are using the Windows Operating System, we recommend that you download the Git bash utility for running the commands.

Accessing Global VRF on the Cisco IOS XR Linux Shell by Using a Vagrant Box

The Third-Party Network Namespace (TPNNS) is renamed as Global VRF (global-vrf) in Cisco IOS XR Version 6.0.2 and higher. From Cisco IOS XR Version 6.1.1 and higher, you can use a Linux-based vagrant box to directly access the Global VRF on IOS XR, as described in the following procedure.

Procedure

To access Global VRF by using a vagrant box, use the following steps.

1. Generate an API key and a CCO ID by using the steps described in https://xrdocs.github.io/getting-started/steps-download-iosxr-vagrant.
2. Download the latest stable version of the IOS XR vagrant box.

```
$ curl <cco-id>:<API-KEY>

$ BOXURL --output ~/iosxrv-fullk9-x64.box

$ vagrant box add --name IOS-XRv ~/iosxrv-fullk9-x64.box
```

3. Verify if the vagrant box has been successfully installed.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ vagrant box list
IOS-XRv (virtualbox, 0)
```

4. Create a working directory.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ mkdir ~/iosxrv
annseque@ANNSEQUE-WS02 MINGW64 ~ cd ~/iosxrv
```

5. Initialize the vagrant file with the new vagrant box.

```
ANNSEQUE-WS02 MINGW64:iosxrv annseque$ vagrant init IOS-XRv
A `Vagrantfile` has been placed in this directory. You are now
ready to `vagrant up` your first virtual environment! Please read
the comments in the Vagrantfile as well as documentation on
`vagrantup.com` for more information on using Vagrant.
```

6. Launch the vagrant instance on your device.

```
ANNSEQUE-WS02 MINGW64:iosxrv annseque$
$ vagrant up
Bringing machine 'default' up with 'virtualbox' provider...
==> default: Importing base box 'IOS-XRv'...
==> default: Matching MAC address for NAT networking...
==> default: Setting the name of the VM: annseque_default_1472028191221_94197
==> default: Clearing any previously set network interfaces...
==> default: Preparing network interfaces based on configuration...
```

```
    default: Adapter 1: nat
==> default: Forwarding ports...
    default: 57722 (guest) => 2222 (host) (adapter 1)
    default: 22 (guest) => 2223 (host) (adapter 1)
==> default: Running 'pre-boot' VM customizations...
==> default: Booting VM...
==> default: Waiting for machine to boot. This may take a few minutes...
    default: SSH address: 127.0.0.1:2222
    default: SSH username: vagrant
    default: SSH auth method: private key
    default: Warning: Remote connection disconnect. Retrying...
   ...
    default:
    default: Vagrant insecure key detected. Vagrant will automatically replace
    default: this with a newly generated keypair for better security.
    default:
    default: Inserting generated public key within guest...
    default: Removing insecure key from the guest if it's present...
    default: Key inserted! Disconnecting and reconnecting using new SSH key...
==> default: Machine booted and ready!
==> default: Checking for guest additions in VM...
    default: No guest additions were detected on the base box for this VM! Guest
    default: additions are required for forwarded ports, shared folders, host only
    default: networking, and more. If SSH fails on this machine, please install
    default: the guest additions and repackage the box to continue.
    default:
    default: This is not an error message; everything may continue to work properly,
    default: in which case you may ignore this message.
==> default: Running provisioner: shell...
    default: Running: inline script
==> default: Running provisioner: shell...
    default: Running: inline script
==> default: Running provisioner: shell...
    default: Running: inline script

==> default: Machine 'default' has a post `vagrant up` message. This is a message
==> default: from the creator of the Vagrantfile, and not from Vagrant itself:
==> default:
==> default:
==> default:     Welcome to the IOS XRv (64-bit) Virtualbox.
==> default:     To connect to the XR Linux shell, use: 'vagrant ssh'.
==> default:     To ssh to the XR Console, use: 'vagrant port' (vagrant version > 1.8)
==> default:     to determine the port that maps to guestport 22,
==> default:     then: 'ssh vagrant@localhost -p <forwarded port>'
==> default:
==> default:     IMPORTANT:  READ CAREFULLY
==> default:     The Software is subject to and governed by the terms and conditions
==> default:     of the End User License Agreement and the Supplemental End User
==> default:     License Agreement accompanying the product, made available at the
==> default:     time of your order, or posted on the Cisco website at
==> default:     www.cisco.com/go/terms (collectively, the 'Agreement').
==> default:     As set forth more fully in the Agreement, use of the Software is
==> default:     strictly limited to internal use in a non-production environment
==> default:     solely for demonstration and evaluation purposes. Downloading,
==> default:     installing, or using the Software constitutes acceptance of the
==> default:     Agreement, and you are binding yourself and the business entity
==> default:     that you represent to the Agreement. If you do not agree to all
==> default:     of the terms of the Agreement, then Cisco is unwilling to license
==> default:     the Software to you and (a) you may not download, install or use the
==> default:     Software, and (b) you may return the Software as more fully set forth
==> default:     in the Agreement.
```

7. Access the XR Linux shell by using SSH on vagrant.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ vagrant ssh
xr-vm_node0_RP0_CPU0:~$
```

You have successfully accessed the IOS XR Linux shell.

8. (Optional) You can check the version of Linux.

```
xr-vm_node0_RP0_CPU0:~$ uname -a
Linux xr-vm_node0_RP0_CPU0 3.14.23-WR7.0.0.2_standard
#1 SMP Tue May 24 22:48:36 PDT 2016 x86_64 x86_64 x86_64 GNU/Linux
```

9. (Optional) You can view the list of available namespaces.

```
[xr-vm_node0_RP0_CPU0:~]$ ip netns list
tpnns
xrnns
global-vrf
```

10. View the network interfaces in the global VRF namespace.

```
[XR-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)
fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
```

```
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

The interfaces displayed in the output are replicas of the IOS XR interfaces in the Linux environment. (They have the same MAC and IP addresses.)

- `Gi0_0_0_0` is the IOS XR GigabitEthernet 0/0/0/0 interface.
- `Mg0_RP0_CPU0_0` is the IOS XR management interface, used for administrative operations on XR.
- `fwd_ew` is the interface used for communication (east to west) between third-party applications and IOS XR.
- `fwdintf` is the interface used for communication between third-party applications and the network outside IOS XR.
- `lo:0` is the IOS XR loopback0 interface used for communication between third-party applications and the outside network through the `fwdintf` interface. The loopback0 interface must be configured for applications to communicate outside XR. Alternatively, applications can also configure a GigE interface for external communication, as explained in the Communication Outside Cisco IOS XR, on page 45 section.

  The presence of `fwd_ew` and `fwdintf` interfaces confirm that you are in the global VRF namespace. All interfaces that are enabled (with the **no shut** command) are added to `global-vrf` on IOS XR.

11. (Optional) View the IP addresses used by the `fwd_ew` and `fwdintf` interfaces.

```
[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 1.1.1.1
8.8.8.8 dev fwd_ew  scope link
192.168.122.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 192.168.122.213
```

12. To access the IOS XR router prompt, use the following steps.

a. Log out of the XR Linux shell virtual box.

```
xr-vm_node0_RP0_CPU0:~$ exit
logout
Connection to 127.0.0.1 closed.
```

b. Check the port number for accessing XR through SSH.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ vagrant port
The forwarded ports for the machine are listed below. Please note that
these values may differ from values configured in the Vagrantfile if the
provider supports automatic port collision detection and resolution.

    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)
```

c. Use the port number, **2223**, and the password, **vagrant**, for accessing XR through SSH .

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:


RP/0/RP0/CPU0:ios#
```

You have successfully accessed the XR router prompt.

13. View the network interfaces by using the **bash -c ifconfig** command at the XR router prompt.

```
RP/0/RP0/CPU0:ios# bash -c ifconfig
Thu Jul 21 06:03:49.098 UTC

Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)
fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

You can view all the interfaces available in global VRF namespace through the XR router prompt.

14. (Optional) To navigate to the XR Linux shell, you can use the **run** command. To navigate back to the router prompt, you can use the **exit** command.

```
RP/0/RP0/CPU0:ios# run
Thu Jul 21 05:57:04.232 UTC

[xr-vm_node0_RP0_CPU0:~]$

[xr-vm_node0_RP0_CPU0:~]$ exit
exit
RP/0/RP0/CPU0:ios#
```

You are ready to use the IOS XR Linux shell for hosting applications.

Applying Bootstrap Configuration to Cisco IOS XR by Using a Vagrant Box

Configuration that is applied to a router or a device during boot-up is known as bootstrap configuration. By using a vagrant box, you can create a bootstrap configuration and apply it to an instance of the Cisco IOS XR running on a vagrant box.

Procedure

To bootstrap configuration to an instance of XR running on a vagrant box, use the following steps.

1. Generate an API key and a CCO ID by using the steps described in https://xrdocs.github.io/getting-started/steps-download-iosxr-vagrant.
2. Download the latest stable version of the IOS XR vagrant box.

```
$ curl <cco-id>:<API-KEY>

$ BOXURL --output ~/iosxrv-fullk9-x64.box

$ vagrant box add --name IOS-XRv ~/iosxrv-fullk9-x64.box
```

3. Verify if the vagrant box has been successfully installed.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ vagrant box list
IOS-XRv (virtualbox, 0)
```

4. Create a working directory.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ mkdir ~/iosxrv
annseque@ANNSEQUE-WS02 MINGW64 ~ cd ~/iosxrv
```

5. Initialize the vagrant file with the new vagrant box.

```
ANNSEQUE-WS02 MINGW64:iosxrv annseque$ vagrant init IOS-XRv
A `Vagrantfile` has been placed in this directory. You are now
ready to `vagrant up` your first virtual environment! Please read
the comments in the Vagrantfile as well as documentation on
`vagrantup.com` for more information on using Vagrant.
```

6. Clone the `vagrant-xrdocs` repository.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ git clone https://github.com/ios-xr/vagrant-xrdocs.git
```

7. Navigate to the `vagrant-xrdocs` repository and locate the vagrant file containing the configuration with which you want to bootstrap the XR.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ cd vagrant-xrdocs/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ ls
ansible-tutorials/       native-app-topo-bootstrap/  simple-mixed-topo/
lxc-app-topo-bootstrap/  README.md                   single_node_bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ ls single_node_bootstrap/
```

```
configs/  scripts/  Vagrantfile
```

8. Create the bootstrap configuration file which uses a vagrant shell provisioner.

   You would need a shell provisioner section for each node in your network. A sample configuration file is as follows:

```
#Source a config file and apply it to XR

 config.vm.provision "file", source: "configs/rtr_config", destination:
"/home/vagrant/rtr_config"

 config.vm.provision "shell" do |s|
   s.path =  "scripts/apply_config.sh"
   s.args = ["/home/vagrant/rtr_config"]
 end
```

   In the shown sample file, you are using a vagrant file provisioner (`config.vm.provision "file"`) to transfer a file from your host machine to the XR Linux shell. The root of the source directory is the working directory for your vagrant instance. Hence, the `rtr_config` file is located in the `configs` directory.

   You are using a shell script (`config.vm.provision "shell"`) to apply the bootstrap configuration to XR. The shell script eventually runs on the XR Linux shell of the vagrant instance. This script is placed in the `scripts` directory and is named as `apply_config.sh`. The script uses the location of the router configuration file as the destination parameter in the vagrant file provisioner.

9. Verify the directory structure for the single node bootstrap configuration example used in this section.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ cd single_node_bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ tree ./
./
├── Vagrantfile
├── configs
│   └── rtr_config
└── scripts
    └── apply_config.sh

2 directories, 3 files
```

10. Verify the contents of the bootstrap configuration file.

    The bootstrap configuration example we are using in this section configures the gRPC server on port 57789.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ cat configs/rtr_config
!! XR configuration
!
grpc
  port 57789
!
end
```

Note The bootstrap configuration is appended to the existing configuration on the instance of XR.

11. Verify the contents of the shell script you are using to apply the configuration to XR.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ cat scripts/apply_config.sh
#!/bin/bash

## Source ztp_helper.sh to get the xrapply and xrcmd functions.
source /pkg/bin/ztp_helper.sh

function configure_xr()
{
   ## Apply a blind config
   xrapply $1
   if [ $? -ne 0 ]; then
       echo "xrapply failed to run"
   fi
   xrcmd "show config failed" > /home/vagrant/config_failed_check
}

## The location of the config file is an argument to the script
config_file=$1

## Call the configure_xr() function to use xrapply and xrcmd in parallel
configure_xr $config_file

## Check if there was an error during config application
grep -q "ERROR" /home/vagrant/config_failed_check

## Condition based on the result of grep ($?)
if [ $? -ne 0 ]; then
    echo "Configuration was successful!"
    echo "Last applied configuration was:"
    xrcmd "show configuration commit changes last 1"
else
    echo "Configuration Failed. Check /home/vagrant/config_failed on the router for
logs"
    xrcmd "show configuration failed" > /home/vagrant/config_failed
    exit 1
fi
```

In this example, the shell script blindly applies the configuration file specified as an argument ($1) and then checks to see if there was an error while applying the configuration.

The following new commands are introduced in the shell script:

- **xrcmd**: Allows you to run privileged exec commands at the XR router prompt on the XR Linux shell.

  For example, **show run**, **show version**, and so on.

- **xrapply**: Allows you to apply (append) a configuration file to the existing configuration.

- **xrapply_string**: Applies a configuration directly using a single inline string.

  For example, **xrapply_string "interface Gig0/0/0/0\n ip address 1.1.1.2/24 \n no shutdown**

Note To enable the **xrapply**, **xrapply_string**, and **xrcmd** commands`source /pkg/bin/ztp_helper.sh`, it is mandatory to include `source /pkg/bin/ztp_helper.sh` in the script.

12. Verify if the shell provisioner code has been included in the vagrant file.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ cat Vagrantfile
# -*- mode: ruby -*-
# vi: set ft=ruby :

# All Vagrant configuration is done below. The "2" in Vagrant.configure
# configures the configuration version (we support older styles for
# backwards compatibility). Please don't change it unless you know what
# you're doing.

Vagrant.configure(2) do |config|

    config.vm.box = "IOS-XRv"

    #Source a config file and apply it to XR

    config.vm.provision "file", source: "configs/rtr_config", destination:
"/home/vagrant/rtr_config"

    config.vm.provision "shell" do |s|
        s.path =  "scripts/apply_config.sh"
        s.args = ["/home/vagrant/rtr_config"]
    end
end
```

13. Launch the vagrant instance from the current directory.

Launching the vagrant instance should bootstrap the configuration to XR.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ vagrant up
Bringing machine 'default' up with 'virtualbox' provider...
==> default: Importing base box 'IOS-XRv'...
==> default: Matching MAC address for NAT networking...
==> default: Setting the name of the VM:
single_node_bootstrap_default_1472117544017_81536
==> default: Clearing any previously set network interfaces...
==> default: Preparing network interfaces based on configuration...
    default: Adapter 1: nat
==> default: Forwarding ports...
    default: 57722 (guest) => 2222 (host) (adapter 1)
    default: 22 (guest) => 2223 (host) (adapter 1)
==> default: Running 'pre-boot' VM customizations...
==> default: Booting VM...
==> default: Waiting for machine to boot. This may take a few minutes...
    default: SSH address: 127.0.0.1:2222
    default: SSH username: vagrant
    default: SSH auth method: private key
    default: Warning: Remote connection disconnect. Retrying...
    ...
    default:
    default: Vagrant insecure key detected. Vagrant will automatically replace
    default: this with a newly generated keypair for better security.
    default:
    default: Inserting generated public key within guest...
    default: Removing insecure key from the guest if it's present...
```

```
    default: Key inserted! Disconnecting and reconnecting using new SSH key...
==> default: Machine booted and ready!
==> default: Checking for guest additions in VM...
    default: No guest additions were detected on the base box for this VM! Guest
    default: additions are required for forwarded ports, shared folders, host only
    default: networking, and more. If SSH fails on this machine, please install
    default: the guest additions and repackage the box to continue.
    default:
    default: This is not an error message; everything may continue to work properly,
    default: in which case you may ignore this message.
==> default: Running provisioner: shell...
    default: Running: inline script
==> default: Running provisioner: shell...
    default: Running: inline script
==> default: Running provisioner: shell...
    default: Running: inline script
==> default: Running provisioner: file...
==> default: Running provisioner: shell...
    default: Running:
C:/Users/annseque/AppData/Local/Temp/vagrant-shell20160825-3292-1wncpa3.sh
==> default: Configuration was successful!
==> default: Last applied configuration was:
==> default: Building configuration...
==> default: !! IOS XR Configuration version = 6.1.1.18I
==> default: grpc
==> default:  port 57789
==> default: !
==> default: end

==> default: Machine 'default' has a post `vagrant up` message. This is a message
==> default: from the creator of the Vagrantfile, and not from Vagrant itself:
==> default:
==> default:
==> default:     Welcome to the IOS XRv (64-bit) Virtualbox.
==> default:     To connect to the XR Linux shell, use: 'vagrant ssh'.
==> default:     To ssh to the XR Console, use: 'vagrant port' (vagrant version > 1.8)
==> default:     to determine the port that maps to guestport 22,
==> default:     then: 'ssh vagrant@localhost -p <forwarded port>'
==> default:
==> default:     IMPORTANT:  READ CAREFULLY
==> default:     The Software is subject to and governed by the terms and conditions
==> default:     of the End User License Agreement and the Supplemental End User
==> default:     License Agreement accompanying the product, made available at the
==> default:     time of your order, or posted on the Cisco website at
==> default:     www.cisco.com/go/terms (collectively, the 'Agreement').
==> default:     As set forth more fully in the Agreement, use of the Software is
==> default:     strictly limited to internal use in a non-production environment
==> default:     solely for demonstration and evaluation purposes. Downloading,
==> default:     installing, or using the Software constitutes acceptance of the
==> default:     Agreement, and you are binding yourself and the business entity
==> default:     that you represent to the Agreement. If you do not agree to all
==> default:     of the terms of the Agreement, then Cisco is unwilling to license
==> default:     the Software to you and (a) you may not download, install or use the
==> default:     Software, and (b) you may return the Software as more fully set forth
==> default:     in the Agreement.
```

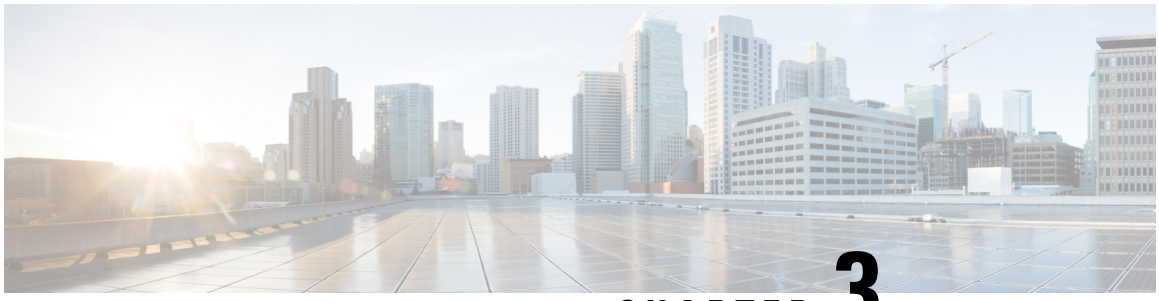
You can see the vagrant file and shell provisioner applying the gPRC server port configuration to XR.

14. (Optional) You can verify the bootstrap configuration on the XR router console from the XR Linux shell.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ vagrant port
The forwarded ports for the machine are listed below. Please note that
```

```
these values may differ from values configured in the Vagrantfile if the
provider supports automatic port collision detection and resolution.

    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)


annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/single_node_bootstrap (master)
$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:


RP/0/RP0/CPU0:ios# show running-config grpc
Thu Aug 25 09:42:24.010 UTC
grpc
 port 57789
!

RP/0/RP0/CPU0:ios# show configuration commit changes last 1
Thu Aug 25 09:42:34.971 UTC
Building configuration...
!! IOS XR Configuration version = 6.1.1.18I
grpc
 port 57789
!
end

RP/0/RP0/CPU0:ios#
```

You have successfully applied a bootstrap configuration to XR.



CHAPTER 3

Accessing the Networking Stack

The Cisco IOS XR Software serves as a networking stack for communication. This section explains how applications on IOS XR can communicate with internal processes, and with servers or outside devices.

Packet I/O on IOS XR

This section illustrates how, with the Packet I/O functionality, you can use Linux applications to manage communication with the IOS XR interfaces. It describes how the OS environment must be set up to establish packet I/O communication with hosted applications.

Exposed IOS-XR Interfaces in Linux

The secondary IPv4 addresses that are configured for an XR interface are now synchronized into the Linux operating system automatically. With this secondary IPv4 address synchronization, the third party applications that are deployed on Cisco IOS XR can now use the secondary IPv4 addresses. Prior to this release, only primary IPv4 addresses were supported and the secondary IPv4 addresses had to be configured manually in the Linux operating system.

Exposed XR interfaces (EXIs) and address-only interfaces support secondary IPv4 address synchronization:

- EXIs have secondary IP addresses added to their corresponding Linux interface
- Address-only interfaces have secondary IP addresses added to the Linux loopback device. For additional information on address-only interfaces, see show linux networking interfaces address-only.

The restrictions of secondary IPv4 addresses synchronization are:

- Secondary IPv4 addresses are not synchronized from Linux to XR for Linux-managed interfaces.
- The **ifconfig** Linux command only displays the first configured IPv4 address. To view the complete list of IPv4 addresses, use the **ip addr show** Linux command.

For additional information on secondary IPv4 addresses, see ipv4 address (network).

You can run **bash** commands at the IOS XR router prompt to view the interfaces and IP addresses stored in global VRF. When you access the Cisco IOS XR Linux shell, you directly enter the global VRF.

SUMMARY STEPS

1. From your Linux box, access the IOS XR console through SSH, and log in.
2. View the ethernet interfaces on IOS XR.
3. Check the IP and MAC addresses of the interface that is in `Up` state. Here, interfaces `HundredGigE0/0/0/24` and `MgmtEth0/RP0/CPU0/0` are in the `Up` state.
4. Verify that the bash command runs in global VRF to view the network interfaces.
5. Access the Linux shell.
6. (Optional) View the IP routes used by the `to_xr` interfaces.

DETAILED STEPS

Step 1 From your Linux box, access the IOS XR console through SSH, and log in.

Example:

```
cisco@host:~$ ssh root@192.168.122.188
root@192.168.122.188's password:
Router#
```

Step 2 View the ethernet interfaces on IOS XR.

Example:

```
Router#show ip interface brief
Interface IP-Address Status Protocol Vrf-Name
FourHundredGigE0/0/0/0 unassigned Shutdown Down default
FourHundredGigE0/0/0/1 unassigned Shutdown Down default
FourHundredGigE0/0/0/2 unassigned Shutdown Down default
FourHundredGigE0/0/0/3 unassigned Shutdown Down default
FourHundredGigE0/0/0/4 unassigned Shutdown Down default
FourHundredGigE0/0/0/5 unassigned Shutdown Down default
FourHundredGigE0/0/0/6 unassigned Shutdown Down default
FourHundredGigE0/0/0/7 unassigned Shutdown Down default
FourHundredGigE0/0/0/8 unassigned Shutdown Down default
FourHundredGigE0/0/0/9 unassigned Shutdown Down default
FourHundredGigE0/0/0/10 unassigned Shutdown Down default
FourHundredGigE0/0/0/11 unassigned Shutdown Down default
FourHundredGigE0/0/0/12 unassigned Shutdown Down default
FourHundredGigE0/0/0/13 unassigned Shutdown Down default
FourHundredGigE0/0/0/14 unassigned Shutdown Down default
FourHundredGigE0/0/0/15 unassigned Shutdown Down default
FourHundredGigE0/0/0/16 unassigned Shutdown Down default
FourHundredGigE0/0/0/17 unassigned Shutdown Down default
FourHundredGigE0/0/0/18 unassigned Shutdown Down default
FourHundredGigE0/0/0/19 unassigned Shutdown Down default
FourHundredGigE0/0/0/20 unassigned Shutdown Down default
FourHundredGigE0/0/0/21 unassigned Shutdown Down default
FourHundredGigE0/0/0/22 unassigned Shutdown Down default
FourHundredGigE0/0/0/23 unassigned Shutdown Down default
HundredGigE0/0/0/24 10.1.1.10 Up Up default
HundredGigE0/0/0/25 unassigned Shutdown Down default
HundredGigE0/0/0/26 unassigned Shutdown Down default
HundredGigE0/0/0/27 unassigned Shutdown Down default
HundredGigE0/0/0/28 unassigned Shutdown Down default
HundredGigE0/0/0/29 unassigned Shutdown Down default
```

```
HundredGigE0/0/0/30 unassigned Shutdown Down default
HundredGigE0/0/0/31 unassigned Shutdown Down default
HundredGigE0/0/0/32 unassigned Shutdown Down default
HundredGigE0/0/0/33 unassigned Shutdown Down default
HundredGigE0/0/0/34 unassigned Shutdown Down default
HundredGigE0/0/0/35 unassigned Shutdown Down default
MgmtEth0/RP0/CPU0/0 192.168.122.22 Up Up default
```

Note Use the **ip addr show** or **ip link show** commands to view all corresponding interfaces in Linux. The IOS XR interfaces that are `admin-down` state also reflects a `Down` state in the Linux kernel.

Step 3 Check the IP and MAC addresses of the interface that is in `Up` state. Here, interfaces `HundredGigE0/0/0/24` and `MgmtEth0/RP0/CPU0/0` are in the `Up` state.

Example:

```
Router#show interfaces HundredGigE0/0/0/24
...
HundredGigE0/0/0/24 is up, line protocol is up
Interface state transitions: 4
Hardware is HundredGigE0/0/0/24, address is 5246.e8a3.3754 (bia
5246.e8a3.3754)
Internet address is 10.1.1.1/24
MTU 1514 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
reliability 255/255, txload 0/255, rxload 0/255
Encapsulation ARPA,
Duplex unknown, 1000Mb/s, link type is force-up
output flow control is off, input flow control is off
loopback not set,
Last link flapped 01:03:50
ARP type ARPA, ARP timeout 04:00:00
Last input 00:38:45, output 00:38:45
Last clearing of "show interface" counters never
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
12 packets input, 1260 bytes, 0 total input drops
0 drops for unrecognized upper-level protocol
Received 2 broadcast packets, 0 multicast packets
0 runts, 0 giants, 0 throttles, 0 parity
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
12 packets output, 1224 bytes, 0 total output drops
Output 1 broadcast packets, 0 multicast packets
```

Step 4 Verify that the bash command runs in global VRF to view the network interfaces.

Example:

```
Router#bash -c ifconfig
Hu0_0_0_24 Link encap:Ethernet HWaddr 78:e7:e8:d3:20:c0
inet addr:10.1.1.10 Bcast:0.0.0.0 Mask:255.255.255.0
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
RX packets:4 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:360 (360.0 B) TX bytes:0 (0.0 B)
Mg0_RP0_CPU0_0 Link encap:Ethernet HWaddr 54:00:00:00:bd:49
inet addr:192.168.122.22 Bcast:0.0.0.0 Mask:255.255.255.0
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
RX packets:3859 errors:0 dropped:0 overruns:0 frame:0
TX packets:1973 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:2377782 (2.2 MiB) TX bytes:593602 (579.6 KiB)
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
```

```
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:242 errors:0 dropped:0 overruns:0 frame:0
TX packets:242 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:12100 (11.8 KiB) TX bytes:12100 (11.8 KiB)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:1 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:60 (60.0 B)
```

The `to_xr` interface indicates access to the global VRF.

Step 5 Access the Linux shell.

Example:

```
Router#bash
[ios:~]$
```

Step 6 (Optional) View the IP routes used by the `to_xr` interfaces.

Example:

```
[ios:~]$ip route
default dev to_xr scope link metric 2048
6.1.0.0/16dev Mg0_RP0_CPU0_0 proto kernel scope link src 6.1.22.41
20.1.0.0/16dev Hu0_0_0_0 proto kernel scope link src 20.1.1.1
20.2.0.0/16dev Hu0_0_0_20 proto kernel scope link src 20.2.1.1
30.1.0.0/24dev BE500 proto kernel scope link src 30.1.0.1
172.17.0.0/16dev docker0 proto kernel scope link src 172.17.0.1linkdown
```

Note You can also enter the global VRF directly after logging into IOS XR using the **run ip netns exec vrf-default bash** command.

Setting up Virtual IP Addresses

Feature Name	Release Information	Description
Virtual IP address in the Linux networking stack	Release 7.5.2	Virtual IP addresses allow a single IP address to connect to the current active RP after an RP switchover event. In addition, this functionality enables your network stack to support virtual IP addresses for third-party applications and IOS XR applications that use the Linux networking stack. The following commands are modified: • ipv4 virtual address • ipv6 virtual address • show linux networking interfaces address-only

Interfaces configured on IOS XR are programmed into the Linux kernel. These interfaces allow Linux applications to run as if they were running on a regular Linux system. This packet I/O capability ensures that off-the-shelf Linux applications can be run alongside IOS XR, allowing operators to use their existing tools and automate deployments with IOS XR.

The IP address on the Linux interfaces, MTU settings, MAC address are inherited from the corresponding settings of the IOS XR interface. Accessing the global VRF network namespace ensures that when you issue the **bash** command, the default or the global VRF in IOS XR is reflected in the kernel. This ensures default reachability based on the routing capabilities of IOS XR and the packet I/O infrastructure.

Virtual addresses can be configured to access a router from the management network such as gRPC using a single virtual IP address. On a device with two or more RPs, the virtual address refers to the management interface that is currently active. This functionality can be used across RP failover without the information of which RP is currently active. This is applicable to the Linux packet path.

Procedure

	Command or Action	Purpose
Step 1	You can use the following commands to verify the IP Address in the Linux networking stack:	• ipv4 virtual address • ipv6 virtual address • show linux networking interfaces address-only

Program Routes in Linux

The basic routes required to allow applications to send or receive traffic can be programmed into the kernel. The Linux network stack that is part of the kernel is used by normal Linux applications to send/receive packets.

In an IOS XR stack, IOS XR acts as the network stack for the system. Therefore to allow the Linux network stack to connect into and use the IOS XR network stack, basic routes must be programmed into the Linux Kernel.

Step 1 View the routes from the bash shell.

Example:

```
[ios:~]$ip route
default dev to_xr scope link src 10.1.1.10 metric 2048
10.1.1.0/24 dev Hu0_0_0_24 proto kernel scope link src 10.1.1.10
192.168.122.0/24 dev Mg0_RP0_CPU0_0 proto kernel scope link src 192.168.122.22
```

Step 2 Programme the routes in the kernel.

Two types of routes can be programmed in the kernel:

- **Default Route:** The default route sends traffic destined to unknown subnets out of the kernel using a special `to_xr` interface. This interface sends packets to IOS XR for routing using the routing state in XR Routing Information Base (RIB) or Forwarding Information Base (FIB). The `to_xr` interface does not have an associated IP address. In Linux, most applications expect the outgoing packets to use the IP address of the outgoing interface as the source IP address.

  With the `to_xr` interface, because there is no IP address, a source hint is required. The source hint can be changed to use the IP address another physical interface IP or loopback IP address. In the following example, the source hint is set to 10.1.1.10, which is the IP address of the Hu0_0_0_24 interface. To use the Management port IP address, change the source hint:

  ```
  Router#bash

  [ios:~]$ip route replace default dev to_xr scope link src 192.168.122.22 metric 2048

  [ios:~]$ip route
  default dev to_xr scope link src 192.168.122.22 metric 2048
  10.1.1.0/24 dev Hu0_0_0_24 proto kernel scope link src 10.1.1.10
  192.168.122.0/24 dev Mg0_RP0_CPU0_0 proto kernel scope link src 192.168.122.22
  ```

  With this updated source hint, any default traffic exiting the system uses the Management port IP address as the source IP address.

- **Local or Connected Routes:** The routes are associated with the subnet configured on interfaces. For example, the 10.1.1.0/24 network is associated with the `Hu0_0_0_24` interface, and the 192.168.122.0/24 subnet is associated with the `Mg0_RP0_CPU0` interface .

Configure VRFs in Linux

VRFs configured in IOS XR are automatically synchronized to the kernel. In the kernel, the VRFs appear as network namespaces (netns). For every globally-configured VRF, a Linux network namespace is created. With this capability it is possible to isolate Linux applications or processes into specific VRFs like an out-of-band management VRF and open-up sockets or send or receive traffic only on interfaces in that VRF.

Every VRF, when synchronized with the Linux kernel, is programmed as a network namespace with the same name as a VRF but with the string `vrf` prefixed to it. The default VRF in IOS XR has the name `default`. This name gets programmed as `vrf-default` in the Linux kernel.

The following example shows how to configure a custom VRF `blue`:

Step 1 Identify the current network namespace or VRF.

Example:

```
[ios:~]$ip netns identify $$
vrf-default
global-vrf
```

Step 2 Configure a custom VRF `blue`.

Example:

```
Router#conf t

Router(config)#vrf blue
Router(config-vrf)#commit
```

Step 3 Verify that the VRF `blue` is configured in IOS XR.

Example:

```
Router#show run vrf
vrf blue
!
```

Step 4 Verify that the VRF `blue` is created in the kernel.

Example:

```
Router#bash

[ios:~]$ls -l /var/run/netns
total 0
-r--r--r--. 1 root root 0 Jul 30 04:17 default
-r--r--r--. 1 root root 0 Jul 30 04:17 global-vrf
-r--r--r--. 1 root root 0 Jul 30 04:17 tpnns
-r--r--r--. 1 root root 0 Aug 1 17:01 vrf-blue
-r--r--r--. 1 root root 0 Jul 30 04:17 vrf-default
-r--r--r--. 1 root root 0 Jul 30 04:17 xrnns
```

Step 5 Access VRF `blue` to launch and execute processes from the new network namespace.

Example:

```
[ios:~]$ip netns exec vrf-blue bash
[ios:~]$
[ios:~]$ip netns identify $$
vrf-blue
[ios:~]$
```

Running an **ifconfig** command shows only the default `to-xr` interface because there is no IOS XR interface in this VRF.

```
[ios:~]$ifconfig
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
```

```
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
[ios:~]$
```

Step 6 Configure an interface in the VRF `blue` in IOS XR. This interface will be configured automatically in the network namespace `vrf-blue` in the kernel.

Example:

The following example shows how to configure HundredGigE 0/0/0/24 interface in `vrf-blue` from IOS XR:

```
Router#conf t
Router(config)#int HundredGigE 0/0/0/24
Router(config-if)#no ipv4 address
Router(config-if)#vrf blue
Router(config-if)#ipv4 address 10.1.1.10/24
Router(config-if)#commit
```

Step 7 Verify that the HundredGigE 0/0/0/24 interface is configured in the VRF `blue` in IOS XR.

Example:

```
Router#show run int HundredGigE 0/0/0/24
interface HundredGigE0/0/0/24
vrf blue
ipv4 address 10.1.1.10 255.255.255.0
!
```

Step 8 Verify that the interface is configured in the VRF `blue` in the kernel.

Example:

```
Router#bash
Thu Aug 1 17:09:39.314 UTC
[ios:~]$
[ios:~]$ip netns exec vrf-blue bash
[ios:~]$
[ios:~]$ifconfig
Hu0_0_0_24 Link encap:Ethernet HWaddr 78:e7:e8:d3:20:c0
inet addr:10.1.1.10 Bcast:0.0.0.0 Mask:255.255.255.0
UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
[ios:~]$
```

Open Linux Sockets

The socket entries are programmed into the Local Packet Transport Services (LPTS) infrastructure that distributes the information through the line cards. Any packet received on a line card interface triggers an LPTS lookup to send the packet to the application opening the socket. Because the required interfaces and routes already appear in the kernel, the applications can open the sockets — TCP or UDP.

Step 1 Verify that applications open up sockets.

Example:

```
Router#bash
[ios:~]$nc -l 0.0.0.0 -p 5000 &
[1] 1160
[ios:~]$
[ios:~]$netstat -nlp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address Foreign Address State PID/Program name
tcp 0 0 0.0.0.0:5000 0.0.0.0:* LISTEN 1160/nc
tcp 0 0 0.0.0.0:57777 0.0.0.0:* LISTEN 14723/emsd
tcp 0 0 0.0.0.0:22 0.0.0.0:* LISTEN 8875/ssh_server
tcp6 0 0 :::22 :::* LISTEN 8875/ssh_server
udp 0 0 0.0.0.0:68 0.0.0.0:* 13235/xr_dhcpcd
Active UNIX domain sockets (only servers)
Proto RefCnt Flags Type State I-Node PID/Program name Path
[ios:~]$exit
Logout
Router#
Router#show lpts pifib brief | i 5000
Thu Aug 1 17:16:00.938 UTC
IPv4 default TCP any 0/RP0/CPU0 any,5000 any
Router#
```

Step 2 Verify that the socket is open.

Example:

```
Router#show lpts pifib brief | i 5000
IPv4 default TCP any 0/RP0/CPU0 any,5000 any
```

Netcat starts listening on port 5000, which appears as an IPv4 TCP socket in the netstat output like a typical Linux kernel. This socket gets programmed to LPTS, creating a corresponding entry in the hardware to the lookup tcp port 5000. The incoming traffic is redirected to the kernel of the active RP where the netcat runs.

Send and Receive Traffic

Connect to the nc socket from an external server. For example, the nc socket was started in the `vrf-default` network namespace. So, connect over an interface that is in the same VRF.

```
[root@localhost ~]#nc -vz 192.168.122.22 5000
Ncat: Version 7.50 ( https://nmap.org/ncat )
Ncat: Connected to 192.168.122.22:5000.
Ncat: 0 bytes sent, 0 bytes received in 0.01 seconds.
```

Manage IOS XR Interfaces through Linux

The Linux system contains a number of individual network namespaces. Each namespace contains a set of interfaces that map to a single interface in the XR control plane. These interfaces represent the exposed XR interfaces (eXI). By default, all interfaces in IOS XR are managed through the IOS XR configuration (CLI or YANG models), and the attributes of the interface (IP address, MTU, and state) are inherited from the corresponding configuration and the state of the interface in XR.

With the new Packet I/O functionality, it is possible to have an IOS XR interface completely managed by Linux. This also means that one or more of the interfaces can be configured to be managed by Linux, and standard automation tools can be used on Linux servers can be used to manage interfaces in IOS XR.

Note Secondary IPv4 addresses cannot be managed by Linux.

Configure an Interface to be Linux-Managed

This section shows how to configure an interface to be Linux-managed.

Step 1 Check the available exposed-interfaces in the system.

Example:

```
Router(config)#linux networking exposed-interfaces interface ?

  Bundle-Ether     Aggregated Ethernet interface(s) | short name is BE
  FiftyGigE        FiftyGigabitEthernet/IEEE 802.3 interface(s) | short name is Fi
  FortyGigE        FortyGigabitEthernet/IEEE 802.3 interface(s) | short name is Fo
  FourHundredGigE  FourHundredGigabitEthernet/IEEE 802.3 interface(s) | short name is FH
  GigabitEthernet  GigabitEthernet/IEEE 802.3 interface(s) | short name is Gi
  HundredGigE      HundredGigabitEthernet/IEEE 802.3 interface(s) | short name is Hu
  Loopback         Loopback interface(s) | short name is Lo
  MgmtEth          Ethernet/IEEE 802.3 interface(s) | short name is Mg
  TenGigE          TenGigabitEthernet/IEEE 802.3 interface(s) | short name is Te
  TwentyFiveGigE   TwentyFiveGigabitEthernet/IEEE 802.3 interface(s) | short name is TF
  TwoHundredGigE   TwoHundredGigabitEthernet/IEEE 802.3 interface(s) | short name is TH
```

Step 2 Configure the interface to be managed by Linux.

Example:

The following example shows how to configure a HundredGigE interface to be managed by Linux:

```
Router#configure
Router(config)#linux networking exposed-interfaces interface HundredGigE 0/0/0/24 linux-managed
Router(config-exi-if)#commit
```

Step 3 View the interface details and the VRF.

Example:

The following example shows the information for HundredGigE interface:

```
Router#show run interface HundredGigE0/0/0/24
interface HundredGigE0/0/0/24
mtu 4110
vrf blue
ipv4 mtu 4096
ipv4 address 10.1.1.10 255.255.255.0
```

```
ipv6 mtu 4096
ipv6 address fe80::7ae7:e8ff:fed3:20c0 link-local
!
```

Step 4 Verify the configuration in XR.

Example:

The following example shows the configuration for HundredGigE interface:

```
Router#show running-config linux networking

linux networking
 exposed-interfaces
  interface HundredGigE0/0/0/24 linux-managed
  !
 !
!
```

Step 5 Verify the configuration from Linux.

Example:

The following example shows the configuration for HundredGigE interface:

```
Router#bash
Router:Aug 1 17:40:02.873 UTC: bash_cmd[67805]: %INFRA-INFRA_MSG-5-RUN_LOGIN : User vagrant logged
into shell from vty0

[ios:~]$ip netns exec vrf-blue bash

[ios:~]$ifconfig
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)

[ios:~]$ifconfig -a
Hu0_0_0_24 Link encap:Ethernet HWaddr 78:e7:e8:d3:20:c0
BROADCAST MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
```

```
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
```

Configure New IP address on the Interface in Linux

This section shows how to configure a new IP address on the Linux-managed interface.

Step 1 Configure the IP address on the interface.

Example:

```
[ios:~]$ip addr add 10.1.1.10/24 dev Hu0_0_0_24
[ios:~]$Router:Aug 1 17:41:11.546 UTC: xlncd[253]: %MGBL-CONFIG-6-DB_COMMIT : Configuration
committed by user 'system'. Use 'show configuration commit changes 1000000021' to view the changes.
```

Step 2 Verify that the new IP address is configured.

Example:

```
[ios:~]$ifconfig Hu0_0_0_24
Hu0_0_0_24 Link encap:Ethernet HWaddr 78:e7:e8:d3:20:c0
inet addr:10.1.1.10 Bcast:0.0.0.0 Mask:255.255.255.0
BROADCAST MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
```

Configure Custom MTU Setting

This section shows how to bring up the interface and configure a custom MTU in a Linux-managed interface.

Step 1 Configure the MTU setting.

Example:

```
[ios:~]$ifconfig Hu0_0_0_24 up

[ios:~]$Router:Aug 1 17:41:54.824 UTC: ifmgr[266]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/0/0/24, changed state to Down
Router:Aug 1 17:41:54.824 UTC: ifmgr[266]: %PKT_INFRA-LINEPROTO-5-UPDOWN : Line protocol on
Interface HundredGigE0/0/0/24, changed state to Down
Router:Aug 1 17:41:56.448 UTC: xlncd[253]: %MGBL-CONFIG-6-DB_COMMIT : Configuration committed by
user 'system'. Use 'show configuration commit changes 1000000022' to view the changes.
Router:Aug 1 17:41:56.471 UTC: ifmgr[266]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/0/0/24, changed state to Up
Router:Aug 1 17:41:56.484 UTC: ifmgr[266]: %PKT_INFRA-LINEPROTO-5-UPDOWN : Line protocol on
Interface HundredGigE0/0/0/24, changed state to Up
Router:Aug 1 17:41:58.493 UTC: xlncd[253]: %MGBL-CONFIG-6-DB_COMMIT : Configuration committed by
user 'system'. Use 'show configuration commit changes 1000000023' to view the changes.

[ios:~]$
[ios:~]$ ip link set dev Hu0_0_0_24 mtu 4096
[ios:~]$
```

```
[ios:~]$Router:Aug 1 17:42:46.830 UTC: xlncd[253]: %MGBL-CONFIG-6-DB_COMMIT : Configuration
committed by user 'system'. Use 'show configuration commit changes 1000000024' to view the changes.
```

Step 2 Verify that the MTU setting has been updated in Linux.

Example:

```
[ios:~]$ifconfig
Hu0_0_0_24 Link encap:Ethernet HWaddr 78:e7:e8:d3:20:c0
inet addr:10.1.1.10 Bcast:0.0.0.0 Mask:255.255.255.0
inet6 addr: fe80::7ae7:e8ff:fed3:20c0/64 Scope:Link
UP BROADCAST RUNNING MULTICAST MTU:4096 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:0 (0.0 B) TX bytes:648 (648.0 B)
lo Link encap:Local Loopback
inet addr:127.0.0.1 Mask:255.0.0.0
inet6 addr: ::1/128 Scope:Host
UP LOOPBACK RUNNING MTU:65536 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
to_xr Link encap:UNSPEC HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
UP POINTOPOINT RUNNING NOARP MULTICAST MTU:1500 Metric:1
RX packets:0 errors:0 dropped:0 overruns:0 frame:0
TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:500
RX bytes:0 (0.0 B) TX bytes:0 (0.0 B)
```

Step 3 Check the effect on the IOS XR configuration with the change in MTU setting on this interface.

Example:

```
Router#show running-config int HundredGigE0/0/0/24
interface HundredGigE0/0/0/24
 mtu 4110
  vrf blue
  ipv4 mtu 4096
  ipv4 address 10.1.1.10 255.255.255.0
  ipv6 mtu 4096
  ipv6 address fe80::7ae7:e8ff:fed3:20c0 link-local
  !
 !
!
Router#
Router#show ip int br | i HundredGigE0/0/0/24
HundredGigE0/0/0/24 10.1.1.10 Up Up blue
```

The output indicates that the interface acts as a regular Linux interface, and IOS XR configuration receives inputs from Linux.

Configure Traffic Protection for Linux Networking

Traffic protection provides a mechanism to configure Linux firewalls using IOS XR configuration. These rules can be used to restrict traffic to Linux applications. You can restrict traffic to Linux applications using native Linux firewalls or configuring IOS XR Linux traffic protection. It is not recommended to use both mechanisms at the same time. Any combination of remote address, local address and ingress interface can be

specified as rules to either allow or deny traffic. However, at least one parameter must be specified for the traffic protection rule to be valid.

Note If traffic is received on a protocol or port combination that has no traffic protection rules configured, then all traffic is allowed by default.

This example explains how to configure a traffic protection rule on IOS XR to deny all traffic on port 999 except for traffic arriving on interface HundredGigE0/0/0/25.

Step 1 Configure traffic protection rules.

Example:

```
Router(config)#linux networking vrf default address-family ipv4 protection protocol
tcp local-port 999 default-action deny permit hundredgigE0/0/0/25
Router(config)#commit
```

where —

- **address-family:** Configuration for a particular IPv4 or IPv6 address family.
- **protection:** Configure traffic protection for Linux networking.
- **protocol:** Select the supported protocol - TCP or UDP.
- **local-port:** L4 port number to specify traffic protection rules for Linux networking.
- **port number:** Port number ranges from 1 to 65535 or all ports.
- **default-action:** Default action to take for packets matching this traffic protection service.
- **deny:** Drop packets for this service.
- **permit:** Permit packets to reach Linux application for this service.

Step 2 Verify that the traffic protection rule is applied successfully.

Example:

```
Router(config)#show run linux networking
linux networking
 vrf default
  address-family ipv4
   protection
    protocol tcp local-port 999 default-action deny
     permit interface HundredGigE0/0/0/25
     !
    !
   !
 !
```

Communication Outside Cisco IOS XR

To communicate outside Cisco IOS XR, applications use the `fwdintf` interface address that maps to the `loopback0` interface or a configured Gigabit Ethernet interface address. For information on the various interfaces on IOS XR, see Application Hosting on the Cisco IOS XR Linux Shell, on page 5.

To have an iPerf or Chef client on IOS XR communicate with its respective server outside IOS XR, you must configure an interface address as the source address on XR. The remote servers must configure this route address to reach the respective clients on IOS XR.

This section provides an example of configuring a Gigabit Ethernet interface address as the source address for external communication.

Using a Gigabit Ethernet Interface for External Communication

To configure a GigE interface on IOS XR for external communication, use these steps:

1. Configure a GigE interface.

```
RP/0/RP0/CPU0:ios(config)# interface GigabitEthernet 0/0/0/1
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 192.57.43.10 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# no shut
RP/0/RP0/CPU0:ios(config-if)# commit
Fri Oct 30 07:51:14.785 UTC
RP/0/RP0/CPU0:ios(config-if)# exit
RP/0/RP0/CPU0:ios(config)# exit
```

2. Verify whether the configured interface is up and operational on IOS XR.

```
RP/0/RP0/CPU0:ios# show ipv4 interface brief
Fri Oct 30 07:51:48.996 UTC

Interface                      IP-Address      Status                Protocol
Loopback0                      1.1.1.1         Up                    Up
Loopback1                      8.8.8.8         Up                    Up
GigabitEthernet0/0/0/0         192.164.168.10  Up                    Up
GigabitEthernet0/0/0/1         192.57.43.10    Up                    Up
GigabitEthernet0/0/0/2         unassigned      Shutdown              Down
MgmtEth0/RP0/CPU0/0            192.168.122.197 Up                    Up
RP/0/RP0/CPU0:ios#
```

3. Enter the Linux bash shell and verify if the configured interface is up and running.

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2, run the following command */
RP/0/RP0/CPU0:ios# bash


[xr-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)
```

```
Gi0_0_0_1 Link encap:Ethernet  HWaddr 52:46:2e:49:f6:ff
          inet addr:192.57.43.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:2eff:fe49:f6ff/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:3 errors:0 dropped:0 overruns:0 frame:0
          TX packets:6 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:294 (294.0 B)  TX bytes:504 (504.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:4 errors:0 dropped:0 overruns:0 frame:0
          TX packets:6 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:392 (392.0 B)  TX bytes:532 (532.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:8 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:672 (672.0 B)  TX bytes:672 (672.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

4. Exit the Linux bash shell and configure the GigE interface as the source address for external communication.

```
[xr-vm_node0_RP0_CPU0:~]$ exit

RP/0/RP0/CPU0:ios# config
Fri Oct 30 08:55:17.992 UTC
RP/0/RP0/CPU0:ios(config)# tpa address-family ipv4 update-source gigabitEthernet 0/0/0/1
RP/0/RP0/CPU0:ios(config)# commit
Fri Oct 30 08:55:38.795 UTC
```

Note By default, the `fwdintf` interface maps to the `loopback0` interface for external communication. This is similar to binding a routing process or router ID to the `loopback0` interface. When you use the `tpa address-family ipv4 update-source` command to bind the `fwdintf` interface to a Gigabit Ethernet interface, network connectivity can be affected if the interface goes down.

5. Enter the Linux bash shell and verify whether the GigE interface address is used by the `fwdintf` interface for external communication.

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2, run the following command */
RP/0/RP0/CPU0:ios# bash

[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 192.57.43.10
8.8.8.8 dev fwd_ew  scope link
192.168.122.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 192.168.122.197
[xr-vm_node0_RP0_CPU0:~]$
```

External communication is successfully enabled on IOS XR.

East-West Communication for Third-Party Applications

East-West communication on IOS XR is a mechanism by which applications hosted in containers interact with native XR applications (hosted in the XR control plane).

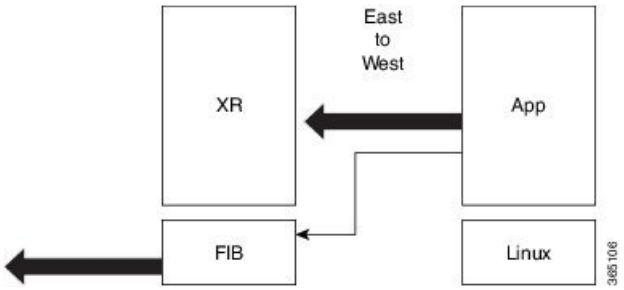
The following figure illustrates how a third-party application hosted on IOS XR interacts with the XR Control Plane.

The application sends data to the Forwarding Information Base (FIB) of IOS XR. The application is hosted in the east portion of IOS XR, while the XR control plane is located in the west region. Therefore, this form of communication between a third-party application and the XR control plane is termed as East-West (E-W) communication.

Third-party applications such as Chef Client and Puppet Agent use this mode of communication to configure and manage containers, packages, and applications on IOS XR. In the future, this support could be extended to IOS XR, configured and managed by such third-party applications.

Note East-West communication is not supported on IOS XR from software release 7.9.1.

Figure 3: East-West Communication on IOS XR



For a third-party application to communicate with IOS XR, the Loopback1 interface must be configured. This is explained in the following procedure.

1. Configure the Loopback1 interface on IOS XR.

```
RP/0/RP0/CPU0:ios(config)# interface Loopback1
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 8.8.8.8/32
RP/0/RP0/CPU0:ios(config-if)# no shut
RP/0/RP0/CPU0:ios(config-if)# commit
RP/0/RP0/CPU0:ios(config-if)# exit
RP/0/RP0/CPU0:ios(config)#
```

2. Verify the creation of the Loopback1 interface.

```
RP/0/RP0/CPU0:ios# show ipv4 interface brief
Thu Nov 12 10:01:00.874 UTC

Interface                      IP-Address      Status                Protocol
Loopback0                      1.1.1.1         Up                    Up
Loopback1                      8.8.8.8         Up                    Up
GigabitEthernet0/0/0/0         192.164.168.10  Up                    Up
GigabitEthernet0/0/0/1         192.57.43.10    Up                    Up
GigabitEthernet0/0/0/2         unassigned      Shutdown              Down
MgmtEth0/RP0/CPU0/0            192.168.122.197 Up                    Up
RP/0/RP0/CPU0:ios#
```

3. Enter the third-party network namespace or global VRF depending on the version of IOS XR version you are using for your network.

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2, run the following command */
RP/0/RP0/CPU0:ios# bash
```

4. Verify whether the Loopback1 interface address has been mapped to the E-W interface.

```
[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 192.57.43.10
8.8.8.8 dev fwd_ew  scope link
192.168.122.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 192.168.122.197
[xr-vm_node0_RP0_CPU0:~]$
```

Telemetry Data Export from Line Card Port via User Defined VRF

Table 7: Feature History Table

Feature Name	Release Information	Description
Telemetry Data Export from Line Card Port via User Defined VRF	Release 24.1.1	You can now ensure that the collection and transmission of telemetry data does not interfere with your primary network operations, thus enhancing network isolation and security by reducing the risk of the data being tampered with or intercepted. This is achieved by exporting telemetry data from the router to your specified destination address through line card data ports, using either user-defined or default VRFs.

Starting from Cisco IOS XR 24.1.1 software release, we ensure that the collection and transmission of telemetry data do not interfere with your primary network operations, thus enhancing network isolation and security by reducing the risk of the data being tampered with or intercepted. This is achieved by exporting telemetry data from user-defined VRFs to a specified destination address through data ports of line cards. Using this functionality, you can export telemetry data through user-defined or default VRFs.

Prior to this release, telemetry data export was supported only through the default VRF. By leveraging data ports of line cards and user-defined VRFs, this release expands the scope of telemetry data export configurations on the Cisco ASR 9000 platform.

Configuring Telemetry Data Export from Line Card Port

This section provides you with the configuration steps for enabling a line card port for telemetry data forwarding using a user-defined VRF.

1. This example shows how to configure an interface for telemetry data export.

```
Router#config
Router(config)#interface TenGigE0/2/0/3
Router(config-if)#ipv4 address 111.1.1.1/24
Router(config-if)#vrf vrf_telemetry
```

2. This example shows how to configure gRPC on a user-defined port for telemetry data export.

```
Router(config)#grpc
Router(config-grpc)#port 57400
Router(config-grpc)#vrf vrf_telemetry
Router(config-grpc)#!
Router#grpc no-tls
```

Verification

This example shows how to verify VRF forwarding through user defined port.

```
Router# openconfig_gnmi_client get --path
"openconfig-interfaces:interfaces/interface[name=MgmtEth0/RSP1/CPU0/0]/state/mtu" --format
json -t OPERATIONAL --insecure -u cafyauto -p cisco123 -e json_ietf --timeout 120s -a
111.1.1.1:57400
[
{
"source": "111.1.1.1:57400",
"timestamp": 1702969098985896297,
"time": "2023-12-19T06:58:18.985896297Z",
"updates": [
{
"Path": "openconfig:interfaces/interface[name=MgmtEth0/RSP1/CPU0/0]/state/mtu",
"values": {
"interfaces/interface/state/mtu": 1514
}
}
]
}
]
```

The "source" field shows the source for VRF forwarding, and the "value" field indicates the retrieved VRF MTU value of 1514 bytes.

MPLS Explicit Null Label for IPv6 Data Packets

Table 8: Feature History Table

Feature Name	Release Information	Description
MPLS Explicit Null Label for IPv6 Data packets	Release 24.1.1	You now get a comprehensive insight into telemetry data for IPv6 gRPC sessions for Linux Third Party Applications (TPAs) within your network, providing data for swift identification and resolution of network issues as they arise. This is achieved by supporting IPv6 explicit null labels, which allows MPLS-labeled packets to be forwarded to Linux TPAs without removing their labels.

Starting with the Cisco IOS XR 24.1.1 software release, you can now retain MPLS labels for telemetry streaming of gRPC sessions over IPv6 traffic and gain visibility over MPLS labeled packets in your network. This empowers you to handle telemetry gRPC streams in-band, where IPv6 traffic is carried over RSVP-TE IPv4 tunnels. Previously, explicit null was only supported on IPv4 traffic. The MPLS labeled packets destined for Linux TPA are processed and forwarded to their respective TPAs, ensuring that their MPLS labels are retained and received at the egress router without them being removed. This is achieved by using the **explicit-null** command.

Note The null label does not use the Border Gateway Protocol (BGP) to transport labels.

Configuration to Enable Explicit Null

This example shows how to configure explicit null label.

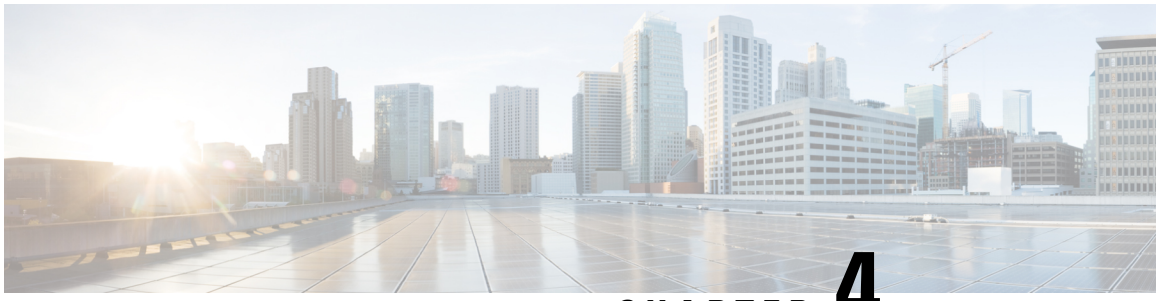
```
Router(config)# mpls ldp
Router(config-ldp)# address-family ipv6
Router(config-ldp-af)# label local advertise explict-null
```

Verification

This example shows how to verify explicit null label configuration.

```
Router(config)# show cef ipv6 58:1:1:1:: detail
58:1:1:1::/64, version 15294, internal 0x1000001 0x20 (ptr 0xa2ea9c68) [1], 0x600
(0xbeb55ee8), 0xa28 (0xa4610ab0)
 Updated Dec 19 06:45:20.809
 Prefix Len 64, traffic index 0, precedence n/a, priority 2, encap-id 0x100c700000001
  gateway array (0xc020ca58) reference count 2, flags 0x28, source rib (7), 0 backups
                [3 type 1 flags 0x8401 (0xc1004ab8) ext 0x0 (0x0)]
  LW-LDI[type=1, refc=1, ptr=0xbeb55ee8, sh-ldi=0xc1004ab8]
  gateway array update type-time 1 Dec 19 06:45:20.809
 LDI Update time Dec 19 06:45:20.809
 LW-LDI-TS Dec 19 06:45:20.809
 Accounting: Disabled
   via ::/128, named_TE_R2_R1_, 5 dependencies, weight 0, class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xc1ee20a0 0x0]
    next hop VRF - 'default', table - 0xe0000000
    next hop ::/128
    local adjacency
     labels imposed {ExpNullv6}

    Load distribution: 0 (refcount 3)

    Hash  OK  Interface                 Address
    0     Y   named_TE_R2_R1_           point2point

[
{
"source": "[58:1:1:1::1]:57400",
"timestamp": 1702969041524464897,
"time": "2023-12-19T06:57:21.524464897Z",
"updates": [
{
"Path": "openconfig:interfaces/interface[name=MgmtEth0/RSP1/CPU0/0]/state/mtu",
"values": {
"interfaces/interface/state/mtu": 1514
}
}
]
}
]
```

The label imposed field shows explicit null enabled.



CHAPTER 4

Hosting Applications on IOS XR

This section explains the different kinds of application hosting, and demonstrates how a simple application, such as iPerf, can be hosted natively or in a third-party container on IOS XR.

Application Hosting in IOS XR Container

You can create your own container on IOS XR, and host applications within the container. The applications can be developed using any Linux distribution. This is well suited for applications that use system libraries that are different from that provided by the IOS XR root file system.

Selecting the Type of Application Hosting

You can select an application hosting type, depending on your requirement and the following criteria.

- **Resources**: If you need to manage the amount of resources consumed by the hosted applications, you must choose the container model, where constraints can be configured. In a native model, you can only deploy applications that use allotted resources, which are shared with internal IOS XR processes.
- **Choice of Environment**: Applications to be hosted natively must be built with the Wind River Linux 7 distribution that is offered by IOS XR. If you decide to choose the Linux distribution that is to be used for building your applications, then you must choose the container model. When you host an application using the container model, you can pre-package it prior to deployment.

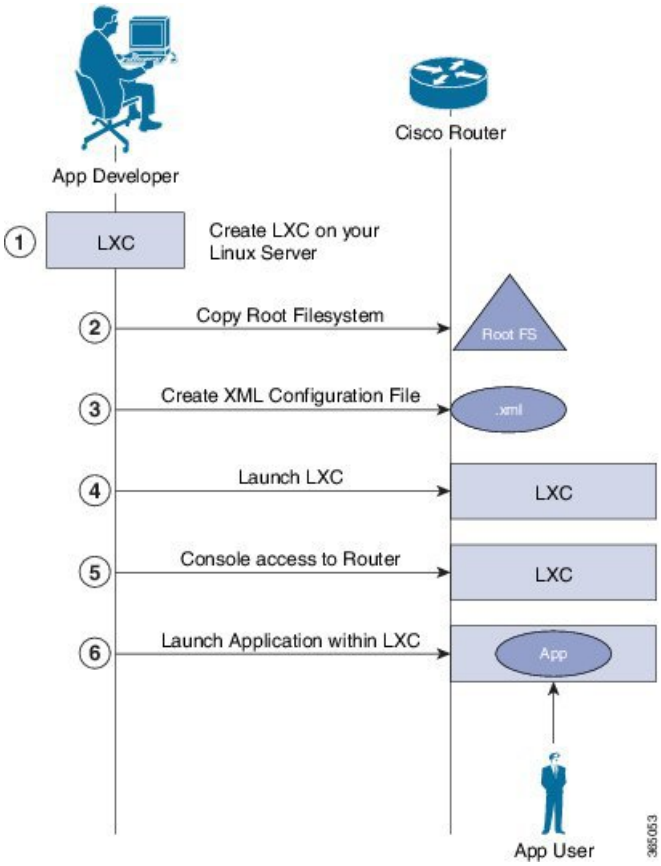
Container Application Hosting

This section introduces the concept of container application hosting and describes its workflow.

Container application hosting makes it possible for applications to be hosted in their own environment and process space (namespace) within a Linux container on Cisco IOS XR. The application developer has complete control over the application development environment, and can use a Linux distribution of choice. The applications are isolated from the IOS XR control plane processes; yet, they can connect to networks outside XR through the XR GigE interfaces. The applications can also easily access local file systems on IOS XR.

This figure illustrates the workflow for creating a Linux container for application hosting. For the complete configuration procedure, see Running iPerf as a Container Application, on page 55.

Figure 4: Container Application Hosting Workflow



There are two components in container application hosting:

- **Linux server**: This is the server you use to develop your application, to bring up the Linux Container (LXC), and to prepare the container environment.
- **Router**: This is the router running the 64-bit IOS XR that is used to host your container with the application you want to run.

1. On the Linux server, bring up the LXC, and do the following:
   a. Prepare the container environment and the required libraries.
   b. Shut down the LXC.
2. Connect to the router running IOS XR, and copy the root file system.
3. Create the configuration file for the container in .xml format. This file specifies the attributes for the container, such as name of the container, default namespace, and so on.

Note If you specify a network namespace (third-party), then by default, the LXC is launched in that namespace.

4. Launch the LXC on the router.
5. Log into the LXC on the router through IOS XR console access.
6. Manually start the application, or configure the application to start automatically when the LXC is launched.

   You can use a container, like a Linux box, to install and host applications for users.

Running iPerf as a Container Application

As an example of container application hosting, you can install an iPerf client within a LXC on IOS XR, and check its connectivity with an iPerf server installed within an LXC on another router, as described in this section.

Topology

The following illustration describes the topology used in this example.

Figure 5: iPerf as a Container Application

iPerf server is installed on Router A, and iPerf client is installed on Router B. Both installations are done within containers on the 64-bit IOS XR. The iPerf client communicates with the iPerf server through the interfaces offered by IOS XR.

Prerequisites

Ensure that you have configured the two routers as shown in the topology.

Configuration Procedure

To run iPerf as a container application, follow these steps:

1. Log into Router A, and enter the XRNNS.

```
RP/0/RP0/CPU0:ios# run
[xr-vm_node0_RP0_CPU0:~]$
```

2. Launch the LXC.

```
[xr-vm_node0_RP0_CPU0:~]$virsh -c lxc+tcp://10.11.12.15:16509/ -e ^Q console demo1
```

3. Log into the LXC when prompted.

```
Connected to domain demo
Escape character is ^Q
Kernel 3.14.23-WR7.0.0.2_standard on an x86_64
```

```
host login: Password:
```

4. Install the iPerf server within the LXC on Router A.

```
[root@host ~]#apt-get install iperf
```

5. Perform Steps 1 to 4 to install the iPerf client on Router B.

6. Verify the iPerf server installation on Router A.

```
[root@host ~]#iperf -v


iperf version 2.0.5 (08 Jul 2010) pthreads
```

Similarly, verify the iPerf client installation on Router B.

7. Bind the Loopback0 interface on Router A to the iPerf server, and launch the iPerf server instance.

In this example, 1.1.1.1 is the assigned Loopback0 interface address of Router A, and 57730 is the port number used for communication.

```
[root@host ~]#iperf -s -B 1.1.1.1 -p 57730
Server listening on TCP port 57730
Binding to local address 1.1.1.1
TCP window size: 85.3 KByte (default)
```

8. Launch the iPerf client instance on Router B, by specifying the same port number used for the iPerf server, and the management IP address of Router A.

In this example, 192.168.122.213 is the management IP address of Router A, and 57730 is the port number used to access the iPerf server.

```
[root@host ~]#iperf -c 192.168.122.213 -p 57730
------------------------------------------------------------
Client connecting to 192.168.122.213, TCP port 57730
TCP window size: 85.0 KByte (default)
------------------------------------------------------------
[  3] local 192.168.122.1 port 46974 connected with 192.168.122.213 port 57730
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   146 MBytes   122 Mbits/sec
```

To use UDP, instead of TCP, to communicate with the iPerf server, use the following command.

```
[root@host ~]#iperf -c 192.168.122.213 -p 57730 -u
------------------------------------------------------------
Client connecting to 192.168.122.213, UDP port 57730
Sending 1470 byte datagrams
UDP buffer size:  208 KByte (default)
------------------------------------------------------------
[  3] local 192.168.122.1 port 41466 connected with 192.168.122.213 port 57730
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec   0.233 ms    0/  893 (0%)
[root@hostB ~]#
```

9. Ping the iPerf server from the iPerf client on Router B.

```
[root@host ~]#/bin/ping 192.164.168.10
PING 192.164.168.10 (192.164.168.10) 56(84) bytes of data.
64 bytes from 192.164.168.10: icmp_seq=1 ttl=255 time=13.0 ms
64 bytes from 192.164.168.10: icmp_seq=2 ttl=255 time=2.14 ms
64 bytes from 192.164.168.10: icmp_seq=3 ttl=255 time=2.21 ms
```

The iPerf client hosted on Router B can access the iPerf server hosted on Router A.

Using Docker for Hosting Applications on Cisco IOS XR

Like an LXC, docker is a container used for hosting applications on Cisco IOS XR. Docker provides isolation for application processes from the underlying host processes on XR by using Linux network namespaces.

Need for Docker on Cisco IOS XR

Docker is becoming the industry-preferred packaging model for applications in the virtualization space. Docker provides the foundation for automating application life cycle management.

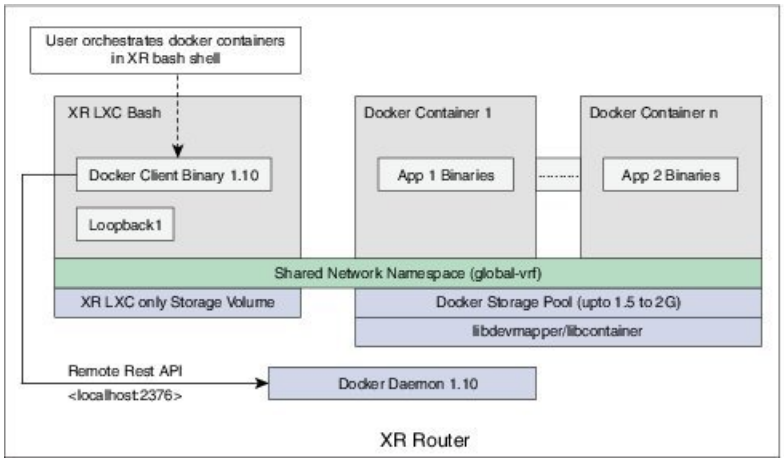
Docker follows a layered approach that consists of a base image at the bottom that supports layers of applications on top. The base images are available publicly in a repository, depending on the type of application you want to install on top. You can manipulate docker images by using the docker index and registry.

Docker provides a git-like workflow for developing container applications and supports the "thin update" mechanism, where only the difference in source code is updated, leading to faster upgrades. Docker also provides the "thin download" mechanism, where newer applications are downloaded faster because of the sharing of common base docker layers between multiple docker containers. The sharing of docker layers between multiple docker containers leads to lower footprint for docker containers on XR.

Docker Architecture on Cisco IOS XR

The following figure illustrates the docker architecture on IOS XR.

Figure 6: Docker on IOS XR

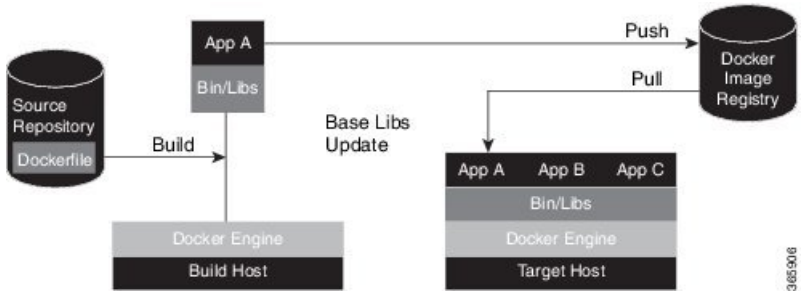


The docker containers are created alongside the LXC on XR. To create and manage the containers, you can use the XR bash shell. This is where the docker client is installed. The application binaries for the applications to be hosted are installed inside the docker container.

Hosting Applications in Docker Containers

The following figure illustrates the workflow for hosting applications in Docker containers on IOS XR.

Figure 7: Docker Workflow for Application Hosting

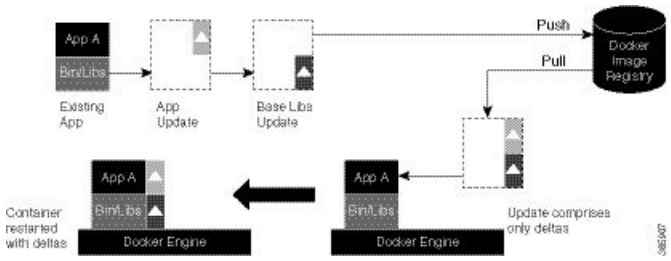


1. The docker file in the source repository is used to build the application binary file on your (docker engine build) host machine.
2. The application binary file is pushed into the docker image registry.
3. The application binary file is pulled from the docker image registry and copied to the docker container on XR (docker engine target host).
4. The application is built and hosted in the docker container on XR.

Updating Applications in Docker Containers

The following figure illustrates the workflow for updating applications hosted in docker containers.

Figure 8: Docker Workflow for Updating Applications



1. The application update is generated as a base libs update file (delta update file) and pushed to the docker image registry.
2. The delta update file (containing only the difference in application code) is pulled from the docker image registry and copied to the docker containers on XR (docker engine target host).
3. The docker containers are restarted with the delta update file.

Customize Docker Run Options Using Application Manager

Table 9: Feature History Table

Feature Name	Release Information	Description
Customize Docker Run Options Using Application Manager	Release 24.1.1	You can now leverage Application Manager to efficiently overwrite default docker runtime configurations, tailoring them to specific parameters like CPU usage, security settings, and health checks. You can thus optimize application performance, maintain fair resource allocation among multiple dockers, and establish non-default network security settings to meet specific security requirements. Additionally, you can accurately monitor and reflect the health of individual applications. This feature modifies the **docker-run-opts** option command.

With this feature, runtime options for docker containerized applications on IOS-XR can be configured during launch using the **appmgr activate**" command. AppMgr, which oversees docker containerized applications, ensures that these runtime options can effectively override default configurations, covering aspects like CPU, security, and health checks during the container launch.

This feature introduces multiple runtime options that allow users to customize different parameters of docker containers. The configuration of these runtime options is flexible, as users can use either command or Netconf for the configuration process. Regardless of the chosen method, runtime options must be added to **docker-run-opts** as needed.

The following are the docker run option commands introduced in IOS-XR software release 24.1.1.

Table 10: Docker Run Options

Docker Run Option	Description
--cpus	Number of CPUs
--cpuset-cpus	CPUs in which to allow execution (0-3, 0,1)
--cap-drop	Drop Linux capabilities
--user, -u	Sets the username or UID
--group-add	Add additional groups to run
--health-cmd	Run to check health

Docker Run Option	Description
--health-interval	Time between running the check
--health-retries	Consecutive failures needed to report unhealthy
--health-start-period	Start period for the container to initialize before starting health-retries countdown
--health-timeout	Maximum time to allow one check to run
--no-healthcheck	Disable any container-specified HEALTHCHECK
--add-host	Add a custom host-to-IP mapping (host:ip)
--dns	Set custom DNS servers
--dns-opt	Set DNS options
--dns-search	Set custom DNS search domains
--domainname	Container NIS domain name
--oom-score-adj	Tune host's OOM preferences (-1000 to 1000)
--shm-size	Option to set the size of /dev/shm
--init	Run an init inside the container that forwards signals and reaps processes
--label, -l	Set meta data on a container
--label-file	Read in a line delimited file of labels
--pids-limit	Tune container pids limit (set -1 for unlimited)
--work-dir	Working directory inside the container
--ulimit	Ulimit options
--read-only	Mount the container's root filesystem as read only
--volumes-from	Mount volumes from the specified container(s)
--stop-signal	Signal to stop the container
--stop-timeout	Timeout (in seconds) to stop a container

Prior to IOS-XR software release 24.1.1, only the below mentioned docker run option commands were supported.

Table 11: Docker Run Options

Docker Run Option	Description
--publish	Publish a container's port(s) to the host

Docker Run Option	Description
--entrypoint	Overwrite the default ENTRYPOINT of the image
--expose	Expose a port or a range of ports
--link	Add link to another container
--env	Set environment variables
--env-file	Read in a file of environment variables
--network	Connect a container to a network
--hostname	Container host name
--interactive	Keep STDIN open even if not attached
--tty	Allocate a pseudo-TTY
--publish-all	Publish all exposed ports to random ports
--volume	Bind mount a volume
--mount	Attach a filesystem mount to the container
--restart	Restart policy to apply when a container exits
--cap-add	Add Linux capabilities
--log-driver	Logging driver for the container
--log-opt	Log driver options
--detach	Run container in background and print container ID
--memory	Memory limit
--memory-reservation	Memory soft limit
--cpu-shares	CPU shares (relative weight)
--sysctl	Sysctl options

Restrictions and Limitations

- For the options `--mount` and `--volume`, only the following values can be configured:
  - "/var/run/netns"
  - "/var/lib/docker"
  - "/misc/disk1"
  - "/disk0"
- The maximum allowed size for shm-size option is 64 Mb.

Configuration

This section provides the information on how to configure the docker run time options.

In this example we configure the docker run time option **--pids-limit** to limit the number of process IDs using appmgr.

```
Router#appmgr application alpine_app activate type docker source alpine docker-run-opts
"-it –pids-limit 90" docker-run-cmd "sh"
Router#
```

In this example we configure the docker run time option **--pids-limit** to limit the number of process IDs using Netconf.

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <edit-config>
    <target>
      <candidate/>
    </target>
    <config>
      <appmgr xmlns=http://cisco.com/ns/yang/Cisco-IOS-XR-um-appmgr-cfg>

        <applications>
          <application>
            <application-name>alpine_app</application-name>
            <activate>
              <type>docker</type>
                                              <source-name>alpine</source-name>
                                              <docker-run-cmd>/bin/sh</docker-run-cmd>
                                              <docker-run-opts>-it
--pids-limit=90</docker-run-opts>
            </activate>
          </application>
        </applications>
      </appmgr>
    </config>
  </edit-config>
```

Verification

This example shows how to verify the docker run time option configuration.

```
Router# show running-config appmgr
Thu Mar 23 08:22:47.014 UTC
appmgr
 application alpine_app
  activate type docker source alpine docker-run-opts "-it –pids-limit 90" docker-run-cmd
"sh"
 !
!
```

You can also use **docker inspect** *container id* to verify the docker run time option configuration.

```
Router# docker inspect 25f3c30eb424
[
    {
                "PidsLimit": 90,
    }
]
```

Using Vagrant for Hosting Applications

You can use vagrant on a host device of your choice, for hosting applications as described in the following sections.

Note IOS-XR software version 6.x.x and above is not supported on Vagrant.

Pre-requisites for Using Vagrant

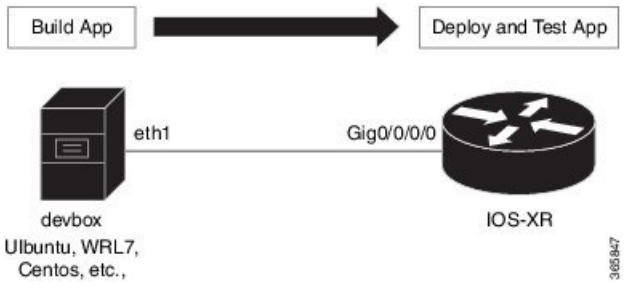
Before you can start using vagrant, ensure that you have fulfilled the following requirements on your host device.

- Latest version of Vagrant for your operating system. We recommend Version 1.8.6.
- Latest version of a virtual box for your operating system. We recommend Version 5.1+.
- Minimum of 5 GB of RAM with two cores.
- (Optional) If you are using the Windows Operating System, we recommend that you download the Git bash utility for running the commands.

Setting up an Application Development Topology By Using Vagrant

For the sake of illustration, we will use a simple two-node topology, where an instance of Cisco IOS XR behaves as one node (`rtr`), and an instance of Ubuntu (hypervisor) behaves as the other (`devbox`). We will use the `devbox` to develop the app topology and deploy it on the `rtr`.

Figure 9: Application Development Topology



Procedure

To create an application development topology on vagrant, follow these steps.

1. Generate an API key and a CCO ID by using the steps described on Github.
2. Download the latest stable version of the IOS-XRv vagrant box.

```
$ curl <cco-id>:<API-KEY>

$ BOXURL --output ~/iosxrv-fullk9-x64.box
```

```
$ vagrant box add --name IOS-XRv ~/iosxrv-fullk9-x64.box
```

3. Verify if the vagrant box has been successfully installed.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ vagrant box list
IOS-XRv (virtualbox, 0)
```

4. Create a working directory.

```
annseque@ANNSEQUE-WS02 MINGW64 ~ mkdir ~/iosxrv
annseque@ANNSEQUE-WS02 MINGW64 ~ cd ~/iosxrv
```

5. Initialize the vagrant file with the new vagrant box.

```
ANNSEQUE-WS02 MINGW64:iosxrv annseque$ vagrant init IOS-XRv
A `Vagrantfile` has been placed in this directory. You are now
ready to `vagrant up` your first virtual environment! Please read
the comments in the Vagrantfile as well as documentation on
`vagrantup.com` for more information on using Vagrant.
```

6. Clone the `vagrant-xrdocs` repository.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ git clone https://github.com/ios-xr/vagrant-xrdocs.git
```

7. Navigate to the `vagrant-xrdocs` repository and locate the `lxc-app-topo-bootstrap` directory.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ cd vagrant-xrdocs/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ ls
ansible-tutorials/       native-app-topo-bootstrap/  simple-mixed-topo/
lxc-app-topo-bootstrap/  README.md                   single_node_bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ ls lxc-app-topo-bootstrap/
configs/  scripts/  Vagrantfile
```

8. (Optional) View the contents of the vagrant file in the `lxc-app-topo-bootstrap` directory.

   The vagrant file (`Vagrantfile`) contains the two node topology for application development. You can modify this by using a vi editor, if required.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ cd lxc-app-topo-bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ cat Vagrantfile
# -*- mode: ruby -*-
# vi: set ft=ruby :

# All Vagrant configuration is done below. The "2" in Vagrant.configure
# configures the configuration version (we support older styles for
# backwards compatibility). Please don't change it unless you know what
# you're doing.

Vagrant.configure(2) do |config|
```

```
   config.vm.define "rtr" do |node|
      node.vm.box =  "IOS-XRv"

      # gig0/0/0 connected to "link1"
      # auto_config is not supported for XR, set to false

      node.vm.network :private_network, virtualbox__intnet: "link1", auto_config
                                                                                :
false


      #Source a config file and apply it to XR

      node.vm.provision "file", source: "configs/rtr_config", destination: "/hom

e/vagrant/rtr_config"

      node.vm.provision "shell" do |s|
          s.path =  "scripts/apply_config.sh"
          s.args = ["/home/vagrant/rtr_config"]
      end

    end


    config.vm.define "devbox" do |node|
      node.vm.box =  "ubuntu/trusty64"

      # eth1 connected to link1
      # auto_config is supported for an ubuntu instance

      node.vm.network :private_network, virtualbox__intnet: "link1", ip: "11.1.1

.20"

    end

end
```

You have successfully created an application development topology on vagrant. See Deploying an Application Development Topology by Using Vagrant, on page 65 for information on deploying the topology on vagrant.

Deploying an Application Development Topology by Using Vagrant

This section describes how you can deploy an application development topology on vagrant for creating and hosting your applications.

Procedure

To deploy an application development topology on vagrant, follow these steps.

Note Ensure you have created an application development topology as described in Setting up an Application Development Topology By Using Vagrant, on page 63, before proceeding with the following steps.

1. Ensure you are in the `lxc-app-topo-bootstrap` directory, and launch the vagrant instance.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant up

Bringing machine 'rtr' up with 'virtualbox' provider...
Bringing machine 'devbox' up with 'virtualbox' provider...
==> rtr: Clearing any previously set forwarded ports...
==> rtr: Clearing any previously set network interfaces...
==> rtr: Preparing network interfaces based on configuration...
    rtr: Adapter 1: nat
    rtr: Adapter 2: intnet
==> rtr: Forwarding ports...
    rtr: 57722 (guest) => 2222 (host) (adapter 1)
    rtr: 22 (guest) => 2223 (host) (adapter 1)
==> rtr: Running 'pre-boot' VM customizations...
==> rtr: Booting VM...
==> rtr: Waiting for machine to boot. This may take a few minutes...
    rtr: SSH address: 127.0.0.1:2222
    rtr: SSH username: vagrant
    rtr: SSH auth method: private key
    rtr: Warning: Remote connection disconnect. Retrying...
    ...
==> rtr: Machine booted and ready!
==> rtr: Checking for guest additions in VM...
    rtr: No guest additions were detected on the base box for this VM! Guest
    rtr: additions are required for forwarded ports, shared folders, host only
    rtr: networking, and more. If SSH fails on this machine, please install
    rtr: the guest additions and repackage the box to continue.
    rtr:
    rtr: This is not an error message; everything may continue to work properly,
    rtr: in which case you may ignore this message.
==> rtr: Machine already provisioned. Run `vagrant provision` or use the `--provision`
==> rtr: flag to force provisioning. Provisioners marked to run always will still run.
==> devbox: Checking if box 'ubuntu/trusty64' is up to date...
==> devbox: A newer version of the box 'ubuntu/trusty64' is available! You currently
==> devbox: have version '20160801.0.0'. The latest is version '20160826.0.1'. Run
==> devbox: `vagrant box update` to update.
==> devbox: Clearing any previously set forwarded ports...
==> devbox: Fixed port collision for 22 => 2222. Now on port 2200.
==> devbox: Clearing any previously set network interfaces...
==> devbox: Preparing network interfaces based on configuration...
    devbox: Adapter 1: nat
    devbox: Adapter 2: intnet
==> devbox: Forwarding ports...
    devbox: 22 (guest) => 2200 (host) (adapter 1)
==> devbox: Booting VM...
==> devbox: Waiting for machine to boot. This may take a few minutes...
    devbox: SSH address: 127.0.0.1:2200
    devbox: SSH username: vagrant
    devbox: SSH auth method: private key
    devbox: Warning: Remote connection disconnect. Retrying...
    devbox: Warning: Remote connection disconnect. Retrying...
==> devbox: Machine booted and ready!
==> devbox: Checking for guest additions in VM...
    devbox: The guest additions on this VM do not match the installed version of
    devbox: VirtualBox! In most cases this is fine, but in rare cases it can
    devbox: prevent things such as shared folders from working properly. If you see
    devbox: shared folder errors, please make sure the guest additions within the
    devbox: virtual machine match the version of VirtualBox you have installed on
    devbox: your host and reload your VM.
    devbox:
    devbox: Guest Additions Version: 4.3.36
    devbox: VirtualBox Version: 5.0
==> devbox: Configuring and enabling network interfaces...
```

```
==> devbox: Mounting shared folders...
    devbox: /vagrant => C:/Users/annseque/vagrant-xrdocs/lxc-app-topo-bootstrap
==> devbox: Machine already provisioned. Run `vagrant provision` or use the `--provision`
==> devbox: flag to force provisioning. Provisioners marked to run always will still
run.

==> rtr: Machine 'rtr' has a post `vagrant up` message. This is a message
==> rtr: from the creator of the Vagrantfile, and not from Vagrant itself:
==> rtr:
==> rtr:
==> rtr:     Welcome to the IOS XRv (64-bit) Virtualbox.
==> rtr:     To connect to the XR Linux shell, use: 'vagrant ssh'.
==> rtr:     To ssh to the XR Console, use: 'vagrant port' (vagrant version > 1.8)
==> rtr:     to determine the port that maps to guestport 22,
==> rtr:     then: 'ssh vagrant@localhost -p <forwarded port>'
==> rtr:
==> rtr:     IMPORTANT:  READ CAREFULLY
==> rtr:     The Software is subject to and governed by the terms and conditions
==> rtr:     of the End User License Agreement and the Supplemental End User
==> rtr:     License Agreement accompanying the product, made available at the
==> rtr:     time of your order, or posted on the Cisco website at
==> rtr:     www.cisco.com/go/terms (collectively, the 'Agreement').
==> rtr:     As set forth more fully in the Agreement, use of the Software is
==> rtr:     strictly limited to internal use in a non-production environment
==> rtr:     solely for demonstration and evaluation purposes. Downloading,
==> rtr:     installing, or using the Software constitutes acceptance of the
==> rtr:     Agreement, and you are binding yourself and the business entity
==> rtr:     that you represent to the Agreement. If you do not agree to all
==> rtr:     of the terms of the Agreement, then Cisco is unwilling to license
==> rtr:     the Software to you and (a) you may not download, install or use the
==> rtr:     Software, and (b) you may return the Software as more fully set forth
==> rtr:     in the Agreement.
```

You have successfully deployed the two nodes, `rtr` and `devbox` on your host machine.

2. To access the XR router console, check the port number that maps to the guest port number 22.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant port rtr
The forwarded ports for the machine are listed below. Please note that
these values may differ from values configured in the Vagrantfile if the
provider supports automatic port collision detection and resolution.

    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)
```

You need to use port number 2223 to SSH to the `rtr` node (XR).

3. Access the XR router console (`rtr` console) through SSH.

   The password for `vagrant@localhost` is **vagrant**.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:


RP/0/RP0/CPU0:ios#
```

You are at the XR router console, or the console of the `rtr` node in this example.

4. Check the GigE interface IP address of the `rtr`.

You will need the GigE interface IP address to access the `rtr` console from the `devbox` console at a later stage.

```
RP/0/RP0/CPU0:ios# show ipv4 interface gigabitEthernet 0/0/0/0 brief
Wed Aug 31 04:00:48.006 UTC

Interface                      IP-Address      Status                Protocol
GigabitEthernet0/0/0/0         11.1.1.10       Up                    Up
```

Note To access the XR Linux shell from the `rtr` console, use the **run** command.

```
RP/0/RP0/CPU0:ios# run
Wed Aug 31 04:01:45.119 UTC

[xr-vm_node0_RP0_CPU0:~]$
```

5. Exit the `rtr` console, and access the `devbox` console through SSH.

```
RP/0/RP0/CPU0:ios# exit
Connection to localhost closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$  vagrant ssh devbox

Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

 System information disabled due to load higher than 1.0

  Get cloud support with Ubuntu Advantage Cloud Guest:
    http://www.ubuntu.com/business/services/cloud

25 packages can be updated.
12 updates are security updates.


vagrant@vagrant-ubuntu-trusty-64:~$
```

6. Verify if you can access the `rtr` console from the `devbox` console, by pinging the GigE interface of the `rtr`.

   Use the GigE interface IP address you retrieved in Step 12.

```
vagrant@vagrant-ubuntu-trusty-64:~$ ping 11.1.1.10 -c 2
PING 11.1.1.10 (11.1.1.10) 56(84) bytes of data.
64 bytes from 11.1.1.10: icmp_seq=1 ttl=255 time=40.2 ms
64 bytes from 11.1.1.10: icmp_seq=2 ttl=255 time=6.67 ms

--- 11.1.1.10 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 6.670/23.457/40.245/16.788 ms
vagrant@vagrant-ubuntu-trusty-64:~$
```

Note To access the XR Linux console, exit the `devbox` console and run the **vagrant ssh rtr** command from the `lxc-app-topo-bootstrap` directory.

```
vagrant@vagrant-ubuntu-trusty-64:~$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh rtr
Last login: Thu Jul 21 05:51:28 2016 from 10.0.2.2
xr-vm_node0_RP0_CPU0:~$
```

You have successfully deployed an application development topology on your host device.

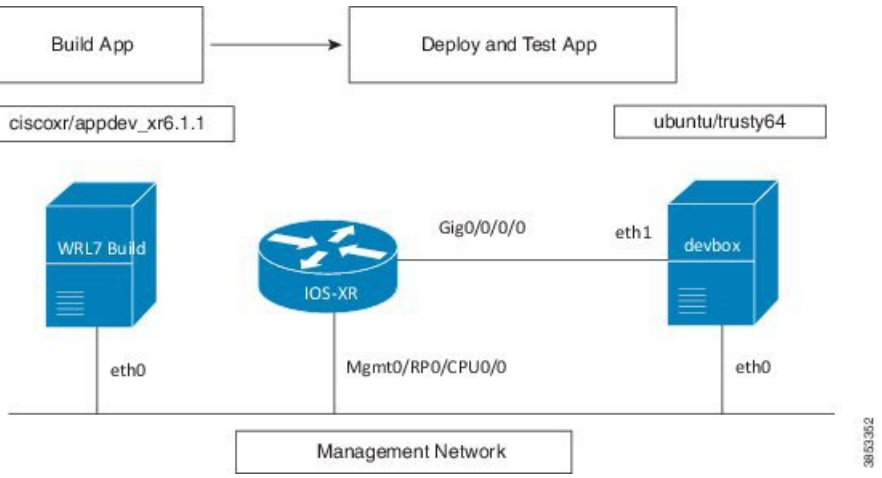
Hosting a Wind River Linux (WRL7) Application Natively By Using Vagrant

This section describes how you can host a Wind river Linux (WRL7) application natively by using vagrant.

Native Application Hosting Topology

For the sake of illustration, we will use the three vagrant instance topology as shown in the following figure.

Figure 10: Native Application Hosting Topology on a Vagrant Box



Procedure

Use the following steps to host an application natively on IOS XR.

Note Ensure you have created an application development topology as described in Setting up an Application Development Topology By Using Vagrant, on page 63, before proceeding with the following steps.

1. Verify if you have the `IOS-XRv` and the `ciscoxr/appdev-xr6.1.1` vagrant boxes installed on your machine.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ vagrant box list
IOS-XRv                (virtualbox, 0)
ciscoxr/appdev-xr6.1.1 (virtualbox, 1.0)
ubuntu/trusty64        (virtualbox, 20160602.0.0)
```

2. Clone the `vagrant-xrdocs` repository.

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ git clone https://github.com/ios-xr/vagrant-xrdocs.git
```

3. Navigate to the `vagrant-xrdocs/native-app-topo-bootstrap` directory and launch the vagrant instance.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ cd native-app-topo-bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant up

Bringing machine 'rtr' up with 'virtualbox' provider...
Bringing machine 'devbox' up with 'virtualbox' provider...
Bringing machine 'wrl7_build' up with 'virtualbox' provider...
==> rtr: Clearing any previously set forwarded ports...
==> rtr: Clearing any previously set network interfaces...
==> rtr: Preparing network interfaces based on configuration...
    rtr: Adapter 1: nat
    rtr: Adapter 2: intnet
==> rtr: Forwarding ports...
    rtr: 57722 (guest) => 2222 (host) (adapter 1)
    rtr: 22 (guest) => 2223 (host) (adapter 1)
==> rtr: Running 'pre-boot' VM customizations...
==> rtr: Booting VM...
==> rtr: Waiting for machine to boot. This may take a few minutes...
    rtr: SSH address: 127.0.0.1:2222
    rtr: SSH username: vagrant
    rtr: SSH auth method: private key
    rtr: Warning: Remote connection disconnect. Retrying...
 ...
==> rtr: Machine booted and ready!
==> rtr: Checking for guest additions in VM...
    rtr: No guest additions were detected on the base box for this VM! Guest
    rtr: additions are required for forwarded ports, shared folders, host only
    rtr: networking, and more. If SSH fails on this machine, please install
    rtr: the guest additions and repackage the box to continue.
    rtr:
    rtr: This is not an error message; everything may continue to work properly,
    rtr: in which case you may ignore this message.
==> rtr: Machine already provisioned. Run `vagrant provision` or use the `--provision`
==> rtr: flag to force provisioning. Provisioners marked to run always will still run.
==> devbox: Checking if box 'ubuntu/trusty64' is up to date...
==> devbox: A newer version of the box 'ubuntu/trusty64' is available! You currently
==> devbox: have version '20160801.0.0'. The latest is version '20160907.0.0'. Run
==> devbox: `vagrant box update` to update.
==> devbox: Clearing any previously set forwarded ports...
==> devbox: Fixed port collision for 22 => 2222. Now on port 2200.
==> devbox: Clearing any previously set network interfaces...
==> devbox: Preparing network interfaces based on configuration...
    devbox: Adapter 1: nat
    devbox: Adapter 2: intnet
==> devbox: Forwarding ports...
    devbox: 22 (guest) => 2200 (host) (adapter 1)
==> devbox: Booting VM...
==> devbox: Waiting for machine to boot. This may take a few minutes...
    devbox: SSH address: 127.0.0.1:2200
```

```
    devbox: SSH username: vagrant
    devbox: SSH auth method: private key
    devbox: Warning: Remote connection disconnect. Retrying...
    devbox: Warning: Remote connection disconnect. Retrying...
==> devbox: Machine booted and ready!
...
==> wrl7_build: Checking if box 'ciscoxr/appdev-xr6.1.1' is up to date...
==> wrl7_build: Clearing any previously set forwarded ports...
==> wrl7_build: Fixed port collision for 22 => 2222. Now on port 2201.
==> wrl7_build: Clearing any previously set network interfaces...
==> wrl7_build: Preparing network interfaces based on configuration...
    wrl7_build: Adapter 1: nat
==> wrl7_build: Forwarding ports...
    wrl7_build: 22 (guest) => 2201 (host) (adapter 1)
==> wrl7_build: Booting VM...
==> wrl7_build: Waiting for machine to boot. This may take a few minutes...
    wrl7_build: SSH address: 127.0.0.1:2201
    wrl7_build: SSH username: vagrant
    wrl7_build: SSH auth method: private key
    wrl7_build: Warning: Remote connection disconnect. Retrying...
...
==> wrl7_build: Welcome to the IOS XR Application Development (AppDev) VM that provides
 a WRL7 based native environment to build appli
                                                                cations for IOS XR (Release
 6.1.1) platforms.
```

4. Verify if the WRL7 build instance has launched.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant status
Current machine states:

rtr                       running (virtualbox)
devbox                    running (virtualbox)
wrl7_build                running (virtualbox)
...
```

5. Access the WRL7 build instance through SSH, and retrieve the source code of the application you want to host natively.

   In this example, we fetch the source code for the iPerf application.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant ssh wrl7_build

------------------------------------------------------------------------------------------

localhost:~$ wget https://iperf.fr/download/source/iperf-2.0.9-source.tar.gz
--2016-09-13 01:54:58--  https://iperf.fr/download/source/iperf-2.0.9-source.tar.gz
Resolving iperf.fr... 194.158.119.186, 2001:860:f70a::2
Connecting to iperf.fr|194.158.119.186|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 277702 (271K) [application/x-gzip]
Saving to: 'iperf-2.0.9-source.tar.gz'

100%[======================================================================>] 277,702
 153KB/s   in 1.8s

2016-09-13 01:55:01 (153 KB/s) - 'iperf-2.0.9-source.tar.gz' saved [277702/277702]

------------------------------------------------------------------------------------------

localhost:~$ ls
iperf-2.0.9-source.tar.gz
```

```
localhost:~$
```

6. Copy the source code tar ball to the `/usr/src/rpm/SOURCES/` build location.

```
localhost:~$ sudo cp /home/vagrant/iperf-2.0.9-source.tar.gz /usr/src/rpm/SOURCES/
```

7. Retrieve the XML spec file (`iperf.spec`) for building the RPM.

```
localhost:~$ wget http://10.30.110.214/iperf.spec
--2016-09-13 01:58:44--  http://10.30.110.214/iperf.spec
Connecting to 10.30.110.214:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 609
Saving to: 'iperf.spec'

100%[======================================================>] 609         --.-K/s
   in 0s

2016-09-13 01:58:45 (38.2 MB/s) - 'iperf.spec' saved [609/609]

-----------------------------------------------------------------------------------------------
localhost:~$ ls
iperf-2.0.9-source.tar.gz  iperf.spec
```

8. Build the RPM by using the retrieved spec file.

```
localhost:~$ sudo rpmbuild -ba iperf.spec
Executing(%prep): /bin/sh -e /var/tmp/rpm-tmp.59743
+ umask 022
+ cd /usr/lib64/rpm/../../src/rpm/BUILD
+ cd /usr/src/rpm/BUILD
+ rm -rf iperf-2.0.9
+ /bin/tar -xf -
...
Requires: libc.so.6()(64bit) libc.so.6(GLIBC_2.14)(64bit) libc.so.6(GLIBC_2.2.5)(64bit)

 libc.so.6(GLIBC_2.3)(64bit) libc.so.6(GLIBC_2.7)(64bit)
 libgcc_s.so.1()(64bit) libgcc_s.so.1(GCC_3.0)(64bit) libm.so.6()
(64bit) libm.so.6(GLIBC_2.2.5)(64bit) libpthread.so.0()(64bit)
libpthread.so.0(GLIBC_2.2.5)(64bit) libpthread.so.0(GLIBC_2.3.2)(64bit)
librt.so.1()(64bit) librt.so.1(GLIBC_2.2.5)(64bit) libstdc++.so.6()(64bit)
libstdc++.so.6(CXXABI_1.3)(64bit) libstdc++.so.6(GLIBCXX_3.4)(64bit) rtld(GNU_HASH)
Checking for unpackaged file(s): /usr/lib64/rpm/check-files
/usr/lib64/rpm/../../../var/tmp/iperf-root
Wrote: /usr/src/rpm/SRPMS/iperf-2.0.9-XR_6.1.1.src.rpm
Wrote: /usr/src/rpm/RPMS/x86_64/iperf-2.0.9-XR_6.1.1.x86_64.rpm
...

localhost:~$ ls -l /usr/src/rpm/RPMS/x86_64/
total 48
-rw-r--r-- 1 root root 48118 Sep 13 02:03 iperf-2.0.9-XR_6.1.1.x86_64.rpm
```

9. Transfer the RPM file to XR.

   a. Note down the port number on XR for transferring the RPM file.

```
localhost:~$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant port rtr
The forwarded ports for the machine are listed below. Please note that
these values may differ from values configured in the Vagrantfile if the
```

```
provider supports automatic port collision detection and resolution.

    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)
```

b. Access the WRL7 build instance, and copy the RPM file by using the SCP command with the port number of XR.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant ssh wrl7_build
Last login: Tue Sep 13 01:49:37 2016 from 10.0.2.2

localhost:~$ scp -P 2222 /usr/src/rpm/RPMS/x86_64/iperf-2.0.9-XR_6.1.1.x86_64.rpm
vagrant@10.0.2.2:/home/vagrant/
vagrant@10.0.2.2's password:
iperf-2.0.9-XR_6.1.1.x86_64.rpm
```

10. Install the application (iPerf) on XR.

a. Access XR through SSH.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant ssh rtr
Last login: Fri Sep  9 19:20:56 2016 from 10.0.2.2
xr-vm_node0_RP0_CPU0:~$
```

b. Verify the presence of the RPM file on XR.

```
xr-vm_node0_RP0_CPU0:~$ ls -l iperf-2.0.9-XR_6.1.1.x86_64.rpm
-rw-r--r-- 1 vagrant vagrant 48118 Sep 13 06:33 iperf-2.0.9-XR_6.1.1.x86_64.rpm
```

c. Install iPerf by using yum.

```
xr-vm_node0_RP0_CPU0:~$ sudo yum install -y  iperf-2.0.9-XR_6.1.1.x86_64.rpm
Loaded plugins: downloadonly, protect-packages, rpm-persistence
Setting up Install Process
Examining iperf-2.0.9-XR_6.1.1.x86_64.rpm: iperf-2.0.9-XR_6.1.1.x86_64
Marking iperf-2.0.9-XR_6.1.1.x86_64.rpm to be installed
Resolving Dependencies
--> Running transaction check
---> Package iperf.x86_64 0:2.0.9-XR_6.1.1 will be installed
--> Finished Dependency Resolution

...

Total size: 103 k
Installed size: 103 k
Downloading Packages:
Running Transaction Check
Running Transaction Test
Transaction Test Succeeded
Running Transaction
  Installing : iperf-2.0.9-XR_6.1.1.x86_64

Installed:
  iperf.x86_64 0:2.0.9-XR_6.1.1


Complete!
xr-vm_node0_RP0_CPU0:~$
```

d. Verify iPerf installation.

```
xr-vm_node0_RP0_CPU0:~$ iperf -v
iperf version 2.0.9 (1 June 2016) pthreads
```

11. Test the natively installed application (iPerf) on XR.

    a. Access the XR router console and configure the Third-party Application (TPA) access for outside networks.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:

RP/0/RP0/CPU0:ios# config
Tue Sep 13 06:46:56.368 UTC
RP/0/RP0/CPU0:ios(config)# tpa address-family ipv4 update-source loopback 0
RP/0/RP0/CPU0:ios(config)# commit
Tue Sep 13 06:47:04.642 UTC
RP/0/RP0/CPU0:ios(config)# end
RP/0/RP0/CPU0:ios# bash -c ip route
Tue Sep 13 06:47:43.792 UTC
default dev fwdintf  scope link  src 1.1.1.1
10.0.2.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 10.0.2.15
```

    b. Exit the XR router console, and launch the iPerf server on XR.

```
RP/0/RP0/CPU0:ios# exit
Connection to localhost closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant ssh rtr
Last login: Tue Sep 13 06:44:53 2016 from 10.0.2.2

xr-vm_node0_RP0_CPU0:~$ iperf -s -u
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 64.0 MByte (default)
------------------------------------------------------------
```

12. Install the iPerf (client) on `devbox`.

    a. Access `devbox` through SSH.

```
xr-vm_node0_RP0_CPU0:~$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/native-app-topo-bootstrap (master)
$ vagrant ssh devbox
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.13.0-92-generic x86_64)
...
```

13. Install iPerf application.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo apt-get -y install iperf
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
```

```
  iperf
...
```

14. Test the iPerf application on `devbox`.

    a. Configure TPA route to XR from `devbox`.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo ip route add 1.1.1.1/32 via 11.1.1.10
vagrant@vagrant-ubuntu-trusty-64:~$ ping 1.1.1.1
PING 1.1.1.1 (1.1.1.1) 56(84) bytes of data.
64 bytes from 1.1.1.1: icmp_seq=1 ttl=255 time=15.1 ms
64 bytes from 1.1.1.1: icmp_seq=2 ttl=255 time=3.81 ms
^C
--- 1.1.1.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 3.817/9.480/15.143/5.663 ms
```

    b. Test if the iPerf client on `devbox` can communicate with the iPerf server on XR.

```
vagrant@vagrant-ubuntu-trusty-64:~$ iperf -c 1.1.1.1 -u
------------------------------------------------------------
Client connecting to 1.1.1.1, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  208 KByte (default)
------------------------------------------------------------
[  3] local 11.1.1.20 port 34348 connected with 1.1.1.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec   0.256 ms    0/  893 (0%)
```

You have successfully built an application RPM and hosted it natively by using vagrant.

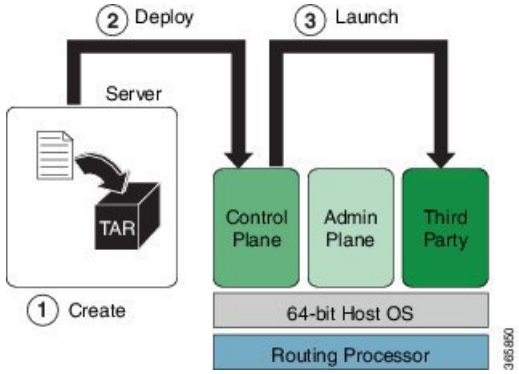
Hosting an Application within a Linux Container (LXC) by Using Vagrant

This section describes how you can host an application within your own Linux container (LXC) by using vagrant.

Workflow for Deploying Your LXC Container

The workflow for launching your container on IOS XR is described in this section and illustrated in the following topology.

Figure 11: LXC Container Deployment Workflow



1. Build the container `rootfs` tar ball on `devbox`.
2. Transfer the `rootfs` tar ball to IOS XR (`rtr`).
3. Launch the `rootfs` by running the **virsh** command.

Procedure

To host your application within your own container, use the following steps.

Note Ensure you have created an application development topology as described in Setting up an Application Development Topology By Using Vagrant, on page 63, before proceeding with the following steps.

1. Navigate to the `lxc-app-topo-bootstrap` directory and ensure the vagrant instance is running. If not, launch the vagrant instance.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant status
Current machine states:

rtr                       aborted (virtualbox)
devbox                    aborted (virtualbox)

This environment represents multiple VMs. The VMs are all listed
above with their current state. For more information about a specific
VM, run `vagrant status NAME`.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant up
Bringing machine 'rtr' up with 'virtualbox' provider...
Bringing machine 'devbox' up with 'virtualbox' provider...
==> rtr: Clearing any previously set forwarded ports...
==> rtr: Clearing any previously set network interfaces...
==> rtr: Preparing network interfaces based on configuration...
    rtr: Adapter 1: nat
    rtr: Adapter 2: intnet
==> rtr: Forwarding ports...
    rtr: 57722 (guest) => 2222 (host) (adapter 1)
    rtr: 22 (guest) => 2223 (host) (adapter 1)
==> rtr: Running 'pre-boot' VM customizations...
==> rtr: Booting VM...
==> rtr: Waiting for machine to boot. This may take a few minutes...
    rtr: SSH address: 127.0.0.1:2222
    rtr: SSH username: vagrant
    rtr: SSH auth method: private key
    rtr: Warning: Remote connection disconnect. Retrying...
    ...
==> rtr: Machine booted and ready!
...
==> rtr: Machine already provisioned. Run `vagrant provision` or use the `--provision`
==> rtr: flag to force provisioning. Provisioners marked to run always will still run.
==> devbox: Checking if box 'ubuntu/trusty64' is up to date...
==> devbox: A newer version of the box 'ubuntu/trusty64' is available! You currently
==> devbox: have version '20160801.0.0'. The latest is version '20160826.0.1'. Run
==> devbox: `vagrant box update` to update.
==> devbox: Clearing any previously set forwarded ports...
==> devbox: Fixed port collision for 22 => 2222. Now on port 2200.
==> devbox: Clearing any previously set network interfaces...
==> devbox: Preparing network interfaces based on configuration...
```

```
    devbox: Adapter 1: nat
    devbox: Adapter 2: intnet
==> devbox: Forwarding ports...
    devbox: 22 (guest) => 2200 (host) (adapter 1)
==> devbox: Booting VM...
==> devbox: Waiting for machine to boot. This may take a few minutes...
    devbox: SSH address: 127.0.0.1:2200
    devbox: SSH username: vagrant
    devbox: SSH auth method: private key
    devbox: Warning: Remote connection disconnect. Retrying...
    devbox: Warning: Remote connection disconnect. Retrying...
==> devbox: Machine booted and ready!
...
    devbox: Guest Additions Version: 4.3.36
    devbox: VirtualBox Version: 5.0
==> devbox: Configuring and enabling network interfaces...
==> devbox: Mounting shared folders...
    devbox: /vagrant => C:/Users/annseque/vagrant-xrdocs/lxc-app-topo-bootstrap
==> devbox: Machine already provisioned. Run `vagrant provision` or use the `--provision`
==> devbox: flag to force provisioning. Provisioners marked to run always will still
run.

==> rtr: Machine 'rtr' has a post `vagrant up` message. This is a message
==> rtr: from the creator of the Vagrantfile, and not from Vagrant itself:
==> rtr:
==> rtr:
==> rtr:     Welcome to the IOS XRv (64-bit) Virtualbox.
==> rtr:     To connect to the XR Linux shell, use: 'vagrant ssh'.
==> rtr:     To ssh to the XR Console, use: 'vagrant port' (vagrant version > 1.8)
==> rtr:     to determine the port that maps to guestport 22,
==> rtr:     then: 'ssh vagrant@localhost -p <forwarded port>'
...
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant status
Current machine states:


rtr                       running (virtualbox)
devbox                    running (virtualbox)

This environment represents multiple VMs. The VMs are all listed
above with their current state. For more information about a specific
VM, run `vagrant status NAME`.
```

2. Access the `devbox` through SSH and install LXC tools.

   To launch an LXC container, you need the following, which can be obtained by installing LXC tools:

   - A container rootfs tar ball
   - An XML file to launch the container using **virsh**/**libvirt**

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh devbox
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

  System information as of Thu Sep  1 03:55:29 UTC 2016

  System load:  0.99              Processes:           94
  Usage of /:   3.9% of 39.34GB   Users logged in:     0
  Memory usage: 14%               IP address for eth0: 10.0.2.15
  Swap usage:   0%                IP address for eth1: 11.1.1.20
```

```
  Graph this data and manage this system at:
    https://landscape.canonical.com/

  Get cloud support with Ubuntu Advantage Cloud Guest:
    http://www.ubuntu.com/business/services/cloud

25 packages can be updated.
12 updates are security updates.

New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

------------------------------------------------------------------------------------------------
Last login: Wed Aug 31 04:02:20 2016 from 10.0.2.2
vagrant@vagrant-ubuntu-trusty-64:~$ sudo apt-get update
Ign http://archive.ubuntu.com trusty InRelease
Get:1 http://security.ubuntu.com trusty-security InRelease [65.9 kB]
...
Get:33 http://archive.ubuntu.com trusty-backports/universe Translation-en [36.8 kB]
Hit http://archive.ubuntu.com trusty Release
...
Hit http://archive.ubuntu.com trusty/universe Translation-en
Ign http://archive.ubuntu.com trusty/main Translation-en_US
Ign http://archive.ubuntu.com trusty/multiverse Translation-en_US
Ign http://archive.ubuntu.com trusty/restricted Translation-en_US
Ign http://archive.ubuntu.com trusty/universe Translation-en_US
Fetched 4,022 kB in 16s (246 kB/s)
Reading package lists... Done

------------------------------------------------------------------------------------------------
vagrant@vagrant-ubuntu-trusty-64:~$ sudo apt-get -y install lxc
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  bridge-utils cgmanager cloud-image-utils debootstrap dnsmasq-base euca2ools
  genisoimage libaio1 libboost-system1.54.0 libboost-thread1.54.0 liblxc1
  libmnl0 libnetfilter-conntrack3 libnspr4 libnss3 libnss3-nssdb librados2
  librbd1 libseccomp2 libxslt1.1 lxc-templates python-distro-info python-lxml
  python-requestbuilder python-setuptools python3-lxc qemu-utils sharutils
  uidmap
Suggested packages:
  cgmanager-utils wodim cdrkit-doc btrfs-tools lvm2 lxctl qemu-user-static
  python-lxml-dbg bsd-mailx mailx
The following NEW packages will be installed:
  bridge-utils cgmanager cloud-image-utils debootstrap dnsmasq-base euca2ools
  genisoimage libaio1 libboost-system1.54.0 libboost-thread1.54.0 liblxc1
  libmnl0 libnetfilter-conntrack3 libnspr4 libnss3 libnss3-nssdb librados2
  librbd1 libseccomp2 libxslt1.1 lxc lxc-templates python-distro-info
  python-lxml python-requestbuilder python-setuptools python3-lxc qemu-utils
  sharutils uidmap
0 upgraded, 30 newly installed, 0 to remove and 52 not upgraded.
Need to get 6,469 kB of archives.
After this operation, 25.5 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu/ trusty/main libaio1 amd64 0.3.109-4 [6,364 B]
...
Get:30 http://archive.ubuntu.com/ubuntu/ trusty-updates/main debootstrap all
1.0.59ubuntu0.5 [29.6 kB]
Fetched 6,469 kB in 22s (289 kB/s)
Selecting previously unselected package libaio1:amd64.
(Reading database ... 62989 files and directories currently installed.)
Preparing to unpack .../libaio1_0.3.109-4_amd64.deb ...
...
```

```
Setting up lxc (1.0.8-0ubuntu0.3) ...
lxc start/running
Setting up lxc dnsmasq configuration.
Processing triggers for ureadahead (0.100.0-16) ...
Setting up lxc-templates (1.0.8-0ubuntu0.3) ...
Setting up libnss3-nssdb (2:3.23-0ubuntu0.14.04.1) ...
Setting up libnss3:amd64 (2:3.23-0ubuntu0.14.04.1) ...
Setting up librados2 (0.80.11-0ubuntu1.14.04.1) ...
Setting up librbd1 (0.80.11-0ubuntu1.14.04.1) ...
Setting up qemu-utils (2.0.0+dfsg-2ubuntu1.27) ...
Setting up cloud-image-utils (0.27-0ubuntu9.2) ...
Processing triggers for libc-bin (2.19-0ubuntu6.9) ...
```

3. Verify that the LXC was properly installed.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-start --version
1.0.8
```

4. Create the LXC container with a standard Ubuntu base template and launch it in `devbox`.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-create -t ubuntu --name xr-lxc-app
Checking cache download in /var/cache/lxc/trusty/rootfs-amd64 ...
Installing packages in template: ssh,vim,language-pack-en
Downloading ubuntu trusty minimal ...
I: Retrieving Release
I: Retrieving Release.gpg
...
Generation complete.
Setting up perl-modules (5.18.2-2ubuntu1.1) ...
Setting up perl (5.18.2-2ubuntu1.1) ...
Processing triggers for libc-bin (2.19-0ubuntu6.9) ...
Processing triggers for initramfs-tools (0.103ubuntu4.4) ...
Download complete
Copy /var/cache/lxc/trusty/rootfs-amd64 to /var/lib/lxc/xr-lxc-app/rootfs ...
Copying rootfs to /var/lib/lxc/xr-lxc-app/rootfs ...
Generating locales...
  en_US.UTF-8... up-to-date
Generation complete.
Creating SSH2 RSA key; this may take some time ...
Creating SSH2 DSA key; this may take some time ...
Creating SSH2 ECDSA key; this may take some time ...
Creating SSH2 ED25519 key; this may take some time ...
update-rc.d: warning: default stop runlevel arguments (0 1 6) do not match ssh
Default-Stop values (none)
invoke-rc.d: policy-rc.d denied execution of start.

Current default time zone: 'Etc/UTC'
Local time is now:      Thu Sep  1 04:46:22 UTC 2016.
Universal Time is now:  Thu Sep  1 04:46:22 UTC 2016.


##
# The default user is 'ubuntu' with password 'ubuntu'!
# Use the 'sudo' command to run tasks as root in the container.
##
```

5. Verify if the LXC container has been successfully created.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-ls --fancy
NAME        STATE    IPV4  IPV6  AUTOSTART
```

```
----------------------------------------
xr-lxc-app  STOPPED  -     -     NO
```

6. Start the LXC container.

   You will be prompted to log into the LXC container. The login credentials are **ubuntu/ubuntu**.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-start --name xr-lxc-app
<4>init: plymouth-upstart-bridge main process (5) terminated with status 1
...

xr-lxc-app login: ubuntu
Password:
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

ubuntu@xr-lxc-app:~$
```

7. Install your application within the LXC container.

   For the sake of illustration, in this example we will install the iPerf application.

```
ubuntu@xr-lxc-app:~$ sudo apt-get -y install iperf
[sudo] password for ubuntu:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  iperf
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 56.3 kB of archives.
After this operation, 174 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu/ trusty/universe iperf amd64 2.0.5-3 [56.3 kB]
Fetched 56.3 kB in 16s (3,460 B/s)
Selecting previously unselected package iperf.
(Reading database ... 14648 files and directories currently installed.)
Preparing to unpack .../iperf_2.0.5-3_amd64.deb ...
Unpacking iperf (2.0.5-3) ...
Setting up iperf (2.0.5-3) ...
ubuntu@xr-lxc-app:~$
```

8. Change the SSH port inside the container and verify that it has been correctly assigned.

   When you deploy your container to IOS XR, it shares the network namespace with XR. Since IOS XR already uses Ports 22 and 57722 for other purposes, you must pick some other port number for your container.

```
ubuntu@xr-lxc-app:~$ sudo sed -i s/Port\ 22/Port\ 58822/ /etc/ssh/sshd_config
[sudo] password for ubuntu:

ubuntu@xr-lxc-app:~$ cat /etc/ssh/sshd_config | grep Port
Port 58822
ubuntu@xr-lxc-app:~$
```

9. Shut the container down.

```
ubuntu@xr-lxc-app:~$ sudo shutdown -h now
ubuntu@xr-lxc-app:~$
Broadcast message from ubuntu@xr-lxc-app
        (/dev/lxc/console) at 5:17 ...

The system is going down for halt NOW!
<4>init: tty4 main process (369) killed by TERM signal
...
wait-for-state stop/waiting
 * Asking all remaining processes to terminate...
   ...done.
 * All processes ended within 1 seconds...
   ...done.
 * Deactivating swap...
   ...done.
mount: cannot mount block device /dev/sda1 read-only
 * Will now halt
```

10. Assume the root user role.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo -s
root@vagrant-ubuntu-trusty-64:~# whoami
root
```

11. Navigate to the `/var/lib/lxc/xr-lxc-app/` directory and package the `rootfs` into a tar ball.

```
root@vagrant-ubuntu-trusty-64:~# cd /var/lib/lxc/xr-lxc-app/
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app# ls
config  fstab  rootfs
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app# cd rootfs
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs# tar -czvf
xr-lxc-app-rootfs.tar.gz *
tar: dev/log: socket ignored
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs#
```

12. Transfer the `rootfs` tar ball to the home directory (`~/` or `/home/vagrant`) and verify if the transfer is successful.

```
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs# mv *.tar.gz /home/vagrant
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs# ls -l /home/vagrant
total 120516
-rw-r--r-- 1 root root 123404860 Sep  1 05:22 xr-lxc-app-rootfs.tar.gz
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs#
```

13. Create an LXC spec XML file for specifying attributes required to launch the LXC container with the application.

    You must navigate to the `/home/vagrant` directory on `devbox` and use a vi editor to create the XML file. Save the file as `xr-lxc-app.xml`.

    A sample LXC spec file to launch the application within the container is as shown.

```
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/xr-lxc-app/rootfs# exit
exit
vagrant@vagrant-ubuntu-trusty-64:~$ pwd
/home/vagrant
vagrant@vagrant-ubuntu-trusty-64:~$ vi xr-lxc-app.xml

--------------------------------------------------------------------------------
```

```
<domain type='lxc' xmlns:lxc='http://libvirt.org/schemas/domain/lxc/1.0' >
<name>xr-lxc-app</name>
<memory>327680</memory>
<os>
<type>exe</type>
<init>/sbin/init</init>
</os>
<lxc:namespace>
<sharenet type='netns' value='global-vrf'/>
</lxc:namespace>
<vcpu>1</vcpu>
<clock offset='utc'/>
<on_poweroff>destroy</on_poweroff>
<on_reboot>restart</on_reboot>
<on_crash>destroy</on_crash>
<devices>
<emulator>/usr/lib64/libvirt/libvirt_lxc</emulator>
<filesystem type='mount'>
<source dir='/misc/app_host/xr-lxc-app/'/>
<target dir='/'/>
</filesystem>
<console type='pty'/>
</devices>
</domain>
```

In IOS-XR the `global-vrf` network namespace contains all the XR GigE or management interfaces. The `sharenet` configuration in the XML file ensures that the container on being launched has native access to all XR interfaces.

`/misc/app_host/` on IOS XR is a special mount volume that is designed to provide nearly 3.9GB of disk space. This mount volume can be used to host custom container `rootfs` and other large files without occupying disk space on XR. In this example, we expect to untar the `rootfs` to the `/misc/app_host/xr-lxc-app/` directory.

14. Verify if the `rootfs` tar ball and the LXC XML spec file are present in the home directory.

```
root@vagrant-ubuntu-trusty-64:~# pwd
/home/vagrant
root@vagrant-ubuntu-trusty-64:~# ls -l
total 119988
-rw-r--r-- 1 root root 122863332 Jun 16 19:41 xr-lxc-app-rootfs.tar.gz
-rw-r--r-- 1 root root       590 Jun 16 23:29 xr-lxc-app.xml
root@vagrant-ubuntu-trusty-64:~#
```

15. Transfer the `rootfs` tar ball and XML spec file to XR.

There are two ways of transferring the files: Through the GigE interface (a little slower) or the management interface. You can use the method that works best for you.

- **Transfer Through the Management Interface of XR:**

  a. Check the port number that maps to the management port on XR.

  Vagrant forwards the port number 57722 to a host port for XR over the management port. In a virtual box, the IP address of the host (your laptop) is always 10.0.2.2 for the port that was translated (NAT).

  ```
  vagrant@vagrant-ubuntu-trusty-64:~$ exit
  logout
  Connection to 127.0.0.1 closed.

  annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
  ```

```
$ vagrant port rtr
The forwarded ports for the machine are listed below. Please note that
these values may differ from values configured in the Vagrantfile if the
provider supports automatic port collision detection and resolution.

    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)
```

The output shows that port number 2222 maps to port number 57722.

b. Access `devbox` and use the port number 2222 to transfer the `rootfs` tar ball and XML spec file to XR.

```
annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh devbox
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

  System information as of Fri Sep  2 05:38:20 UTC 2016

  System load:  0.49              Users logged in:       0
  Usage of /:   6.4% of 39.34GB   IP address for eth0:   10.0.2.15
  Memory usage: 25%               IP address for eth1:   11.1.1.20
  Swap usage:   0%                IP address for lxcbr0: 10.0.3.1
  Processes:    80

  Graph this data and manage this system at:
    https://landscape.canonical.com/

  Get cloud support with Ubuntu Advantage Cloud Guest:
    http://www.ubuntu.com/business/services/cloud

New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


Last login: Fri Sep  2 05:38:20 2016 from 10.0.2.2
vagrant@vagrant-ubuntu-trusty-64:~$ scp -P 2222 /home/vagrant/*.*
vagrant@10.0.2.2:/misc/app_host/scratch
The authenticity of host '[10.0.2.2]:2222 ([10.0.2.2]:2222)' can't be
established.
ECDSA key fingerprint is db:25:e2:27:49:2a:7b:27:e1:76:a6:7a:e4:70:f5:f7.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[10.0.2.2]:2222' (ECDSA) to the list of known hosts.
vagrant@10.0.2.2's password:
xr-lxc-app-rootfs.tar.gz

100%  234MB  18.0MB/s   00:13
xr-lxc-app.xml

100%  591     0.6KB/s   00:00
vagrant@vagrant-ubuntu-trusty-64:~$
```

- **Transfer Through the GigE Interface of XR:**

a. Determine the GigE interface IP address on XR.

```
vagrant@vagrant-ubuntu-trusty-64:~$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh rtr
```

```
Last login: Wed Aug 31 07:09:51 2016 from 10.0.2.2
xr-vm_node0_RP0_CPU0:~$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 08:00:27:5a:29:77
          inet addr:11.1.1.10  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe5a:2977/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1 errors:0 dropped:3 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:42 (42.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 08:00:27:13:ad:eb
          inet addr:10.0.2.15  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe13:adeb/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:94 errors:0 dropped:0 overruns:0 frame:0
          TX packets:66 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:13325 (13.0 KiB)  TX bytes:11041 (10.7 KiB)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1496  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:302 (302.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

In this example, the IP address of the GigE interface is 11.1.1.10.

b. Copy the `rootfs` tar ball to XR by using the GigE interface address.

```
vagrant@vagrant-ubuntu-trusty-64:~$ scp -P 57722
/home/vagrant/xr-lxc-app-rootfs.tar.gz
vagrant@11.1.1.10:/misc/app_host/scratch/
The authenticity of host '[11.1.1.10]:57722 ([11.1.1.10]:57722)' can't be
established.
ECDSA key fingerprint is db:25:e2:27:49:2a:7b:27:e1:76:a6:7a:e4:70:f5:f7.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[11.1.1.10]:57722' (ECDSA) to the list of known
hosts.
vagrant@11.1.1.10's password:
xr-lxc-app-rootfs.tar.gz
```

c. Copy the XML spec file to XR by using the GigE interface address.

```
vagrant@vagrant-ubuntu-trusty-64:~$ scp -P 57722 /home/vagrant/xr-lxc-app.xml
vagrant@11.1.1.10:/misc/app_host/scratch/
vagrant@11.1.1.10's password:
xr-lxc-app.xml
```

16. Create a directory (`/misc/app_host/xr-lxc-app/`)on XR (`rtr`) to untar the `rootfs` tar ball.

```
vagrant@vagrant-ubuntu-trusty-64:~$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh rtr
Last login: Fri Sep  2 05:49:01 2016 from 10.0.2.2

xr-vm_node0_RP0_CPU0:~$ sudo mkdir /misc/app_host/xr-lxc-app/
```

17. Navigate to the `/misc/app_host/xr-lxc-app/` directory and untar the tar ball.

```
xr-vm_node0_RP0_CPU0:~$ cd /misc/app_host/xr-lxc-app/
xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ sudo tar -zxf
../scratch/xr-lxc-app-rootfs.tar.gz
tar: dev/audio3: Cannot mknod: Operation not permitted
...
```

18. Use the XML spec file to launch the container and verify its existence on XR.

```
xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ virsh create
/misc/app_host/scratch/xr-lxc-app.xml
Domain xr-lxc-app created from /misc/app_host/scratch/xr-lxc-app.xml

xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ virsh list
 Id    Name                           State
----------------------------------------------------
 2095  xr-lxc-app                     running
 4932  sysadmin                       running
 12086 default-sdr--1                 running
```

19. Log into the container. The default login credentials are `ubuntu/ubuntu`.

    There are two ways of logging into the container. You can use the method that works best for you:

    - **Logging into the container by using virsh command:**

```
xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ virsh console xr-lxc-app
Connected to domain xr-lxc-app
Escape character is ^]
init: Unable to create device: /dev/kmsg
* Stopping Send an event to indicate plymouth is up                    [ OK ]
* Starting Mount filesystems on boot                                   [ OK ]
* Starting Signal sysvinit that the rootfs is mounted                  [ OK ]
* Starting Fix-up sensitive /proc filesystem entries                   [ OK ]

xr-lxc-app login:  * Starting OpenSSH server                            [ OK ]


Ubuntu 14.04.5 LTS xr-lxc-app tty1
xr-lxc-app login: ubuntu
Password:
Last login: Fri Sep  2 05:40:11 UTC 2016 on lxc/console
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.14.23-WR7.0.0.2_standard x86_64)

 * Documentation:  https://help.ubuntu.com/
```

```
ubuntu@xr-lxc-app:~$
```

- **Logging into the container by using SSH:**

  Use the SSH port number you configured, 58822, and any of XR interface IP addresses to log in.

```
xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ ssh -p 58822 ubuntu@11.1.1.10
Warning: Permanently added '[11.1.1.10]:58822' (ECDSA) to the list of known hosts.
ubuntu@11.1.1.10's password:
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.14.23-WR7.0.0.2_standard x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Fri Sep  2 07:42:37 2016
ubuntu@xr-lxc-app:~$
```

Note

- To exit the container, use the press **CTRL** and **]** keys simultaneously.
- To access the container directly from your host machine, ensure you forward the intended port (in this example, 58822) to your laptop (any port of your choice), in the Vagrant file:

  ```
  node.vm.network "forwarded_port", guest: 58822, host: 58822
  ```

  You can then SSH to the LXC container by using the following command:

  ```
  ssh -p 58822 vagrant@localhost
  ```

20. Verify if the interfaces on XR are available inside the LXC container.

The LXC container operates as your own Linux server on XR. Because the network namespace is shared between the LXC and XR, all of XR interfaces (GigE, management, and so on) are available to bind to and run your applications.

```
ubuntu@xr-lxc-app:~$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 08:00:27:5a:29:77
          inet addr:11.1.1.10  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe5a:2977/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:186070 errors:0 dropped:0 overruns:0 frame:0
          TX packets:155519 errors:0 dropped:3 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:301968784 (301.9 MB)  TX bytes:10762900 (10.7 MB)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 08:00:27:13:ad:eb
          inet addr:10.0.2.15  Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe13:adeb/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:170562 errors:0 dropped:0 overruns:0 frame:0
          TX packets:70309 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:254586763 (254.5 MB)  TX bytes:3886846 (3.8 MB)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)
```

```
fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1496  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:155549 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:10765764 (10.7 MB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:64 errors:0 dropped:0 overruns:0 frame:0
          TX packets:64 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:9400 (9.4 KB)  TX bytes:9400 (9.4 KB)
```

21. Configure the container to communicate outside XR with other nodes in the network.

By default, the IOS-XRv vagrant box is set up to talk to the internet using a default route through your management port. If you want the router to use the routing table to talk to other nodes in the network, then you must configure **tpa-address**. This becomes the **src-hint** for all Linux application traffic.

In this example, we use Loopback 0 for **tpa-address** to ensure that the IP address for any originating traffic for applications on the XR is a reachable IP address across your topology.

```
ubuntu@xr-lxc-app:~$ exit
logout
Connection to 11.1.1.10 closed.
xr-vm_node0_RP0_CPU0:/misc/app_host/xr-lxc-app$ exit
logout
Connection to 127.0.0.1 closed.

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$  vagrant port rtr | grep 22
    22 (guest) => 2223 (host)
 57722 (guest) => 2222 (host)

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:


RP/0/RP0/CPU0:ios# configure
Fri Sep  2 08:03:05.094 UTC
RP/0/RP0/CPU0:ios(config)# interface loopback 0
RP/0/RP0/CPU0:ios(config-if)# ip address 1.1.1.1/32
RP/0/RP0/CPU0:ios(config-if)# exit
RP/0/RP0/CPU0:ios(config)# tpa address-family ipv4 update-source loopback 0
RP/0/RP0/CPU0:ios(config)# commit
Fri Sep  2 08:03:39.602 UTC
RP/0/RP0/CPU0:ios(config)# exit
RP/0/RP0/CPU0:ios# bash
Fri Sep  2 08:03:58.232 UTC

[xr-vm_node0_RP0_CPU0:~]$ ip route
default dev fwdintf  scope link  src 1.1.1.1
10.0.2.0/24 dev Mg0_RP0_CPU0_0  proto kernel  scope link  src 10.0.2.15
```

You can see the configured Loopback 0 IP address (1.1.1.1).

22. Test your application within the launched container.

We installed iPerf in our container. We will run the iPerf server within the container, and the iPerf client on the `devbox` and see if they can communicate. Basically, the hosted application within a container on `rtr` should be able to talk to a client application on `devbox`.

a. Check if the iPerf server is running within the LXC container on XR.

```
[xr-vm_node0_RP0_CPU0:~]$ssh -p 58822 ubuntu@11.1.1.10
Warning: Permanently added '[11.1.1.10]:58822' (ECDSA) to the list of known hosts.
ubuntu@11.1.1.10's password:
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.14.23-WR7.0.0.2_standard x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Fri Sep  2 07:47:28 2016 from 11.1.1.10

ubuntu@xr-lxc-app:~$ iperf -s -u
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 64.0 MByte (default)
------------------------------------------------------------
```

b. Check if XR Loopback interface is accessible on devbox. (Open a new Git bash window for this step.)

```
annseque@ANNSEQUE-WS02 MINGW64 ~
$ cd vagrant-xrdocs

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs (master)
$ cd lxc-app-topo-bootstrap/

annseque@ANNSEQUE-WS02 MINGW64 ~/vagrant-xrdocs/lxc-app-topo-bootstrap (master)
$ vagrant ssh devbox
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

  System information as of Fri Sep  2 05:51:19 UTC 2016

  System load:  0.08              Users logged in:       0
  Usage of /:   6.4% of 39.34GB   IP address for eth0:   10.0.2.15
  Memory usage: 28%               IP address for eth1:   11.1.1.20
  Swap usage:   0%                IP address for lxcbr0: 10.0.3.1
  Processes:    77

  Graph this data and manage this system at:
    https://landscape.canonical.com/

  Get cloud support with Ubuntu Advantage Cloud Guest:
    http://www.ubuntu.com/business/services/cloud

53 packages can be updated.
26 updates are security updates.

New release '16.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


Last login: Fri Sep  2 05:51:21 2016 from 10.0.2.2
vagrant@vagrant-ubuntu-trusty-64:~$ sudo ip route add 1.1.1.1/32 via 11.1.1.10
vagrant@vagrant-ubuntu-trusty-64:~$ ping 1.1.1.1
PING 1.1.1.1 (1.1.1.1) 56(84) bytes of data.
64 bytes from 1.1.1.1: icmp_seq=1 ttl=255 time=1.87 ms
64 bytes from 1.1.1.1: icmp_seq=2 ttl=255 time=10.5 ms
```

```
64 bytes from 1.1.1.1: icmp_seq=3 ttl=255 time=4.13 ms
^C
--- 1.1.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2007ms
rtt min/avg/max/mdev = 1.876/5.510/10.520/3.661 ms
```

c. Install the iPerf client on `devbox`.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo apt-get install iperf
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  iperf
0 upgraded, 1 newly installed, 0 to remove and 52 not upgraded.
Need to get 56.3 kB of archives.
After this operation, 174 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu/ trusty/universe iperf amd64 2.0.5-3 [56.3
kB]
Fetched 56.3 kB in 10s (5,520 B/s)
Selecting previously unselected package iperf.
(Reading database ... 64313 files and directories currently installed.)
Preparing to unpack .../iperf_2.0.5-3_amd64.deb ...
Unpacking iperf (2.0.5-3) ...
Processing triggers for man-db (2.6.7.1-1ubuntu1) ...
Setting up iperf (2.0.5-3) ...
```

d. Launch the iPerf client on `devbox` and verify if it is communicating with the iPerf server within the LXC on XR.

```
vagrant@vagrant-ubuntu-trusty-64:~$ iperf -u -c 1.1.1.1
------------------------------------------------------------
Client connecting to 1.1.1.1, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:  208 KByte (default)
------------------------------------------------------------
[  3] local 11.1.1.20 port 37800 connected with 1.1.1.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec
[  3] Sent 893 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec  1.25 MBytes  1.05 Mbits/sec   1.791 ms    0/  893 (0%)
```

You have successfully hosted an application within a Linux container by using vagrant.

Installing Docker on Cisco IOS XR By Using Vagrant

This section describes how you can install a Docker container on Cisco IOS XR by using Vagrant.

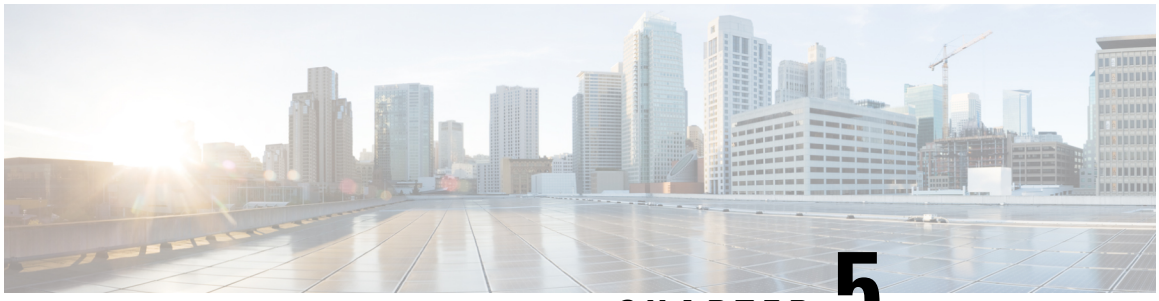
Setup Options for Dockers on XR

You can choose any of the following setups for using Dockers on XR.

- **Public Docker-Hub registry**: You can configure a public Docker-Hub with the correct DNS resolution so that it is accessible to all users. This is the simplest form of Docker setup.
- **Private Docker-Hub unsecured registry**: You can configure a private Docker-Hub registry without security, if you are planning to run the registry inside a secured part of your network.

- **Private Docker-Hub self-signed registry**: You can configure a private Docker-Hub registry enabled with TLS. This is more secure than using a local unsecured registry.
- **Private Docker-Hub secured registry**: You can configure a private Docker-Hub secured registry, created using a certificate obtained from a Certificate Authority (CA) server. The steps used to set this up are identical to a private Docker-Hub self-signed registry except for the creation of the certificate.
- **Tarball image/container**: You can create and configure a Docker container on your laptop and package it as an image or a container tar ball. You can then transfer the tar ball to XR, and extract the Docker container for use.

For information on implementing these setup options, see the XR toolbox, Part 6: Running Docker Containers on IOS-XR (6.1.2+) section on Github.



CHAPTER 5

Hosting Applications Using Configuration Management Tools

Configuration management tools are used to automate manual tasks, such as setting up servers and network devices. As application delivery requirements keep changing, reconfiguring network equipment becomes a challenge. The manual reconfiguration process is prone to errors, which in turn can cause network outages. Configuration management tools help when configurations need to be updated constantly, and on multiple network devices.

The Cisco IOS XR Software works well with the following configuration management tools:

- Chef
- Puppet

This section explains how you can install, configure, and use the configuration management tools, Chef and Puppet for application hosting on IOS XR.

- Using Chef for Configuring Cisco IOS XR, on page 91
- Using Puppet for Configuring Cisco IOS XR, on page 95

Using Chef for Configuring Cisco IOS XR

Chef is an open-source IT automation tool that you can use to install, configure, and deploy various applications natively on Cisco IOS XR.

To use Chef, you need the following components:

- Chef Client RPM Version 12.5, or later for Cisco IOS XR 6.0
- Chef Server Version 12.4, or higher
- Applications that are compatible with the Wind River Linux 7 environment of IOS XR

You also need three Chef built-in resources to deploy your application natively on IOS XR. The three built-in Chef Resources are:

- Package Resource
- File Resource
- Service Resource

Access the links provided in the following table for additional details on Chef and Chef resources:

Table 12: Chef Resources

Topic	Link
Chef Software, Inc.	https://www.chef.io/
Chef Overview	https://docs.chef.io/chef_overview.html
Package Resource Reference	https://docs.chef.io/resource_package.html
File Resource Reference	https://docs.chef.io/resource_file.html
Service Resource Reference	https://docs.chef.io/resource_service.html
Chef Server Reference	https://docs.chef.io/install_server.html
Chef Client for Native XR Environment	Chef Client

Installing and Configuring the Chef Client

This section describes the procedure for installing the Chef Client on IOS XR.

Prerequisites

Ensure that the following requirements are met before you proceed with installation:

- Your workstation is set up with the Chef repository and the Chef Development Kit.
- Chef Server Version 12.4, or higher is installed and accessible from your Linux box.
- The Chef Server identification files are available.
- You have the right name server and domain name entries configured in the Linux environment (`/etc/resolv.conf`).
- The router is using a valid NTP server.

Configuration Procedure

To install and configure the Chef Client on IOS XR, follow these steps:

1. From your Linux box, access the IOS XR console through SSH, and log in.

```
cisco@host:~$ ssh root@192.168.122.188
root@192.168.122.188's password:
RP/0/RP0/CPU0:ios#
```

   You have entered the IOS XR prompt.

2. Enter the third-party network namespace or global VRF, depending on the version of Cisco IOS XR you are using in your network.

   You can verify whether you are in the namespace by viewing the interfaces, as shown here:

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
```

```
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2 or higher, run the following command */
RP/0/RP0/CPU0:ios# bash


[xr-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

3. (Optional) Configure a proxy server (`http_proxy`, `https_proxy`) as needed.

```
http_proxy=http://proxy.youtube.com:8080
https_proxy=https://proxy.youtube.com:8080
```

4. Install the Chef Client.

```
[xr-vm_node0_RP0_CPU0:~]$ yum install https://chef.io/chef/install.sh
```

The Chef **install.sh** script automatically determines the latest version of the Chef Client RPM for installation.

5. Copy the `validation.pem` file from the Chef server to `/etc/chef/validation.pem`
6. Edit the Chef Client configuration file at `/etc/chef/client.rb` with Chef Server identification and Client settings.

```
validation_client_name 'chef-validator'
chef_server_url 'https://my_chef_server.youtube.com/organizations/chef'
node_name 'n3k.youtube.com' # "This" client device.
cookbook_sync_threads 5 # necessary for small memory switches (4G or less)
interval 30 # client-run interval; remove for "never"
```

7. Run the Chef Client.

```
[xr-vm_node0_RP0_CPU0:~]$ chef-client
```

Note To run the Client once, use the **chef-client --once** command. For more information, see the Chef documentation at https://docs.chef.io/chef_client.html

The Chef Client is successfully installed on IOS XR.

Creating a Chef Cookbook with Recipes

A Chef cookbook, loaded with Chef recipes, can be created on your Linux workstation, and copied to the Chef server. After you install the Chef client on IOS XR, the cookbook with recipes can be downloaded from the Chef server, and used while running the client.

Prerequisites

Ensure the following requirements are met before you proceed:

- You have access to the application package compatible with the native IOS XR environment.
- Target application package is hosted on an accessible repository or downloaded to a boot flash.

Configuration Procedure

Use the following procedure to create a Chef recipe that starts the `bootlogd` service, and installs iPerf on IOS XR:

1. Create a cookbook on your Linux workstation by using the corresponding knife command.

```
knife cookbook create cisco-network-chef-cookbook
```

2. Create the Chef recipe file to install iPerf, and add it to the cookbook.

   The Chef recipe must be created in the `cisco-network-chef-cookbook/recipes/` directory. For it to be loaded automatically by the Chef Client, the Chef recipe must be named as `default.rb`.

```
#
# Recipe:: demo_default_providers
#
# Copyright (c) 2015 The Authors, All Rights Reserved.
```

```
package = 'iperf-2.0.5-r0.0.core2_64.rpm'
service = 'bootlogd'

remote_file "/#{package}" do
  source "http://10.105.247.73/wrl7_yum_repo/#{package}"
  action :create
end

yum_package "#{package}" do
  source "/#{package}"
  action :install
end

service "#{service}" do
  action :start
end
```

3. Access the Chef Server from your Linux workstation and upload the cookbook to the server.
4. Log into the IOS XR shell, and run the Chef Client to load and execute the cookbook.

```
[xr-vm_node0_RP0_CPU0:~]$chef-client
```

The iperf RPM is installed on IOS XR.

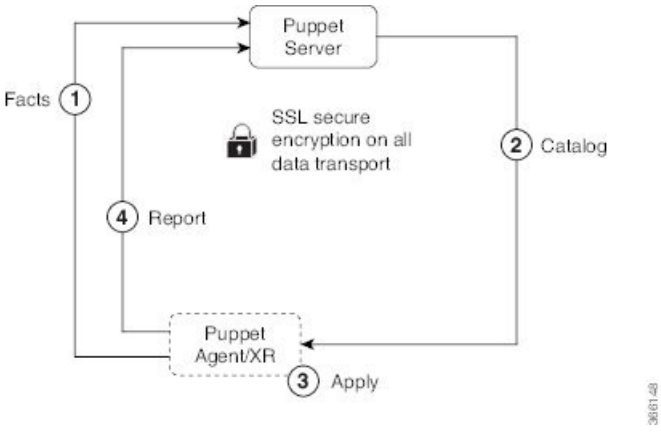
For additional details on the Chef Client, refer to https://docs.chef.io/chef_client.html

Using Puppet for Configuring Cisco IOS XR

Puppet is an open-source configuration management and automation tool that you can use to install and configure various applications on IOS XR. Puppet is provided by Puppet Labs, and runs well on Windows, Unix, and Linux systems. Puppet uses its own declarative langauage to describe system configuration.

Puppet follows a client-server model. The Puppet client is known as the Puppet Agent, and is installed on XR. The configuration file, called the Puppet manifest, is stored on the Puppet Server and contains configuration for multiple nodes. On receiving the information about XR from the Puppet Agent, the Puppet Server compiles the manifest into a catalog that can be used to configure the node that sent the information. This workflow is described in the following illustration.

Figure 12: Basic Puppet Workflow



1. The Puppet Agent sends information about IOS XR to the Puppet Server.
2. The Puppet Server compiles the information into a Catalog, and sends to the Puppet Agent.
3. The Puppet Agent applies the catalog to XR.
4. The Puppet Agent sends a configuration complete report to the Puppet Server.

To use Puppet, you need the following components:

- Puppet RPM built for IOS XR.
- Puppet Server Version 4.0, or higher.

Table 13: Puppet Resources

Topic	Link
Cisco Github Puppet Yang Module	https://github.com/cisco/cisco-yang-puppet-module
Puppet Labs	https://puppetlabs.com/
Package Type Reference	https://docs.puppetlabs.com/references/latest/type.html#package
File Type Reference	https://docs.puppetlabs.com/references/latest/type.html#file
Service Type Reference	https://docs.puppetlabs.com/references/latest/type.html#service
Puppet Server Reference	Puppet Server
Puppet Agent for IOS XR Environment	Puppet Agent

Installing and Configuring the Puppet Agent

This section describes how you can install and configure the Puppet Agent on IOS XR.

Prerequisites

Ensure that the following requirements are met before you proceed with installation.

- Puppet Server Version 4.0, or higher is installed and accessible from your workstation.
- You have the right name server and domain name entries configured in the Linux environment (`/etc/resolv.conf`).
- The router is using a valid NTP server.

Configuration Procedure

To install and configure the Puppet Agent on IOS XR, follow these steps:

1. From your Linux box, access the IOS XR console through SSH, and log in.

```
cisco@host:~$ ssh root@192.168.122.188
root@192.168.122.188's password:
RP/0/RP0/CPU0:ios#
```

You have entered the IOS XR prompt.

2. Enter the third-party network namespace or global VRF, depending on the version of Cisco IOS XR you are using in your network.

   You can verify whether you are in the namespace by viewing the interfaces, as shown:

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2 or higher, run the following command */
RP/0/RP0/CPU0:ios# bash

[xr-vm_node0_RP0_CPU0:~]$ ifconfig
Gi0_0_0_0 Link encap:Ethernet  HWaddr 52:46:04:87:19:3c
          inet addr:192.164.168.10  Mask:255.255.255.0
          inet6 addr: fe80::5046:4ff:fe87:193c/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

Mg0_RP0_CPU0_0 Link encap:Ethernet  HWaddr 52:46:12:7a:88:41
          inet addr:192.168.122.197  Mask:255.255.255.0
          inet6 addr: fe80::5046:12ff:fe7a:8841/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1514  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

fwd_ew    Link encap:Ethernet  HWaddr 00:00:00:00:00:0b
          inet6 addr: fe80::200:ff:fe00:b/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

fwdintf   Link encap:Ethernet  HWaddr 00:00:00:00:00:0a
          inet6 addr: fe80::200:ff:fe00:a/64 Scope:Link
          UP RUNNING NOARP MULTICAST  MTU:1482  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2 errors:0 dropped:1 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:140 (140.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo:0      Link encap:Local Loopback
          inet addr:1.1.1.1  Mask:255.255.255.255
          UP LOOPBACK RUNNING  MTU:1500  Metric:1
```

3. (Optional) Configure a proxy server (`http_proxy`, `https_proxy`), as needed.

```
http_proxy=http://proxy.youtube.com:8080
https_proxy=https://proxy.youtube.com:8080
```

4. Install the Puppet Agent.

```
[xr-vm_node0_RP0_CPU0:~]$ wget http://yum.puppetlabs.com/RPM-GPG-KEY-puppetlabs
[xr-vm_node0_RP0_CPU0:~]$ wget http://yum.puppetlabs.com/RPM-GPG-KEY-reductive
[xr-vm_node0_RP0_CPU0:~]$ rpm --import RPM-GPG-KEY-puppetlabs RPM-GPG-KEY-reductive
[xr-vm_node0_RP0_CPU0:~]$ yum install
http://yum.puppetlabs.com/puppetlabs-release-pc1-cisco-wrlinux-7.noarch.rpm
```

5. Edit the Puppet Agent configuration file at `/etc/puppetlabs/puppet/puppet.conf` with Puppet Server identification and Agent settings.

The Puppet Agent is successfully installed on IOS XR.

Creating a Puppet Manifest

This section explains how you can create a Puppet manifest on the Puppet Server for installing an application, such as iPerf (RPM file).

Prerequisites

Ensure the following requirements are met before you proceed:

- You have access to the application package compatible with the native IOS XR environment.
- Target application package is hosted on an accessible repository, or downloaded to a boot flash.

Configuration Procedure

To create a sample Puppet manifest to start the `bootlogd` service, and install iPerf on IOS XR, follow these steps:

1. Create a Puppet manifest on Puppet Server to install your application.

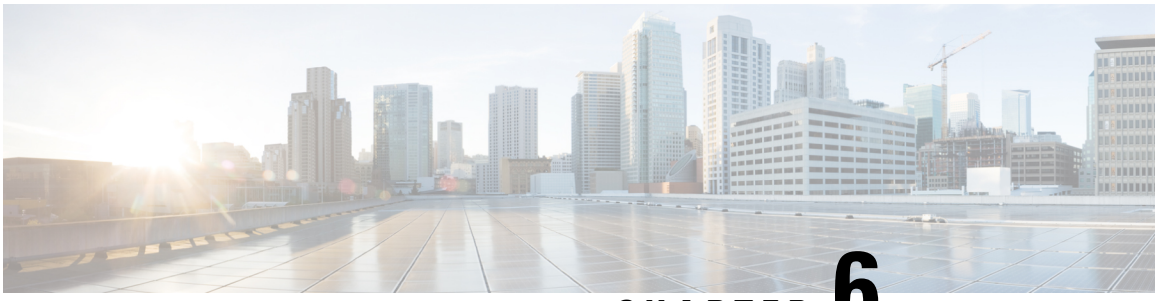
   The manifest must be created in the `/etc/puppetlabs/code/environments/production/manifests/` directory. For it to be launched automatically by Puppet Server, the manifest file must be named, `site.pp`.

```
# Manifest to demo builtin providers
#

class ciscopuppet::demo_builtin_providers {

  $package = 'iperf'
  $service = 'bootlogd'

  yumrepo { 'wrl7-repo':
    ensure => present,
    name => 'wrl7-repo',
    baseurl => 'http://10.105.247.73/wrl7_yum_repo/',
    gpgcheck => 0,
    enabled => 1,
    proxy => '_none_',
  }

  package { $package:
    ensure => present,
    require => Yumrepo['wrl7-repo'],
```

```
  }

  service { $service:
    ensure => running,
  }

}

node 'default' {
  include ciscopuppet::demo_builtin_providers
}
```

2. Access and trigger the Puppet Agent to converge the system based on the manifest defined on the Puppet Server.

The iPerf RPM is installed on IOS XR by the Puppet Agent.



CHAPTER 6

Use Cases: Application Hosting

This chapter describes use cases for running applications on IOS XR.

Running a Telemetry Receiver in a Linux Container (LXC)

For telemetry to work on Cisco IOS XR, it must use GPB (Google Protocol Buffer) over UDP, instead of TCP.

The procedure consists of the following steps:

1. Create a telemetry policy file.
2. Generate and compile a .proto file.
3. Configure the GPB encoder.
4. Launch a third-party container (LXC).
5. Configure the telemetry receiver.

Creating a Telemetry Policy File

A telemetry policy file is used to specify the kind of data to be generated and pushed to the telemetry receiver. The following steps describe how you can create the policy file for telemetry:

1. Determine the schema paths to stream data.

```
RP/0/RP0/CPU0:ios# schema-describe show interface
Wed Aug 26 02:24:40.556 PDT
RootOper.InfraStatistics.Interface(*).Latest.GenericCounters
```

2. Create a policy file that contains these paths:

```
{
"Name": "Test",
"Metadata": {
"Version": 25,
"Description": "This is a sample policy",
"Comment": "This is the first draft",
"Identifier": "<data that may be sent by the encoder to the mgmt stn"
},
"CollectionGroups": {
```

```
"FirstGroup": {
"Period": 30,
"Paths": [
"RootOper.InfraStatistics.Interface(*).Latest.GenericCounters"
   ]
  }
 }
}
```

3. Enter the XR Linux bash shell, and copy the policy file to IOS XR by using Secure Copy Protocol (SCP).

```
/* If you are using Cisco IOS XR Version 6.0.0, run the following command */
RP/0/RP0/CPU0:ios# run ip netns exec tpnns bash

/* If you are using Cisco IOS XR Version 6.0.2, run the following command */
RP/0/RP0/CPU0:ios# bash


[XR-vm_node0_RP0_CPU0:~]$ scp Test.policy cisco@10.0.0.1:/telemetry/policies
cisco@10.0.0.1's password:
Test.policy
100% 779 0.8KB/s 00:00
Connection to 10.0.0.1 closed by remote host.
```

   Where 10.0.0.1 is the IP address of the device on which you are copying the policy file.

4. Navigate to the IOS XR prompt and verify if the policy file has been successfully installed.

```
RP/0/RP0/CPU0:ios# show telemetry policies brief
Wed Aug 26 02:24:40.556 PDT
Name |Active?| Version | Description
----------------------------|-------|---------|------------------------------
Test N 1 This is a sample policy
```

Generating and Compiling a .proto File

The path in a policy file that you created needs a `.proto` file associated with it. The .proto file describes the GPB message format used to stream data. The following steps describe how you can generate and compile a .proto file for a telemetry receiver:

The `.proto` file is complied into a `.map` file. The compilation is done on a server.

1. Generate a .proto file.

```
telemetry generate gpb-encoding path
"RootOper.InfraStatistics.Interface(*).Latest.GenericCounters" file
disk0:generic_counters.proto
```

   The .proto file is generated by an on-box tool. The tool ignores naming parameters, and are hence optional.

Note The tool ignores text within quotes; therefore, the path should not contain quotes.

2. Compile the .proto file off the box.

   a. Cisco provides a telemetry compiler on Dev Hub. You can copy the directory to your Linux box, and run it, as shown here:

```
telemetry_protoc -f generic_counters.proto -o generic_counters.map
```

b. Access the copy of the .proto file from Dev Hub, and run the standard compiler on your Linux box, as shown here:

```
protoc python_out . -I=/
sw/packages/protoc/current/google/include/:.
generic_counters.proto ipv4_counters.proto
```

3. Copy the map file to IOS XR at `/telemetry/gpb/maps`.

Configuring the GPB Encoder

Configure the GPB encoder to activate the telemetry policy and stream data as outlined in the following steps:

1. Configure a loopback interface address for mapping the telemetry receiver to IOS XR, as shown here:

```
RP/0/RP0/CPU0:ios(config)# interface Loopback2
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 2.2.2.2/32
RP/0/RP0/CPU0:ios(config-if)# no shut
RP/0/RP0/CPU0:ios(config-if)# commit
Fri Oct 30 07:51:14.785 UTC
RP/0/RP0/CPU0:ios(config-if)# exit
RP/0/RP0/CPU0:ios(config)# exit
RP/0/RP0/CPU0:ios# show ipv4 interface brief
Fri Oct 30 07:51:48.996 UTC

Interface                      IP-Address      Status                Protocol
Loopback0                      1.1.1.1         Up                    Up
Loopback1                      8.8.8.8         Up                    Up
Loopback2                      2.2.2.2         Up                    Up
GigabitEthernet0/0/0/0         192.164.168.10  Up                    Up
GigabitEthernet0/0/0/1         192.57.43.10    Up                    Up
GigabitEthernet0/0/0/2         unassigned      Shutdown              Down
MgmtEth0/RP0/CPU0/0            192.168.122.197 Up                    Up
RP/0/RP0/CPU0:ios#
```

2. Configure the encoder to stream the policy to the loopback interface of IOS XR that was just configured.

```
telemetry
          encoder gpb
            policy group alpha
              policy demo
              destination ipv4 2.2.2.2 port 5555
             !
      !
   !
```

Launching a Third-Party Container (LXC)

This section describes how you can launch a third-party container (LXC) on IOS XR.

1. Log into IOS XR.

```
RP/0/RP0/CPU0:ios# run
[xr-vm_node0_RP0_CPU0:~]$
```

2. Launch the third-party container.

```
[xr-vm_node0_RP0_CPU0:~]$ virsh -c lxc+tcp://10.11.12.15:16509/ -e ^Q console demo1
```

3. Log into the container when prompted.

```
Connected to domain demo
Escape character is ^Q
```

```
Kernel 3.14.23-WR7.0.0.2_standard on an x86_64
host login: Password:
```

You have successfully launched a third-party container.

Configuring the Telemetry Receiver

A telemetry receiver listens for streamed data on the specified interface IP address and port number, and it prints the header of the received packets. If .proto files are provided, they are compiled using the protoc compiler and the message contents are also printed. By default, only the first row of each table is printed, though the `print-all` option can be used to print the complete output.

To run a telemetry receiver within the container you launched, use the following steps:

1. Download all the receiver files to the third-party container. The receiver files are available on IOS XR at https://github.com/cisco/bigmuddy-network-telemetry-collector.
2. Run the receiver to stream and print data.

   ```
   python gpb_receiver.py ipaddress 2.2.2.2 port 5555 proto
   generic_counters.proto ipv4_counters.proto
   ```

   You can see data on the telemetry receiver, as shown here:

   ```
   Waiting for message
   Got message of length:1036bytes from address:('10.1.1.1', 5555)
   Encoding:2271560481
   Policy Name:demo
   Version:25
   Identifier:<data that may be sent by the encoder to the mgmt stn>
   Start Time:Wed Jan 21 09:54:33 1970
   End Time:Wed Aug 26 09:28:37 2015
   # Tables:1
   Schema
   Path:RootOper.InfraStatistics.Interface.Latest.GenericCounters
   # Rows:6
   Row 0:
   applique:0
   availability_flag:0
   broadcast_packets_received:0
   broadcast_packets_sent:0
   bytes_received:0
   bytes_sent:0
   carrier_transitions:0
   crc_errors:0
   framing_errors_received:0
   giant_packets_received:0
   input_aborts:0
   input_drops:0
   input_errors:0
   input_ignored_packets:0
   input_overruns:0
   input_queue_drops:0
   interface_name:Null0
   last_data_time:1440606516
   last_discontinuity_time:1440498130
   multicast_packets_received:0
   multicast_packets_sent:0
   output_buffer_failures:0
   output_buffers_swapped_out:0
   output_drops:0
   output_errors:0
   output_queue_drops:0
   ```

```
output_underruns:0
packets_received:0
packets_sent:0
parity_packets_received:0
resets:0
runt_packets_received:0
seconds_since_last_clear_counters:0
seconds_since_packet_received:4294967295
seconds_since_packet_sent:4294967295
throttled_packets_received:0
unknown_protocol_packets_received:0
Waiting for message
Got message of length:510bytes from address:('2.2.2.2', 5555)
Encoding:2271560481
Policy Name:demo
Version:25
Identifier:<data that may be sent by the encoder to the mgmt stn>
Start Time:Wed Jan 21 09:54:33 1970
End Time:Wed Aug 26 09:28:38 2015
# Tables:1
Schema Path:RootOper.InfraStatistics.Interface.Latest.Protocol
# Rows:5
Row 0:
bytes_received:0
bytes_sent:0
input_data_rate:0
input_packet_rate:0
interface_name:Loopback2
last_data_time:1440606517
output_data_rate:0
output_packet_rate:0
packets_received:0
packets_sent:0
protocol:24
protocol_name:IPV4_UNICAST
```

The telemetry receiver runs successfully within the third-party container (LXC).

Use Cases on Vagrant: Container Application Hosting

This section describes how you can use vagrant to run use cases for container application hosting.

Pre-requisites for Using Vagrant

Before you can start using vagrant, ensure that you have fulfilled the following requirements on your host device.

- Latest version of Vagrant for your operating system. We recommend Version 1.8.6.
- Latest version of a virtual box for your operating system. We recommend Version 5.1+.
- Minimum of 5 GB of RAM with two cores.
- (Optional) If you are using the Windows Operating System, we recommend that you download the Git bash utility for running the commands.

OSPF Path Failover by Running iPerf with Netconf on Vagrant

This section describes a use case for solving a path remediation problem by using iPerf and Netconf applications on vagrant.

Topology

The topology used for OSPF path remediation is illustrated in the following figure.

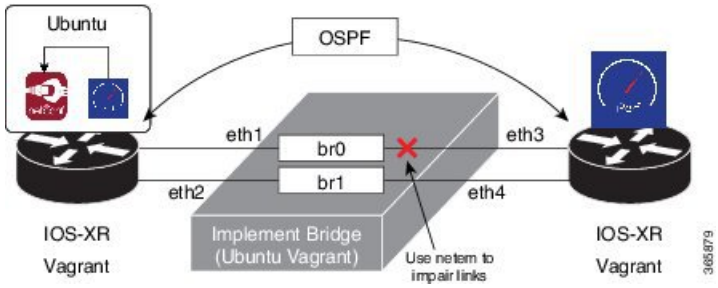
The router on the left is rtr1 and is the source of traffic. We run the pathchecker application inside an LXC on this router. Pathchecker uses an iPerf client to determine the health of the path.

The router on the right is rtr2 and is the destination for traffic. We run the pathchecker application inside an LXC on this router. Pathchecker uses an iPerf server that talks to the iPerf client on rtr1.

`devbox` serves two purposes in this topology:

- To create an LXC tar ball with pathchecker before being deployed to the routers.
- To bridge the two networks between the two routers over the parallel paths.

Figure 13: OSPF Path Failover with iPerf and Netconf on Vagrant



This example uses the following process for OSPF path failover:

1. Configure and establish OSPF neighbor relationship between two routers over two parallel paths.
2. Increase the cost of one path so that the other path is the preferred active path.
3. Use the pathchecker python application to monitor the OSPF active path by determining the bandwidth, jitter, packet loss and other parameters. Pathchecker uses the iPerf application to measure health of the active traffic path.
4. Use pathchecker to simulate network degradation by changing the OSPF active path cost during a Netconf session.

Procedure

Use the following steps to use iPerf with Netconf for OSPF path failover.

1. Generate an API key and a CCO ID by using the steps described on Github.
2. Download the latest stable version of the IOS-XRv vagrant box.

```
$ curl <cco-id>:<API-KEY>

$ BOXURL --output ~/iosxrv-fullk9-x64.box
```

```
$ vagrant box add --name IOS-XRv ~/iosxrv-fullk9-x64.box
```

3. Verify if the vagrant box has been successfully installed.

```
 AKSHSHAR-M-K0DS:~ akshshar$ vagrant box list
IOS-XRv (virtualbox, 0)
```

4. Create a working directory.

```
 AKSHSHAR-M-K0DS:~ akshshar$ mkdir ~/iosxrv
 AKSHSHAR-M-K0DS:~ akshshar$cd ~/iosxrv
```

5. Initialize the vagrant file with the new vagrant box.

```
 AKSHSHAR-M-K0DS:~ akshshar$ vagrant init IOS-XRv
A `Vagrantfile` has been placed in this directory. You are now
ready to `vagrant up` your first virtual environment! Please read
the comments in the Vagrantfile as well as documentation on
`vagrantup.com` for more information on using Vagrant.
```

6. Clone the repository containing the pathchecker code.

```
AKSHSHAR-M-K0DS:~ akshshar$ git clone https://github.com/ios-xr/pathchecker.git
Cloning into 'pathchecker'...
remote: Counting objects: 46, done.
remote: Compressing objects: 100% (28/28), done.
remote: Total 46 (delta 8), reused 0 (delta 0), pack-reused 18
Unpacking objects: 100% (46/46), done.
Checking connectivity... done.
```

7. Navigate to the `pathchecker/vagrant` directory and launch `devbox`.

```
AKSHSHAR-M-K0DS:~ akshshar$ cd pathchecker/
AKSHSHAR-M-K0DS:pathchecker akshshar$ cd vagrant/
AKSHSHAR-M-K0DS:vagrant akshshar$ pwd
/Users/akshshar/pathchecker/vagrant

AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant up devbox
Bringing machine 'devbox' up with 'virtualbox' provider...
==> devbox: Importing base box 'ubuntu/trusty64'...

---------------------------- snip output ---------------------------------

==> devbox: Running provisioner: file...
AKSHSHAR-M-K0DS:vagrant akshshar$
AKSHSHAR-M-K0DS:vagrant akshshar$
AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant status
Current machine states:


rtr1                      not created (virtualbox)
devbox                    running (virtualbox)
rtr2                      not created (virtualbox)

This environment represents multiple VMs. The VMs are all listed
above with their current state. For more information about a specific
VM, run `vagrant status NAME`.
```

8. Launch an LXC within `devbox`.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant ssh devbox

vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-create -t ubuntu --name pathchecker
Checking cache download in /var/cache/lxc/trusty/rootfs-amd64 ...
Installing packages in template: ssh,vim,language-pack-en
Downloading ubuntu trusty minimal ...
I: Retrieving Release
I: Retrieving Release.gpg
I: Checking Release signature
...
vagrant@vagrant-ubuntu-trusty-64:~$ sudo lxc-start --name pathchecker
<4>init: hostname main process (3) terminated with status 1
<4>init: plymouth-upstart-bridge main process (5) terminated with status 1
<4>init: plymouth-upstart-bridge main process ended, respawning


Ubuntu 14.04.4 LTS nc_iperf console


pathchecker login: ubuntu
Password:
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

...
```

9. Install all the required iPerf and Netconf application dependencies within the LXC.

```
ubuntu@pathchecker:~$ sudo apt-get -y install python-pip python-lxml
 python-dev libffi-dev libssl-dev iperf git

ubuntu@pathchecker:~$ sudo pip install ncclient jinja2 cryptography==1.2.1
```

10. Retrieve the iPerf and Netconf application code from Github.

```
ubuntu@pathchecker:~$ git clone https://github.com/ios-xr/pathchecker.git
Cloning into 'pathchecker'...
remote: Counting objects: 46, done.
remote: Compressing objects: 100% (28/28), done.
remote: Total 46 (delta 8), reused 0 (delta 0), pack-reused 18
Unpacking objects: 100% (46/46), done.
Checking connectivity... done.
ubuntu@pathchecker:~$
```

11. Change the SSH port inside the LXC.

When a container is deployed on XR, it shares the network namespace of XR. Since XR uses ports 22 and 57722 for internal processes, we change the port number to 58822 in this example.

```
ubuntu@pathchecker:~$ sudo sed -i s/Port\ 22/Port\ 58822/ /etc/ssh/sshd_config

ubuntu@pathchecker:~$ cat /etc/ssh/sshd_config | grep Port
Port 58822
```

12. Create the LXC tar ball.

a. Shut down the LXC.

```
ubuntu@pathchecker:~$ sudo shutdown -h now
ubuntu@pathchecker:~$
Broadcast message from ubuntu@pathchecker
 (/dev/lxc/console) at 10:24 ...

The system is going down for halt NOW!
```

b. Assume the root user role.

```
vagrant@vagrant-ubuntu-trusty-64:~$ sudo -s
root@vagrant-ubuntu-trusty-64:~# whoami
root
```

c. Navigate to the `/var/lib/lxc/pathchecker/rootfs/` directory and package the `rootfs` into a tar ball.

```
root@vagrant-ubuntu-trusty-64:~# cd /var/lib/lxc/pathchecker/rootfs/
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/pathchecker/rootfs/# tar -czvf
/vagrant/pathchecker_rootfs.tar.gz *
tar: dev/log: socket ignored
root@vagrant-ubuntu-trusty-64:/var/lib/lxc/pathchecker/rootfs/# exit
vagrant@vagrant-ubuntu-trusty-64:~$ exit
logout
Connection to 127.0.0.1 closed.

AKSHSHAR-M-K0DS:vagrant akshshar$ pwd
/Users/akshshar/pathchecker/vagrant
AKSHSHAR-M-K0DS:vagrant akshshar$ ls -l pathchecker_rootfs.tar.gz
-rw-r--r--  1 akshshar  staff  301262995 Jul 18 07:57 pathchecker_rootfs.tar.gz
AKSHSHAR-M-K0DS:vagrant akshshar$
```

13. Launch the two router topology.

a. Navigate to the `pathchecker/vagrant` directory and launch the vagrant instance.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ pwd
/Users/akshshar/pathchecker/vagrant

AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant up
Bringing machine 'rtr1' up with 'virtualbox' provider...
Bringing machine 'devbox' up with 'virtualbox' provider...
Bringing machine 'rtr2' up with 'virtualbox' provider...
```

b. Verify if the topology has been launched.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant status
Current machine states:


rtr1                      running (virtualbox)
devbox                    running (virtualbox)
rtr2                      running (virtualbox)

This environment represents multiple VMs. The VMs are all listed
above with their current state. For more information about a specific
VM, run `vagrant status NAME`.
```

14. Verify if OSPF is running on rtr1 and check the path state.

You can also see the cost of the OSPF path.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant port rtr1
The forwarded ports for the machine are listed below. Please note that
these values may differ from values configured in the Vagrantfile if the
provider supports automatic port collision detection and resolution.

 22 (guest) => 2223 (host)
 57722 (guest) => 2200 (host)
 58822 (guest) => 58822 (host)
AKSHSHAR-M-K0DS:vagrant akshshar$ ssh -p 2223 vagrant@localhost
The authenticity of host '[localhost]:2223 ([127.0.0.1]:2223)' can't be established.
RSA key fingerprint is b1:c1:5e:a5:7e:e7:c0:4f:32:ef:85:f9:3d:27:36:0f.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[localhost]:2223' (RSA) to the list of known hosts.
vagrant@localhost's password:



RP/0/RP0/CPU0:rtr1# show  running-config  router ospf
Mon Jul 18 15:25:53.875 UTC
router ospf apphost
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/0/0/0
  !
  interface GigabitEthernet0/0/0/1
    cost 20
  !
 !
!

RP/0/RP0/CPU0:rtr1# show route 2.2.2.2
Mon Jul 18 15:26:03.576 UTC

Routing entry for 2.2.2.2/32
  Known via "ospf apphost", distance 110, metric 2, type intra area
  Installed Jul 18 15:18:28.218 for 00:07:35
  Routing Descriptor Blocks
   10.1.1.20, from 2.2.2.2, via GigabitEthernet0/0/0/0
      Route metric is 2
  No advertising protos.
RP/0/RP0/CPU0:rtr1#
```

15. Start the iPerf server on `rtr2` and configure it for receiving packets from `rtr1`.

Note iPerf was launched as a native application on `rtr2` while launching the vagrant instance.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant ssh rtr2
Last login: Mon Jul 18 15:57:05 2016 from 10.0.2.2
xr-vm_node0_RP0_CPU0:~$
xr-vm_node0_RP0_CPU0:~$ iperf -s -u
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size: 64.0 MByte (default)
```

16. Launch the pathchecker application within the LXC on `rtr1`.

a. Log in to the LXC on `rtr1`.

Password for user `ubuntu` is **ubuntu**.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ ssh -p 58822 ubuntu@localhost
The authenticity of host '[localhost]:58822 ([127.0.0.1]:58822)' can't be
established.
RSA key fingerprint is 19:54:83:a9:7a:9f:0a:18:62:d1:f3:91:87:3c:e9:0b.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[localhost]:58822' (RSA) to the list of known hosts.
ubuntu@localhost's password:
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.14.23-WR7.0.0.2_standard x86_64)

 * Documentation:  https://help.ubuntu.com/
Last login: Mon Jul 18 15:19:45 2016 from 10.0.2.2
ubuntu@pathchecker:~$
```

b. Navigate to the pathchecker repository within the LXC, and check the contents of the pathchecker script.

```
ubuntu@pathchecker:~$ cd pathchecker/
ubuntu@pathchecker:~/pathchecker$ cat pc_run.sh
#!/bin/bash

./pathchecker.py --host 6.6.6.6 -u vagrant -p vagrant --port 830 -c 10 -o
apphost -a 0 -i GigabitEthernet0/0/0/0 -s 2.2.2.2  -j 4 -l 5 -f -t 10
```

`-I` represents the threshold for packet loss and has been set to 5% for this run. `-j` represents the jitter threshold that has a value of 4.

c. Start the pathchecker application by running the script.

```
ubuntu@pathchecker:~/pathchecker$ ./pc_run.sh
Error while opening state file, let's assume low cost state
Currently, on reference link GigabitEthernet0/0/0/0
Starting an iperf run.....
20160718162513,1.1.1.1,62786,2.2.2.2,5001,6,0.0-10.0,1311240,1048992
20160718162513,1.1.1.1,62786,2.2.2.2,5001,6,0.0-10.0,1312710,1048474
20160718162513,2.2.2.2,5001,1.1.1.1,62786,6,0.0-10.0,1312710,1048679,2.453,0,892,0.000,1

bw is
1025.5546875
jitter is
2.453
pkt_loss is
0.000
verdict is
False
Currently, on reference link GigabitEthernet0/0/0/0
Starting an iperf run.....
```

The pathchecker application is running on the path from `GigabitEthernet0/0/0/0` interface.

17. Open a parallel Git bash window and simulate impairment on the active path.

a. Access `devbox` through SSH.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ cd pathchecker/vagrant

AKSHSHAR-M-K0DS:vagrant akshshar$ vagrant ssh devbox
Welcome to Ubuntu 14.04.4 LTS (GNU/Linux 3.13.0-87-generic x86_64)

 ...
```

b. View the impairment script and run it on `devbox`.

```
vagrant@vagrant-ubuntu-trusty-64:~$ ls
impair_backup.sh  impair_reference.sh  stop_impair.sh

vagrant@vagrant-ubuntu-trusty-64:~$ cat impair_reference.sh
#!/bin/bash
echo "Stopping all current impairments"
sudo tc qdisc del dev eth3 root &> /dev/null
sudo tc qdisc del dev eth4 root &> /dev/null
echo "Starting packet loss on reference link"
sudo tc qdisc add dev eth3 root netem loss 7%

vagrant@vagrant-ubuntu-trusty-64:~$ ./impair_reference.sh
Stopping all current impairments
Starting packet loss on reference link
```

The script creates a packet loss of 7% on the reference link.

18. Open the first Git bash window to view the pathchecker application running on `rtr1`.

```
Currently, on reference link GigabitEthernet0/0/0/0
Starting an iperf run.....
20160718164745,1.1.1.1,60318,2.2.2.2,5001,6,0.0-10.0,1311240,1048992
20160718164745,1.1.1.1,60318,2.2.2.2,5001,6,0.0-10.0,1312710,1048516
20160718164745,2.2.2.2,5001,1.1.1.1,60318,6,0.0-573.0,1312710,18328,5.215,0,892,0.000,1

bw is
1025.5546875
jitter is
5.215
pkt_loss is
0.000
verdict is
True
Woah! iperf run reported discrepancy, increase cost of reference link !
Increasing cost of the reference link GigabitEthernet0/0/0/0
Currently, on backup link
Starting an iperf run.....
20160718164755,1.1.1.1,61649,2.2.2.2,5001,6,0.0-10.0,1311240,1048992
20160718164755,1.1.1.1,61649,2.2.2.2,5001,6,0.0-10.0,1312710,1048577
20160718164755,2.2.2.2,5001,1.1.1.1,61649,6,0.0-583.3,1312710,18002,1.627,0,893,0.000,0

bw is
1025.5546875
jitter is
1.627
pkt_loss is
0.000
verdict is
False
Currently, on backup link
Starting an iperf run.....
20160718164805,1.1.1.1,59343,2.2.2.2,5001,6,0.0-10.0,1311240,1048992
20160718164805,1.1.1.1,59343,2.2.2.2,5001,6,0.0-10.0,1312710,1048520
20160718164805,2.2.2.2,5001,1.1.1.1,59343,6,0.0-593.4,1312710,17697,2.038,0,893,0.000,0
```

Pathchecker has initiated a failover from primary to secondary link.

19. Verify if the failover was successful on `rtr1`.

```
AKSHSHAR-M-K0DS:vagrant akshshar$ ssh -p 2223 vagrant@localhost
vagrant@localhost's password:



RP/0/RP0/CPU0:rtr1# show  running-config  router ospf
Mon Jul 18 17:50:47.851 UTC
router ospf apphost
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/0/0/0
   cost 30
  !
  interface GigabitEthernet0/0/0/1
   cost 20
  !
 !
!
```

The path cost from the GigabitEthernet0/0/0/0 interface is greater than that from the GigabitEthernet0/0/0/1 interface. Hence, failover takes place to the GigabitEthernet0/0/0/1 interface for traffic from `rt1` to `rtr2`.

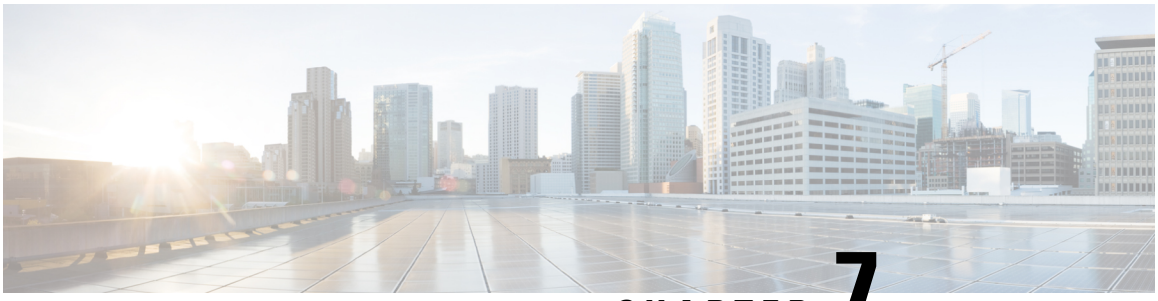
20. Verify the OSPF path failover on **`rtr1`**.

The Loopback 0 interface IP address of `rtr1` in this example is 2.2.2.2

```
RP/0/RP0/CPU0:rtr1# show route 2.2.2.2
Mon Jul 18 18:01:49.297 UTC

Routing entry for 2.2.2.2/32
  Known via "ospf apphost", distance 110, metric 21, type intra area
  Installed Jul 18 16:47:45.705 for 01:14:03
  Routing Descriptor Blocks
  11.1.1.20, from 2.2.2.2, via GigabitEthernet0/0/0/1
      Route metric is 21
  No advertising protos.
RP/0/RP0/CPU0:rtr1#
```

The next hop for `rtr1` is 11.1.1.20 through the backup reference link: GigabitEthernet0/0/0/1

You have successfully configured OSPF path failover by using iPerf and Netconf on vagrant.



CHAPTER 7

Cisco Secure DDoS Edge Protection

Table 14: Feature History Table

Feature Name	Release Information	Description
Cisco Secure DDoS Edge Protection	Release 24.3.1	You can now block malicious traffic at peering edge routers, stopping distributed denial-of-service (DDoS) attacks at the network entry point and ensuring constant service availability and reliability in your network. A centralized controller manages DDoS mitigation capabilities using information from a collection of detectors deployed on the routers. These detectors analyze IPv4 and IPv6 traffic in real-time to identify DDoS attacks. Upon detection, the controller enforces deny ACLs to block malicious traffic while allowing legitimate traffic. This local inspection enhances visibility, speeds up response times, and optimizes the network without the need for additional hardware or attack traffic redirection.

The Cisco Secure DDoS Edge Protection software actively halts DDoS attacks at the network entry point, enabling immediate response to threats. Positioned at the network edge, it identifies and counteracts DDoS threats directly on the router. This strategy minimizes network and application impact without affecting core bandwidth by avoiding backhaul of malicious traffic.

Components of Cisco Secure DDoS Edge Protection

The Cisco Secure DDoS Edge Protection consists of these components:

- A highly available centralized controller that manages a collection of detectors deployed on routers. The controller can be cloud-based or on-premises. Key functions of the controller include
  - managing the container lifecycle for detectors

- configuring and editing detector profiles and security settings
- checking detector health, displaying real-time attack forensics and threat intelligence analyses
- controlling DDoS attack mitigation at the network ingress point
- providing real-time and historical event reporting, and
- operational control and incident response.

- A collection of detectors that are deployed on edge or peering routers. The detector is a resource-efficient application container for real-time DDoS detection deployed on routers and managed by the centralized controller. It analyzes IPv4 and IPv6 traffic on each ingress interface to identify DDoS attacks as they occur.

Upon detecting a DDoS attack, the centralized controller promptly begins mitigation. The mitigation includes enforcing a deny ACL to block the attack traffic while still allowing legitimate traffic to pass through.

Benefits of Cisco Secure DDoS Edge Protection

- Stops DDoS attacks at the network ingress
- Requires no additional hardware or facilities such as power, rack space, and cooling
- Requires no changes to the architecture
- Avoids the need to overprovision network facilities such as links and routers to account for attack traffic
- Prevents backhauling of malicious traffic
- Minimizes network outages and optimizes the end-user experience, and
- Meets low-latency application requirements.

Supported Platform Variants

These line cards support Cisco Secure DDoS Edge Protection.

- A9K-16X100GE-TR
- A99-32X100GE-TR
- A9K-4HG-FLEX-TR
- A9K-4HG-FLEX-SE
- A99-4HG-FLEX-TR
- A99-4HG-FLEX-SE
- A9K-8HG-FLEX-TR
- A9K-8HG-FLEX-SE
- A9K-20HG-FLEX-TR
- A9K-20HG-FLEX-SE
- A99-32X100GE-X-TR

- A99-32X100GE-X-SE
- A99-10X400GE-X-TR, and
- A99-10X400GE-X-SE.

These fixed-port routers support Cisco Secure DDoS Edge Protection.

- ASR 9902 and
- ASR 9903.

Unsupported Platform Variants

These line cards don't support DDoS Edge Protection.

- A9K-8X100G-LB-SE
- A9K-8X100G-LB-TR
- A9K-8X100GE-SE
- A9K-8X100GE-TR
- A9K-4X100GE-SE
- A9K-4X100GE-TR
- A9K-400G-DWDM-TR
- A9K-MOD400-SE
- A9K-MOD400-TR
- A9K-MOD200-SE
- A9K-MOD200-TR
- A9K-24X10GE-1G-SE
- A9K-24X10GE-1G-TR
- A9K-48X10GE-1G-SE
- A9K-48X10GE-1G-TR
- A9-12X100GE
- A99-8X100GE-SE, and
- A99-8X100GE-TR

- Restrictions of Cisco Secure DDoS Edge Protection, on page 117
- Install and Configure DDoS Edge Protection, on page 118

Restrictions of Cisco Secure DDoS Edge Protection

- The DDoS Edge Protection supports only IPv4 and IPv6 traffic.

- The DDoS Edge Protection does not support tunnel traffic.
- The system supports only the default VRF configuration, and it applies solely to the management port. For effective communication between the Docker and the controller, you must configure the management port to operate within the default VRF exclusively. This setup guarantees that the Docker can reliably interact with the controller without any network interruptions.

Install and Configure DDoS Edge Protection

You can install the DDoS Edge Protection application through the DDoS edge protection controller.

Before you begin

- Configure the management interface to reach the DDoS controller IP address.
- Perform the base configuration of the Access Control List (ACL), NetFlow, and Secure Shell (SSH) settings.

Step 1 Download and install the DDoS Edge Protection Controller Software package from the Software Download page.

You can access the user interface when the controller installation is complete. Log in to the controller services instance to monitor, manage, and control the device.

Step 2 Configure a Loopback on the router.

Example:

```
Router(config)# interface Loopback100
Router(config-if)# ipv4 address 209.165.200.225 255.255.255.224
Router(config-if)# exit
Router(config)# interface Loopback101
Router(config-if)# ipv4 address 209.165.200.226 255.255.255.224
Router(config-if)#commit
```

Step 3 Configure an ACL on the router.

Example:

```
Router(config)# ipv4 access-list myACL
Router(config-ipv4-acl)# 1301 permit ipv4 any any
Router(config-ipv4-acl)# exit
Router(config)# ipv6 access-list myACL
Router(config-ipv6-acl)# 1301 permit ipv6 any any
Router(config-ipv6-acl)#exit
Router(config)#commit
```

For more information on implementing access lists and prefix lists, see Understanding Access-List.

If there is any DDoS attack, the controller performs the mitigation action using the ACL rule automatically.

Here is a sample configuration to deny DDoS attacker traffic using a user-defined ACL rule:

```
1 deny udp any eq 19 host 45.0.0.1 eq 0 packet-length eq 128 ttl eq 64
2 deny tcp any host 45.0.0.1 eq www match-all -established -fin -psh +syn -urg packet-length eq 60
ttl eq 64
1301 permit ipv4 any any
```

The controller sends the configuration updates to the router.

Step 4 Configure SSH on the router.

Example:

```
Router(config)#ssh server v2
Router(config)#ssh server netconf
Router(config)#netconf agent tty
Router(config-netconf-tty)#netconf-yang agent ssh
Router(config)#ssh timeout 120
Router(config)#ssh server rate-limit 600
Router(config)#ssh server session-limit 110
Router(config)#ssh server v2
Router(config)#ssh server vrf default
Router(config)#ssh server netconf vrf default
Router(config)#commit
```

Step 5 Execute the **ping** command on the router and check the router connection to the DDoS controller.

Example:

```
Router#ping 10.105.237.54
Thu Jun  1 07:16:43.654 UTC
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.105.237.54 timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/4 ms
RP/0/RP0/CPU0:Router#bash
Thu Jun  1 07:16:53.024 UTC
[Router:~]$ping 10.105.237.54
PING 10.105.237.54 (10.105.237.54) 56(84) bytes of data.
64 bytes from 10.105.237.54: icmp_seq=1 ttl=63 time=1.73 ms
64 bytes from 10.105.237.54: icmp_seq=2 ttl=63 time=1.29 ms
64 bytes from 10.105.237.54: icmp_seq=3 ttl=63 time=1.27 ms
64 bytes from 10.105.237.54: icmp_seq=4 ttl=63 time=1.75 ms
^C
--- 10.105.237.54 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 1.270/1.510/1.751/0.230 ms
[Router:~]$
```

Step 6 Enter the details of the device into the DDoS edge protection controller panel and verify that the Deployment, Container, and Configuration indicators all display green.

The controller automatically performs the following netflow configuration on the router:

```
//Configuring Monitor Map
Router(config)#flow monitor-map DetectPro_Monitor_IPV6
Router(config-fmm)# record ipv6 extended
Router(config-fmm)#exporter DetectPro_GPB
Router(config-fmm)# cache entries 1000000
Router(config-fmm)#cache entries active 1
Router(config-fmm)#cache entries inactive 1
Router(config-fmm)#cache timeout inactive 1
Router(config-fmm)#cache timeout rate-limit 1000000
Router(config-fmm)#exit
Router(config)#flow monitor-map DetectPro_Monitor_IPV4
Router(config-fmm)# record ipv4 extended
Router(config-fmm)#exporter DetectPro_GPB
Router(config-fmm)# cache entries 1000000
Router(config-fmm)#cache entries active 1
Router(config-fmm)#cache entries inactive 1
Router(config-fmm)#cache timeout inactive 1
```

```
Router(config-fmm)#cache timeout rate-limit 1000000
Router(config-fmm)#exit
//Configuring Exporter Map
Router(config)#flow exporter-map DetectPro_GPB
Router(config-fem)#version protobuf
Router(config-fem-ver)#transport udp 5005
Router(config-fem)#source TenGigE0/0/0/16
Router(config-fem)#destination 209.165.200.225
Router(config-fem)#exit
//Configuring Sampler Map
Router(config)#sampler-map DetectPro_NFv9
Router(config-sm)#random 1 out-of 100
```

For more information on installing the DDoS controller, see the Cisco Secure DDoS Edge Protection Installation guide.

For more information on the DDoS Edge Protection, see Cisco Secure DDoS Edge Protection Data Sheet.

Verify DDoS Edge Protection Application Configuration

To ensure the DDoS controller has applied the configuration to the device, check the active configuration on the router.

Step 1 Execute the **show running-config appmgr** command on the router to verify the appmgr configuration.

Example:

```
Router#show running-config appmgr
Thu Jun  1 07:33:36.741 UTC
appmgr
 application esentryd
  activate type docker source esentryd-cisco-20230431633 docker-run-opts "--env-file
/harddisk:/ENV_6478443711ac6830700d1aeb --net=host"
 !
!
```

Step 2 Execute the **show flow monitor** command on the router to check the monitor map that is automatically created.

Example:

```
Router#show flow monitor DetectPro_Monitor_IPV4 cache location 0/0/CPU0
Thu Nov 16 06:13:38.066 UTC
Cache summary for Flow Monitor DetectPro_Monitor_IPV4:
Cache size:                         1000000
Current entries:                          0
Flows added:                     2243884200
Flows not added:                          0
Ager Polls:                      2243884200
  - Active timeout                        0
  - Inactive timeout                      0
  - Immediate                             0
  - TCP FIN flag                          0
  - Emergency aged                        0
  - Counter wrap aged                     0
  - Total                        2243884200
Periodic export:
  - Counter wrap                          0
  - TCP FIN flag                          0
Flows exported                   2243884200


Matching entries:                         0
```

Example:

```
Router#show flow monitor DetectPro_Monitor_IPV6 cache location 0/0/CPU0
Thu Nov 16 06:13:43.734 UTC
Cache summary for Flow Monitor DetectPro_Monitor_IPV6:
Cache size:                         1000000
Current entries:                          0
Flows added:                          59971
Flows not added:                          0
Ager Polls:                           94437
  - Active timeout                    59971
  - Inactive timeout                      0
  - Immediate                             0
  - TCP FIN flag                          0
  - Emergency aged                        0
  - Counter wrap aged                     0
  - Total                             59971
Periodic export:
  - Counter wrap                          0
  - TCP FIN flag                          0
Flows exported                        59971


Matching entries:                         0
```

Step 3 Execute the **show flow exporter** command on the router to check the exporter map that is automatically created.

Example:

```
Router#show flow exporter DetectPro_GPB location 0/0/CPU0
Thu Nov 16 06:13:58.059 UTC
Flow Exporter: DetectPro_GPB
Export Protocol: protobuf
Flow Exporter memory usage: 5265344
Used by flow monitors: DetectPro_Monitor_IPV4
                       DetectPro_Monitor_IPV6

Status: Disabled
Transport:   UDP
Destination: 15.1.1.2        (5005) VRF default
Source:      0.0.0.0         (54482)
Flows exported:                                    0 (0 bytes)
Flows dropped:                                     0 (0 bytes)

Templates exported:                                0 (0 bytes)
Templates dropped:                                 0 (0 bytes)

Option data exported:                              0 (0 bytes)
Option data dropped:                               0 (0 bytes)

Option templates exported:                         0 (0 bytes)
Option templates dropped:                          0 (0 bytes)

Packets exported:                           20355756 (27716506821 bytes)
Packets dropped:                                   0 (0 bytes)

Total export over last interval of:
  1 hour:                                         12 pkts
                                                1879 bytes
                                                  12 flows
  1 minute:                                        0 pkts
                                                   0 bytes
                                                   0 flows
  1 second:                                        0 pkts
```

```
                                                    0 bytes
                                                    0 flows
```

Step 4 Execute the **show appmgr application-table** command on the router to check the status of docker application.

Example:

```
Router#show appmgr application-table
Thu Nov 16 06:13:58.059 UTC
Name     Type   Config State Status
-------- ------ ------------ ------------------------------------------------
esentryd Docker  Activated   Up 8 minutes
Router#
```