Application Hosting Configuration Guide for Cisco NCS 540 Series Routers

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Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

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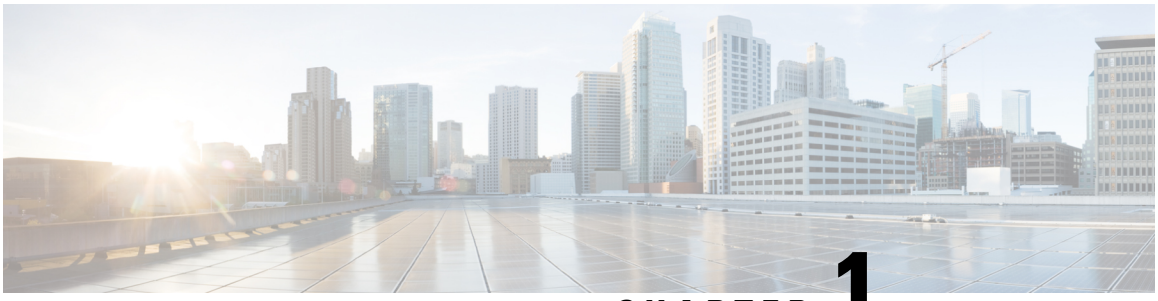


CHAPTER 1

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.

Cisco NCS 540 routers supports docker-based application hosting only.

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 NCS 540 routers support third-party off-the-shelf applications Application hosting is offered in two variants: Native and Container. 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

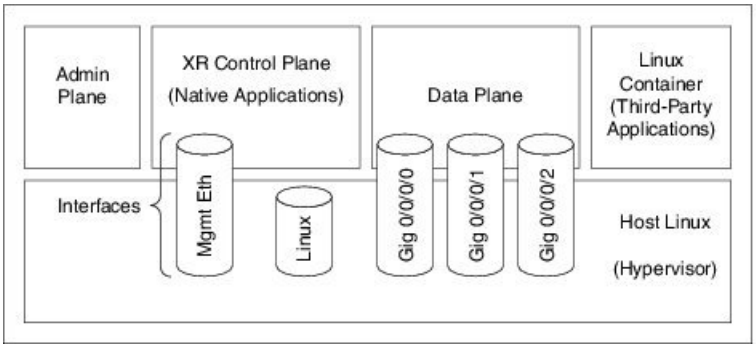
This section describes the architecture of the 64-bit IOS XR and the architecture used for application hosting.

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) is based on the Wind River Yocto distribution, and 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**: XR control plane is a containter that consists of routing information.
- **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.

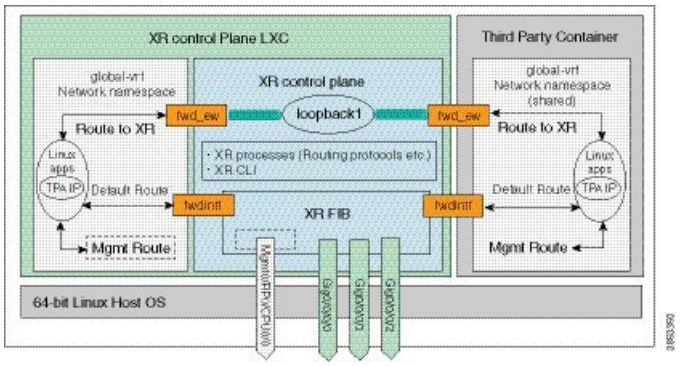
Apart from the Linux containers, several interfaces are offered on the host Linux.

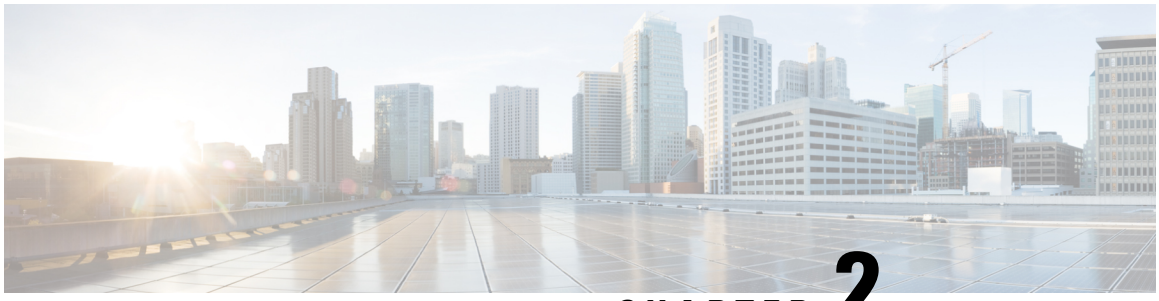
Application Hosting Architecture

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 and in the third-party.

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





CHAPTER 2

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.

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.

To have an application 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. 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.

External communication is successfully enabled on IOS XR.

East-West Communication for Third-Party Applications

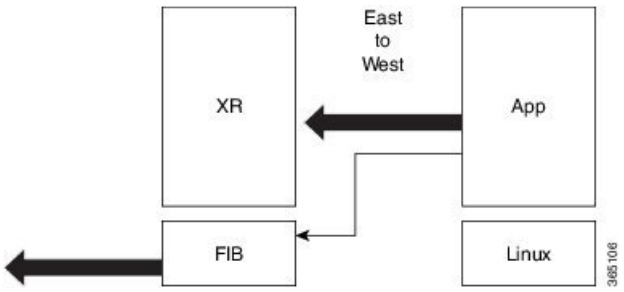
East-West communication on IOS XR is a mechanism by which applications hosted in containers interact with native XR applications (hosted in the XR control plane).

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 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.

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
```

2. Configure another Loopback interface that will be the East interface. You must configure this loopback interface to act as the TPA-facing interface, and Cisco IOS XR interacts with the TPA using this interface.

```
RP/0/RP0/CPU0:ios(config)# interface Loopback100
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 15.1.1.1/32
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
```

3. Verify the creation of the Loopback1 (West) and Loopback100 (East) interfaces.

```
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
Loopback100                    15.1.1.1        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
```

4. Configure the TPAs.

```
RP/0/RP0/CPU0:ios(config)#tpa vrf default east-west loopback 1
RP/0/RP0/CPU0:ios(config)#tpa vrf default address-family ipv4 default-route mgmt
RP/0/RP0/CPU0:ios(config)#tpa vrf default address-family ipv4 update-source dataports
loopback 100
RP/0/RP0/CPU0:ios(config)#commit
```

5. Verify that a TPA interface that sets up Loopback100 as the East interface is configured.

```
RP/0/RP0/CPU0:ios#sh run tpa
Mon Jun 7 07:22:08.324 UTC
tpa
vrf default
east-west Loopback1
address-family ipv4
default-route mgmt
update-source dataports Loopback100
!
!
!
```

6. Verify the E-W communication configuration by logging into the container and checking the routes. You can also ping the router-side East interface.

Note You can use the bash command to connect to the router and execute commands only in the testing environment.

```
RP/0/RP0/CPU0:ios#bash
Mon Jun 7 07:22:57.650 UTC
[ios:~]$ docker exec -it a0 bash
root@host:0_RP0:/# ip route
default dev fwd_ew scope link src 15.1.1.1
8.8.8.8 dev fwd_ew scope link src 15.1.1.1
192.168.104.0/24 dev Mg0_RP0_CPU0_0 scope link src 192.168.104.10
root@host:0_RP0:/# ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=255 time=0.397 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=255 time=0.535 ms
^C
--- 8.8.8.8 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 2ms
rtt min/avg/max/mdev = 0.397/0.466/0.535/0.069 ms
root@host:0_RP0:/#
```

For more information on how to launch your own containers, see Using Docker for Hosting Applications on Cisco IOS XR, on page 14.

Configuring Multiple VRFs for Application Hosting

Cisco NCS 540 routers support the configuration of multiple VRFs. The applications hosted in third-party containers can communicate with VRFs configured on XR, after east-west communication has been enabled on the VRFs.

This section describes the configuration for creating mulitple VRFs, and enabling east-west communication between the applications and the VRFs.

Configuration Procedure

Use the following steps to configure multiple VRFs for use on Cisco IOS XR.

1. Configure VRFs on XR.

```
RP/0/RP0/CPU0:ios(config)# vrf purple
RP/0/RP0/CPU0:ios(config-vrf)# address-family ipv4
RP/0/RP0/CPU0:ios(config-vrf)# address-family ipv6
RP/0/RP0/CPU0:ios(config-vrf)# exit

RP/0/RP0/CPU0:ios(config)# vrf green
RP/0/RP0/CPU0:ios(config-vrf)# address-family ipv4
RP/0/RP0/CPU0:ios(config-vrf)# address-family ipv6
RP/0/RP0/CPU0:ios(config-vrf)# exit


RP/0/RP0/CPU0:ios(config)# telnet vrf purple ipv4 server max-servers 2
RP/0/RP0/CPU0:ios(config)# telnet vrf purple ipv6 server max-servers 2
RP/0/RP0/CPU0:ios(config)# telnet vrf green ipv4 server max-servers 2
RP/0/RP0/CPU0:ios(config)# telnet vrf green ipv6 server max-servers 2
RP/0/RP0/CPU0:ios(config)# telnet ipv4 server max-servers 2
RP/0/RP0/CPU0:ios(config)# telnet ipv6 server max-servers 2
```

2. Configure the interfaces to be used with the VRFs.

```
RP/0/RP0/CPU0:ios(config)# interface loopback1
RP/0/RP0/CPU0:ios(config-if)# vrf purple
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 1.1.1.1 255.255.255.0
```

```
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 10::1/64
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface loopback2
RP/0/RP0/CPU0:ios(config-if)# vrf purple
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 2.2.2.2 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 20::1/64
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface loopback3
RP/0/RP0/CPU0:ios(config-if)#vrf green
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 3.3.3.3 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 30::1/64
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface loopback4
RP/0/RP0/CPU0:ios(config-if)# vrf green
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 4.4.4.4 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 40::1/64
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface mgmtEth 0/RP0/CPU0/0
RP/0/RP0/CPU0:ios(config-if)# vrf purple
RP/0/RP0/CPU0:ios(config-if)# ipv4 address dhcp
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface GigabitEthernet 0/0/0/0
RP/0/RP0/CPU0:ios(config-if)# vrf purple
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 10.20.30.40 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 24::1/64
RP/0/RP0/CPU0:ios(config-if)# exit

RP/0/RP0/CPU0:ios(config)# interface gigabitEthernet 0/0/0/1
RP/0/RP0/CPU0:ios(config-if)# vrf green
RP/0/RP0/CPU0:ios(config-if)# ipv4 address 40.30.20.10 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)# ipv6 address 22::1/64
RP/0/RP0/CPU0:ios(config-if)# exit
RP/0/RP0/CPU0:ios(config)# commit
Fri Sep  1 12:04:37.796 UTC
```

3. Configure TPA VRFs.

```
RP/0/RP0/CPU0:ios(config)# tpa
RP/0/RP0/CPU0:ios(config-tpa)# vrf purple
RP/0/RP0/CPU0:ios(config-tpa-vrf)# east-west loopback1
RP/0/RP0/CPU0:ios(config-tpa-vrf)# east-west loopback2
RP/0/RP0/CPU0:ios(config-tpa-vrf)# address-family ipv4
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# update-source GigabitEthernet 0/0/0/0
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# exit
RP/0/RP0/CPU0:ios(config-tpa-vrf)# address-family ipv6
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# update-source Gigabitethernet 0/0/0/0
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# exit
RP/0/RP0/CPU0:ios(config-tpa-vrf)# exit


RP/0/RP0/CPU0:ios(config-tpa)# vrf green
RP/0/RP0/CPU0:ios(config-tpa-vrf)# east-west loopback3
RP/0/RP0/CPU0:ios(config-tpa-vrf)# east-west loopback4
RP/0/RP0/CPU0:ios(config-tpa-vrf)# address-family ipv4
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# update-source GigabitEthernet 0/0/0/1
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# exit
RP/0/RP0/CPU0:ios(config-tpa-vrf)# address-family ipv6
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# update-source Gigabitethernet 0/0/0/1
RP/0/RP0/CPU0:ios(config-tpa-vrf-afi)# exit
```

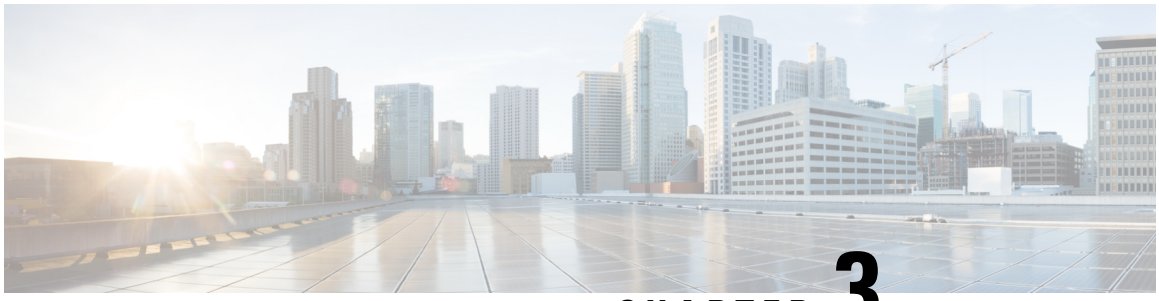
```
RP/0/RP0/CPU0:ios(config-tpa-vrf)# exit
RP/0/RP0/CPU0:ios(config-tpa)# exit
```

4. Validate the configuration.

```
RP/0/RP0/CPU0:ios(config)# show run
Fri Sep  1 12:06:35.596 UTC
...
vrf purple
address-family ipv4
address-family ipv6
vrf green
address-family ipv4
address-family ipv6

telnet vrf green ipv4 server max-servers 2
telnet vrf green ipv6 server max-servers 2
telnet vrf purple ipv4 server max-servers 2
telnet vrf purple ipv6 server max-servers 2
telnet vrf default ipv4 server max-servers 2
telnet vrf default ipv6 server max-servers 2
...
!
tpa
 vrf purple
  east-west loopback1
  east-west loopback2
  address-family ipv4
   update-source GigabitEthernet0/0/0/0
 !
  address-family ipv6
   update-source GigabitEthernet0/0/0/0
 !

 vrf green
  east-west loopback3
  east-west loopback4
  address-family ipv4
   update-source GigabitEthernet0/0/0/1
 !
  address-family ipv6
   update-source GigabitEthernet0/0/0/1
 !
!
interface loopback1
 vrf purple
 ipv4 address 1.1.1.1 255.255.255.0
 ipv6 address 10::1/64
!
interface loopback2
 vrf purple
 ipv4 address 2.2.2.2 255.255.255.0
 ipv6 address 20::1/64
!
interface loopback3
 vrf green
 ipv4 address 3.3.3.3 255.255.255.0
 ipv6 address 30::1/64
!
interface loopback4
 vrf green
 ipv4 address 4.4.4.4 255.255.255.0
 ipv6 address 40::1/64
!
interface MgmtEth0/RP0/CPU0/0
```

```
 vrf purple
 ipv4 address dhcp
!
router static
 address-family ipv4 unicast
  0.0.0.0/0 MgmtEth0/RP0/CPU0/0 10.0.2.2
 !
!
```

You have successfully configured multiple VRFs for use on Cisco IOS XR.



CHAPTER 3

Hosting Applications on IOS XR

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

Types of Application Hosting

Application hosting on IOS XR is offered in two variants:

- **Native**—You can host applications inside the container provided by IOS XR. Applications must be built with a Cisco-specified Linux distribution (Wind River Linux 7), which uses RPM as the package manager. The applications use the libraries found in the IOS XR root file system. Configuration management tools, such as Chef and Puppet, can be used to automate the installation of the application.
- **Container**—You can create your own container on IOS XR using docker, 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. Containers can be of two types:
  - LXC based
  - Docker based—Cisco NCS 540 supports only docker based application hosting.

Docker-Based 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.

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.

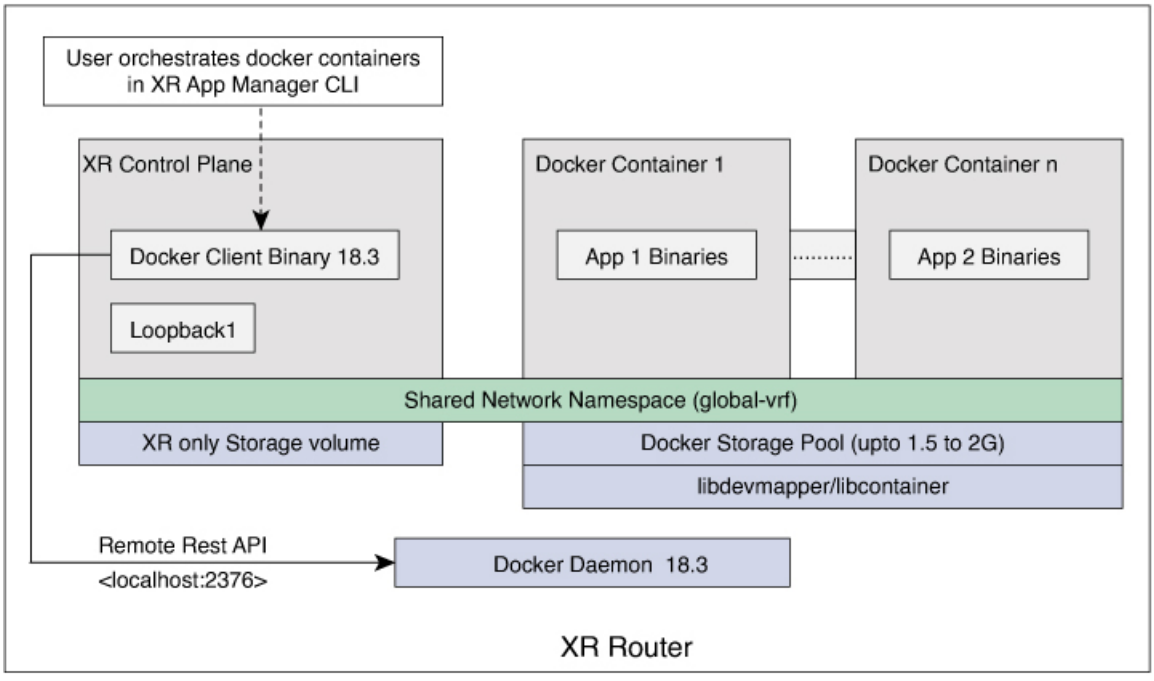
Docker follows a layered approach that consists of a base image at the bottom that supports layers of applications on top. The base images are available publicly in a repository, depending on the type of application you want to install on top. You can manipulate docker images by using the docker index 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 4: Docker Workflow for Updating Applications

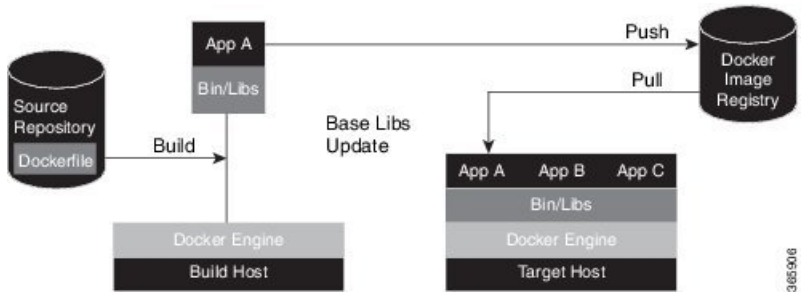


The application binaries for the applications to be hosted are installed inside the docker container.

Hosting Applications in Docker Containers

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

Figure 5: Docker Workflow for Application Hosting

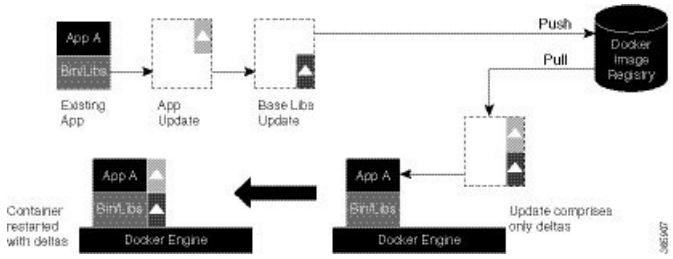


1. The docker file in the source repository is used to build the application binary file on your (docker engine build) host machine.
2. The application binary file is pushed into the docker image registry.
3. The application binary file is pulled from the docker image registry and copied to the docker 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 6: 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.

Hosting and Seamless Activation of Third Party Applications Using Application Manager

Table 1: Feature History Table

Feature Name	Release Information	Feature Description
On-Demand Docker Daemon Service	Release 7.5.1	From this release onwards, the Docker daemon service starts on a router only if you configure a third-party hosting application using the **appmgr** command. Such an on-demand service optimizes operating system resources such as CPU, memory, and power. In earlier releases, the Docker daemon service automatically started during the router boot up.

In previous releases, the applications were hosted and controlled by the Docker commands. These Docker commands were executed in the bash shell of the Kernel that also hosted the Cisco IOS XR software. With the introduction of Application Manager, it is now possible to manage third-party application hosting and their functioning through Cisco IOS XR CLIs. With this feature, all the activated third party applications can restart automatically after a router reload or an RP switchover. This automatic restart of the applications ensure seamless functioning of the hosted applications.

Supported Commands on Application Manager

For every application manager command or configuration executed, the Application Manager performs the requested action by interfacing with the Docker daemon through the Docker socket.

The following table lists the Docker container functionalities, the generic Docker commands that were used in the previous releases, and its equivalent application manager commands that can now be used:

Functionality	Generic Docker Commands	Application Manager Commands
Install the application RPM	NA	**Router#appmgr package install rpm** ***image_name-0.1.0-XR_7.3.1.x86_64.rpm***

Functionality	Generic Docker Commands	Application Manager Commands
Configure and activate the application	• Load image - **[xr-vm_node0_RP0_CPU0:~]$docker load -i /tmp/*image_name*.tar** • Verify the image on the router - **xr-vm_node0_RP0_CPU0:~]$docker images ls** • Create container over the image - **[xr-vm_node0_RP0_CPU0:~]$docker create *image_name*** • Start container - **[xr-vm_node0_RP0_CPU0:~]$docker start *my_container_id***	**Router#config** **Router(config)#appmgr** **Router(config-appmgr)#application *app_name*** **Router(config-application)#activate type docker source *image_name* docker-run-opts "--net=host" docker-run-cmd "iperf3 -s -d"** **Router(config-application)#commit**
View the list, statistics, logs, and details of the application container	• List images -**[xr-vm_node0_RP0_CPU0:~]$docker images ls** • List containers - **[xr-vm_node0_RP0_CPU0:~]$docker ps** • Statistics -**[xr-vm_node0_RP0_CPU0:~]$docker stats** • Logs -**[xr-vm_node0_RP0_CPU0:~]$docker logs**	**Router#show appmgr source-table** **Router#show appmgr application name *app_name* info summary** **Router#show appmgr application name *app_name* info detail** **Router#show appmgr application name *app_name* stats** **Router#show appmgr application-table** **Router#show appmgr application name *app_name* logs**
Run a new command inside a running container	• Execute - **[xr-vm_node0_RP0_CPU0:~]$docker exec -it *my_container_id***	**Router#appmgr application exec name *app_name* docker-exec-cmd**
Stop the application container	• Stop container - **[xr-vm_node0_RP0_CPU0:~]$docker stop *my_container_id***	**Router#appmgr application stop name *app_name***
Kill the application container	• Kill container - **[xr-vm_node0_RP0_CPU0:~]$docker kill *my_container_id***	**Router#appmgr application kill name *app_name***
Start the application container	• Start container - **[xr-vm_node0_RP0_CPU0:~]$docker start *my_container_id***	**Router#appmgr application start name *app_name***

Functionality	Generic Docker Commands	Application Manager Commands
Deactivate the application	• Stop container - **[xr-vm_node0_RP0_CPU0:~]$docker stop *my_container_id*** • Remove container - **[xr-vm_node0_RP0_CPU0:~]$docker rm *my_container_id*** • Remove image - **[xr-vm_node0_RP0_CPU0:~]$docker rmi *image_name***	**Router#configure** **Router(config)#no appmgr application *app_name*** **Router(config)#commit**
Uninstall the application image/RPM	• Uninstall image - **[xr-vm_node0_RP0_CPU0:~]$docker app uninstall *image_name***	**Router#appmgr package uninstall package *image_name-0.1.0-XR_7.3.1.x86_64***

Note The usage of the application manager commands are explained in the "Hosting iPerf in Docker Containers to Monitor Network Performance using Application Manager" section.

Configuring a Docker with Multiple VRFs

This section describes how you can configure a Docker with multiple VRFs on Cisco IOS XR. For information on configuring multiple VRFs, see Configuring Multiple VRFs for Application Hosting, on page 8.

Configuration

Use the following steps to create and deploy a multi-VRF Docker on XR.

1. Create a multi-VRF Docker with NET_ADMIN and SYS_ADMIN privileges.

   The priviliges are required for Docker to switch namespaces and provide the Docker with all required capabilities. In the following example a Docker containing three VRFs: yellow, blue, and green is loaded on XR.

```
[XR-vm_node0_RP0_CPU0:~]$ docker run -td --net=host --name multivrfcontainer1
-v /var/run/netns/yellow:/var/run/netns/yellow
-v /var/run/netns/blue:/var/run/netns/blue
-v /var/run/netns/green:/var/run/netns/green
--cap-add NET_ADMIN --cap-add SYS_ADMIN ubuntu /bin/bash
```

Note

- Mounting the entire content of `/var/run/netns` from host to Docker is not recommended, because it mounts the content of `netns` corresponding to XR, the system admin plane, and a third-party Linux container(LXC) into the Docker.
- You should not delete a VRF from Cisco IOS XR when it is used in a Docker. If one or more VRFs are deleted from XR, the multi-VRF Docker cannot be launched.

2. Verify if the multi-VRF Docker has been successfully loaded.

```
[XR-vm_node0_RP0_CPU0:~]$ Docker ps
CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS
NAMES
29c64bf812f9 ubuntu "/bin/bash" 6 seconds ago Up 4 seconds
multivrfcontainer1
```

3. Run the multi-VRF Docker.

```
[XR-vm_node0_RP0_CPU0:~]$ Docker exec -it multivrfcontainer1 /bin/bash
```

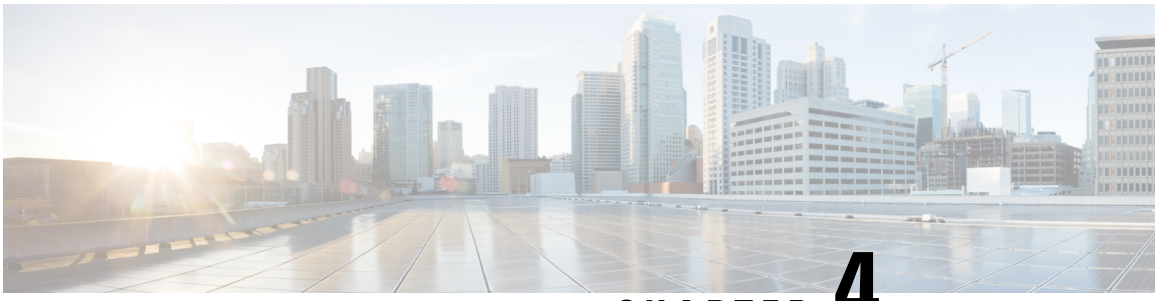
By default, the Docker is loaded in global-vrf namespace on Cisco IOS XR.

4. Verify if the multiple VRFs are accessible from the Docker.

```
root@host:/# ifconfig
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)

root@host:/# ip netns list
yellow
green
blue

root@host:/# /sbin/ip netns exec green bash
root@host:/# ifconfig -a
lo        Link encap:Local Loopback
          LOOPBACK  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)

root@host:/# ifconfig lo up
root@host:/# ifconfig lo 127.0.0.2/32
root@host:/# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.2  Mask:0.0.0.0
          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)


[host:/misc/app_host]$ ip netns exec green bash
[host:/misc/app_host]$ ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.2  Mask:0.0.0.0
          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)
```

You have successfully launched a multi-VRF Docker on Cisco IOS XR.



CHAPTER 4

Use Cases: Application Hosting

This chapter describes use cases for running applications on IOS XR.

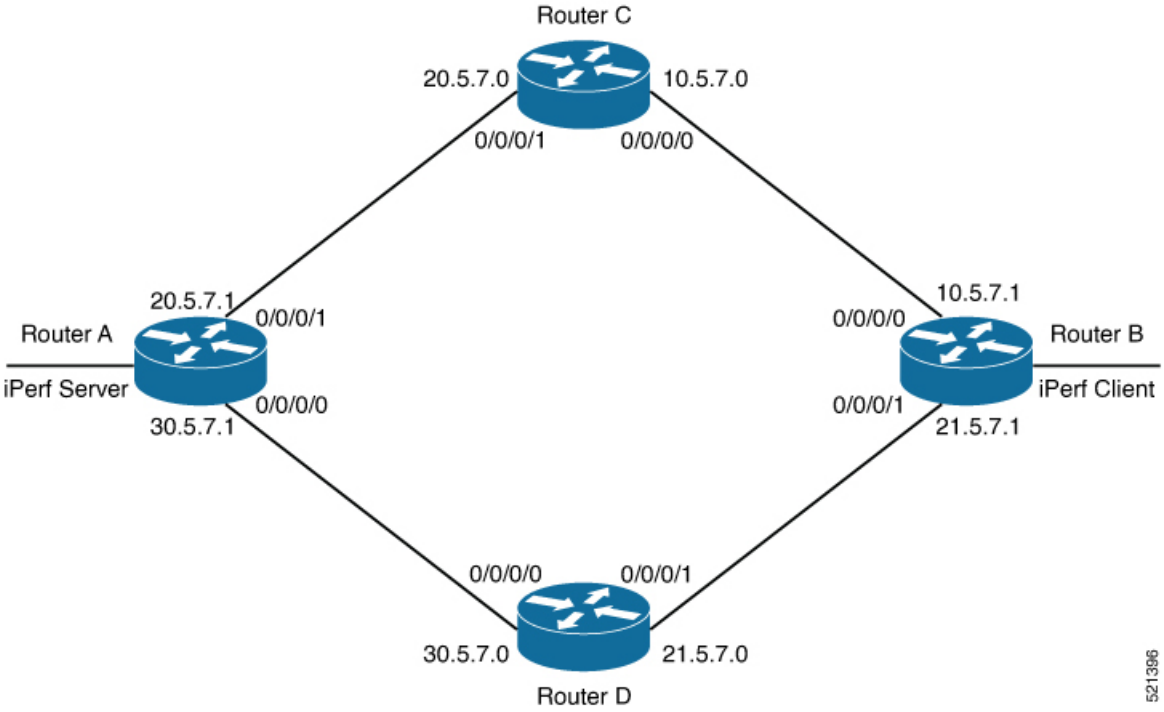
Hosting iPerf in Docker Containers to Measure Network Performance using Application Manager

Measuring the network performance is important to test the efficiency of the network. Network throughput, bandwidth, latency, and packet loss are some of the parameters used to measure the network performance. iPerf is a commonly used application for measuring network performance. The iPerf application is hosted on systems at both ends of the connection that is measured. One system is used as the server, and the other system is used as the client. At least one system must be a Cisco IOS XR router, the other system can be any other external entity like a controller or another router.

This use case illustrates the procedure for hosting the iPerf application in docker containers on two Cisco IOS XR routers, Router A and Router B to measure network performance. Router A hosts the iPerf server and Router B hosts the iPerf client.

In this usecase, we demonstrate the example of testing network bandwidth when a route update takes place. Router A hosts the iPerf Server and Router B hosts the iPerf Client. Router C and Router D are intermediate routers that allow traffic flow from Router A to Router B and vice-versa.

Figure 7: Hosting iPerf Application in Cisco IOS XR Routers



Verify Connection between Router A and Router B

The **ping** command verifies the connection between the IOS XR software on the routers, while the **bash ping** command verifies the connection between the linux kernel that hosts the IOS XR software on the routers.

Check the connection between Router A and Router B using the **ping** and **bash ping** commands.

```
Router#show ip route 30.5.7.1
Tue Dec  1 19:27:28.623 UTC

Routing entry for 30.5.7.0/31
  Known via "ospf 10", distance 110, metric 2, type intra area
  Installed Dec  1 18:09:44.525 for 01:17:44
  Routing Descriptor Blocks
    21.5.7.0, from 100.0.0.7, via FourHundredGigE0/0/0/1
      Route metric is 2
  No advertising protos.
Router#ping 30.5.7.1
Tue Dec  1 19:27:28.769 UTC
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 30.5.7.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/24/30 ms
Router#bash ping -c 5 30.5.7.1
PING 30.5.7.1 (30.5.7.1) 56(84) bytes of data.
64 bytes from 30.5.7.1: icmp_seq=1 ttl=254 time=31.9 ms
64 bytes from 30.5.7.1: icmp_seq=2 ttl=254 time=37.7 ms
64 bytes from 30.5.7.1: icmp_seq=3 ttl=254 time=30.5 ms
64 bytes from 30.5.7.1: icmp_seq=4 ttl=254 time=27.5 ms
```

```
64 bytes from 30.5.7.1: icmp_seq=5 ttl=254 time=30.3 ms

--- 30.5.7.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4004ms
rtt min/avg/max/mdev = 27.549/31.621/37.719/3.371 ms
```

Install the iPerf Server Application

Step 1 Install the iPerf application RPM on Router A. Only the RPM file format is supported.

```
Router#appmgr package install rpm /misc/disk1/iperf-0.1.0-XR_7.3.1.x86_64.rpm

Router#show appmgr source-table
Thu Dec  3 09:57:40.808 UTC
Name            File
--------------- ------------------------------------------------------------------
iperf    iperf.tar.gz
Router#
```

Step 2 Configure the application to run as iPerf server.

```
Router#config
Thu Dec  3 09:57:54.034 UTC
Router(config)#appmgr
Router(config-appmgr)#application iperf-server-app
Router(config-application)#activate type docker source iperf docker-run-opts "--net=host" docker-run-cmd
 "iperf3 -s -d"
Router(config-application)#commit
Thu Dec  3 09:57:54.398 UTC
```

Step 3 Verify the basic details (application name and state) about the activated iPerf server application.

```
Router#show appmgr application-table
Name                 Type    Config State  Status
--------             ------- ------------- -------------------------
iperf-server-app     Docker    Activated   Up 2 seconds
Router#
Thu Dec  3 09:57:54.398 UTC
Router#show appmgr application name iperf-server-app info summary
Thu Dec  3 09:58:15.569 UTC
Application: iperf-server-app
    Type: Docker
    Source: iperf
    Config State: Activated
    Container ID: 0118f9006cde2787e9809eb7c62ad8b552925b559a689c7aaa80f80d7ce43c02
    Image: alpine1:latest
    Command: "iperf3 -s -d"
    Status: Up 7 seconds
Thu Dec  3 09:57:54.398 UTC
Router#show appmgr application name iperf-server-app info detail
Thu Dec  3 09:58:26.401 UTC
Application: iperf-server-app
    Type: Docker
    Source: iperf
    Config State: Activated
    Docker Information:
        Container ID: 0118f9006cde2787e9809eb7c62ad8b552925b559a689c7aaa80f80d7ce43c02
        Container name: iperf-server-app
        Labels:
```

```
        Image: alpine1:latest
        Command: "iperf3 -s -d"
        Created at: 2020-12-03 09:58:08 +0000 UTC
        Running for: 18 seconds ago
        Status: Up 18 seconds
        Size: 0B
        Ports:
        Mounts:
        Networks: host
        LocalVolumes: 0
Router#show appmgr application name iperf-server-app stats
Thu Dec  3 09:58:39.594 UTC
Application Stats: iperf-server-app
   CPU Percentage: 0.00%
   Memory Usage: 624KiB / 31.23GiB
   Memory Percentage: 0.00%
   Network IO: 0B / 0B
   Block IO: 0B / 0B
   PIDs: 1
Router#
```

Step 4 Verify if the iPerf server is listening on the default port (5201) by using the netstat command inside the container.

The appmgr application exec name *app_name* docker-exec-cmd command can be used to execute any commands inside the container.

```
Router#appmgr application exec name iperf-server-app docker-exec-cmd name netstat -lnput
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 127.0.0.11:46727        0.0.0.0:*               LISTEN      -
tcp        0      0 0.0.0.0:5201            0.0.0.0:*               LISTEN      -
udp        0      0 127.0.0.11:39552        0.0.0.0:*
Router#
```

Install the iPerf Client Application

Step 1 Install the iPerf application RPM on Router B.

```
Router#appmgr package install rpm /misc/disk1/iperf-0.1.0-XR_7.3.1.x86_64.rpm
Router#show appmgr source-table
Thu Dec  3 09:57:40.808 UTC
Name            File
--------------- ------------------------------------------------------------------
iperf      iperf.tar.gz
Router#
```

Step 2 Configure the application to run as iPerf client with a timeout (600s in this case).

```
Router#config
Thu Dec  3 09:57:54.034 UTC
Router(config)#appmgr
Router(config-appmgr)#application iperf-client-app
Router(config-application)#activate type docker source iperf docker-run-opts "--net=host" docker-run-cmd
 "iperf3 -c 30.5.7.1 -t 600"
Router(config-application)#commit
Thu Dec  3 09:57:54.398 UTC
```

Note Hosting the iPerf client application on Router B by providing the iPerf server physical interface IP address (30.5.7.1) establishes communication between Router B and Router A.

Step 3 Verify the basic details (application name and state) about the activated iPerf client application.

```
Router#show appmgr application-table
Thu Dec  3 09:59:47.628 UTC
Name                 Type    Config State  Status
--------             ------- ------------ ------------------------
iperf-client-app     Docker    Activated   Up 2 seconds
Router#
Thu Dec  3 09:57:54.398 UTC
Router#show appmgr application name iperf-client-app info summary
Thu Dec  3 09:59:54.534 UTC
Application: iperf-client-app
    Type: Docker
    Source: iperf
    Config State: Activated
    Container ID: 40e1730a97666b2b44c8c9313b94b0138925c9198ae63244ff3bd386132d9c9c
    Image: alpine1:latest
    Command: "iperf3 -c 30.5.7.1 -t 600"
    Status: Up 9 seconds
Router#show appmgr application name iperf-client-app info detail
Application: iperf-client-app
    Type: Docker
    Source: iperf
    Config State: Activated
    Docker Information:
        Container ID: 40e1730a97666b2b44c8c9313b94b0138925c9198ae63244ff3bd386132d9c9c
        Container name: iperf-client-app
        Labels:
        Image: alpine1:latest
        Command: "iperf3 -c 30.5.7.1 -t 600"
        Created at: 2020-12-03 09:59:45 +0000 UTC
        Running for: 20 seconds ago
        Status: Up 20 seconds
        Size: 0B
        Ports:
        Mounts:
        Networks: host
        LocalVolumes: 0
Router#show appmgr application name iperf-client-app stats
Thu Dec  3 10:00:18.079 UTC
Application Stats: iperf-client-app
   CPU Percentage: 0.11%
   Memory Usage: 720KiB / 31.23GiB
   Memory Percentage: 0.00%
   Network IO: 0B / 0B
   Block IO: 0B / 0B
   PIDs: 1
Router#
```

Verify Connection between the iPerf Server and iPerf Client Applications

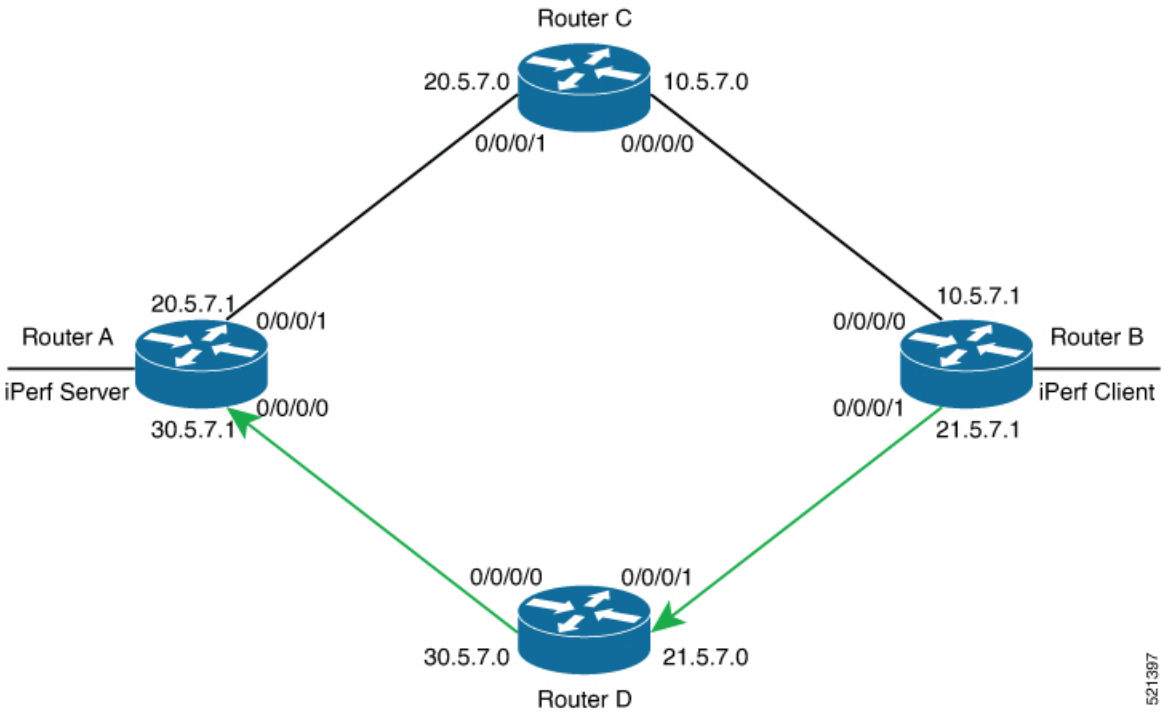
Verify whether the connection is established between iPerf server and iPerf clients by executing the **bash netstat -anput** command on Router A. When the iPerf client is up and running, the entry in the **State** field displays "ESTABLISHED".

```
Router#bash netstat -anput
Thu Dec  3 10:00:33.535 UTC
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
```

```
tcp        0      0 0.0.0.0:646             0.0.0.0:*               LISTEN      8585/mpls_ldp
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      8567/ssh_server
tcp        0      0 0.0.0.0:830             0.0.0.0:*               LISTEN      8567/ssh_server
tcp6       0      0 :::5201                 :::*                    LISTEN      20829/iperf3
tcp6       0      0 :::22                   :::*                    LISTEN      8567/ssh_server
tcp6       0      0 :::830                  :::*                    LISTEN      8567/ssh_server
tcp6       0      0 30.5.7.1:5201           100.0.0.9:65322         ESTABLISHED 20829/iperf3
tcp6       0      0 30.5.7.1:5201           100.0.0.9:65302         ESTABLISHED 20829/iperf3
udp        0      0 0.0.0.0:646             0.0.0.0:*                           8585/mpls_ldp
udp        0      0 0.0.0.0:3232            0.0.0.0:*                           6833/pim
udp        0      0 0.0.0.0:3503            0.0.0.0:*                           10762/lspv_server
udp        0      0 0.0.0.0:68              0.0.0.0:*                           10704/xr_dhcpcd
udp        0      0 0.0.0.0:496             0.0.0.0:*                           6833/pim
udp6       0      0 :::3503                 :::*                                10762/lspv_server
```

Measure Network Performance

Step 1 Verify the traffic route from Router B to Router A using the **show ip route** command, on Router B.




```
Router#show ip route 30.5.7.1
Thu Dec  3 10:08:01.859 UTC

Routing entry for 30.5.7.0/31
  Known via "ospf 10", distance 110, metric 2, type intra area
  Installed Dec  3 04:49:22.281 for 05:18:39
  Routing Descriptor Blocks
    21.5.7.0, from 100.0.0.7, via FourHundredGigE0/0/0/1
      Route metric is 2
  No advertising protos.
Router#
```

Step 2 Check the network performance between iPerf client and iPerf server (on Router B and Router A).

You can view the network monitoring parameters by executing the **show appmgr application name iperf-client-app logs** command, on Router B that hosts the iPerf client.

```
Router#show appmgr application name iperf-client-app logs
Tue Dec 1 12:50:27.862 UTC
Connecting to host 30.5.7.1, port 5201
[ 4] local 100.0.0.9 port 61384 connected to 30.5.7.1 port 5201
[ ID] Interval         Transfer     Bandwidth Retr     Cwnd
[ 4] 0.00-1.00 sec 1.05 MBytes     8.82 Mbits/sec 0     80.6 KBytes
[ 4] 1.00-2.00 sec 1.26 MBytes     10.6 Mbits/sec 0     136 KBytes
[ 4] 2.00-3.00 sec 1.18 MBytes     9.90 Mbits/sec 0     191 KBytes
[ 4] 3.00-4.00 sec 1.24 MBytes     10.4 Mbits/sec 0     246 KBytes
[ 4] 4.00-5.00 sec 1.18 MBytes     9.90 Mbits/sec 0     301 KBytes
[ 4] 5.00-6.00 sec 1.37 MBytes     11.5 Mbits/sec 0     362 KBytes
[ 4] 6.00-7.00 sec 1.37 MBytes     11.5 Mbits/sec 0     423 KBytes
[ 4] 7.00-8.00 sec 1.43 MBytes     12.0 Mbits/sec 0     486 KBytes
[ 4] 8.00-9.00 sec 1.30 MBytes     11.0 Mbits/sec 0     547 KBytes
[ 4] 9.00-10.00 sec 1.43 MBytes     12.0 Mbits/sec 0    611 KBytes
[ 4] 10.00-11.00 sec 1.62 MBytes     13.6 Mbits/sec 0   707 KBytes
[ 4] 11.00-12.00 sec 1.62 MBytes     13.6 Mbits/sec 0    875 KBytes
[ 4] 12.00-13.00 sec 1.93 MBytes     16.2 Mbits/sec 0    1.07 MBytes
[ 4] 13.00-14.00 sec 1.68 MBytes     14.1 Mbits/sec 0    1.29 MBytes
[ 4] 14.00-15.00 sec 1.06 MBytes     8.86 Mbits/sec 0    1.56 MBytes
[ 4] 15.00-16.00 sec 891 KBytes     7.30 Mbits/sec 0     1.83 MBytes
[ 4] 16.00-17.00 sec 970 KBytes     7.95 Mbits/sec 0     2.12 MBytes
[ 4] 17.00-18.00 sec 1.24 MBytes     10.4 Mbits/sec 0    2.58 MBytes
[ 4] 18.00-19.00 sec 885 KBytes     7.24 Mbits/sec 0     2.65 MBytes
[ 4] 19.00-20.00 sec 1.55 MBytes     13.0 Mbits/sec 0    3.10 MBytes
[ 4] 20.00-21.00 sec 820 KBytes     6.71 Mbits/sec 0     3.10 MBytes
[ 4] 21.00-22.00 sec 1.72 MBytes     14.4 Mbits/sec 6     2.42 MBytes
[ 4] 22.00-23.00 sec 0.00 Bytes     0.00 bits/sec 5       2.30 MBytes
[ 4] 23.00-24.00 sec 256 KBytes     2.10 Mbits/sec 0     1.35 MBytes
[ 4] 24.00-25.00 sec 1.56 MBytes     13.1 Mbits/sec 237   1.83 MBytes
[ 4] 25.00-26.00 sec 1.90 MBytes     15.9 Mbits/sec 0     2.17 MBytes
[ 4] 26.00-27.00 sec 382 KBytes     3.12 Mbits/sec 61     1.95 MBytes
[ 4] 27.00-28.00 sec 0.00 Bytes     0.00 bits/sec 0     1.39 MBytes
[ 4] 28.00-29.00 sec 3.35 MBytes     28.1 Mbits/sec 0     1.52 MBytes
[ 4] 29.00-30.00 sec 954 KBytes     7.82 Mbits/sec 0     1.58 MBytes
[ 4] 30.00-31.00 sec 1018 KBytes     8.34 Mbits/sec 0     1.64 MBytes
[ 4] 31.00-32.00 sec 1.24 MBytes     10.4 Mbits/sec 0     1.71 MBytes
[ 4] 32.00-33.00 sec 1.25 MBytes     10.5 Mbits/sec 0     1.76 MBytes
[ 4] 33.00-34.00 sec 1.61 MBytes     13.5 Mbits/sec 0     1.80 MBytes
[ 4] 34.00-35.00 sec 1.46 MBytes     12.2 Mbits/sec 0     1.82 MBytes
[ 4] 35.00-36.00 sec 1.18 MBytes     9.89 Mbits/sec 0     1.83 MBytes
[ 4] 36.00-37.00 sec 1.36 MBytes     11.4 Mbits/sec 0     1.84 MBytes
[ 4] 37.00-38.00 sec 1.36 MBytes     11.4 Mbits/sec 0     1.84 MBytes
[ 4] 38.00-39.00 sec 1.24 MBytes     10.4 Mbits/sec 0     1.84 MBytes
[ 4] 39.00-40.00 sec 1.25 MBytes     10.5 Mbits/sec 0     1.85 MBytes
[ 4] 40.00-41.00 sec 1.25 MBytes     10.5 Mbits/sec 0     1.86 MBytes
[ 4] 41.00-42.00 sec 1.40 MBytes     11.8 Mbits/sec 0     1.88 MBytes
[ 4] 42.00-43.00 sec 1.12 MBytes     9.37 Mbits/sec 0     1.91 MBytes
[ 4] 43.00-44.00 sec 1.12 MBytes     9.40 Mbits/sec 0     1.96 MBytes
[ 4] 44.00-45.00 sec 1.20 MBytes     10.1 Mbits/sec 0     2.02 MBytes
[ 4] 45.00-46.00 sec 1.27 MBytes     10.7 Mbits/sec 0     2.11 MBytes
[ 4] 46.00-47.00 sec 1.30 MBytes     10.9 Mbits/sec 0     2.22 MBytes
[ 4] 47.00-48.00 sec 1.25 MBytes     10.5 Mbits/sec 0     2.36 MBytes
[ 4] 48.00-49.00 sec 1.43 MBytes     12.0 Mbits/sec 0     2.53 MBytes
```

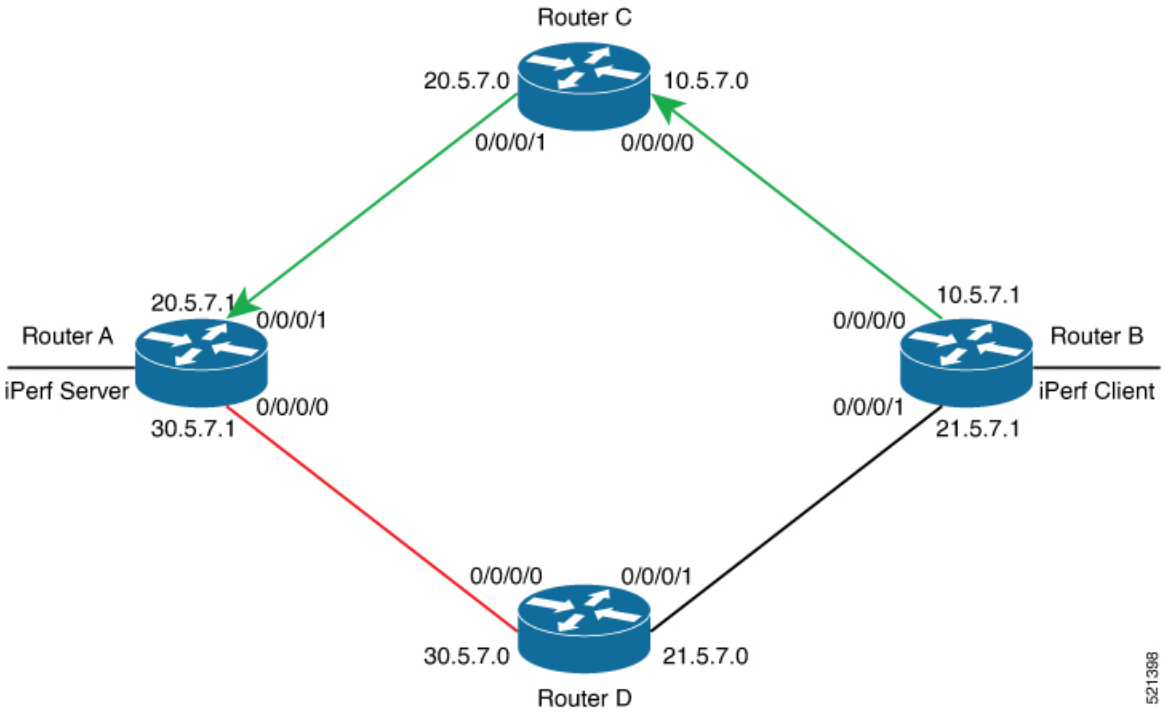
Step 3 Bring down the interface on Router D using the **shut** command to trigger a route update.

```
Router(config)#interface FourhundredGig0/0/0/0
Router(config-if)#shut
Router(config-if)#commit
```

Note Because of the interface shutdown, the route to 30.5.7.1 needs to be updated and hence momentarily there will be no route to this address.

Step 4 During the route update, check the network performance by executing the **show appmgr application name** *app_name* **logs** command.

You will notice that the entries in the **Bandwidth** field is Zero for a short duration, when the new route is installed.




```
Router#show appmgr application name iperf-client-app logs
Tue Dec 1 12:59:40.349 UTC
Connecting to host 30.5.7.1, port 5201
[ 4] local 100.0.0.9 port 61384 connected to 30.5.7.1 port 5201
15
[ ID] Interval         Transfer Bandwidth     Retr     Cwnd
[ 4] 0.00-1.00 sec 1.05 MBytes 8.82 Mbits/sec 0     80.6 KBytes
[ 4] 1.00-2.00 sec 1.26 MBytes 10.6 Mbits/sec 0     136 KBytes
[ 4] 2.00-3.00 sec 1.18 MBytes 9.90 Mbits/sec 0     191 KBytes
[ 4] 3.00-4.00 sec 1.24 MBytes 10.4 Mbits/sec 0     246 KBytes
[ 4] 4.00-5.00 sec 1.18 MBytes 9.90 Mbits/sec 0     301 KBytes
[ 4] 5.00-6.00 sec 1.37 MBytes 11.5 Mbits/sec 0     362 KBytes
[ 4] 6.00-7.00 sec 1.37 MBytes 11.5 Mbits/sec 0     423 KBytes
[ 4] 7.00-8.00 sec 1.43 MBytes 12.0 Mbits/sec 0     486 KBytes
[ 4] 8.00-9.00 sec 1.30 MBytes 11.0 Mbits/sec 0     547 KBytes
[ 4] 9.00-10.00 sec 1.43 MBytes 12.0 Mbits/sec 0     611 KBytes
[ 4] 10.00-11.00 sec 1.62 MBytes 13.6 Mbits/sec 0     707 KBytes
[ 4] 11.00-12.00 sec 1.62 MBytes 13.6 Mbits/sec 0     875 KBytes
[ 4] 12.00-13.00 sec 1.93 MBytes 16.2 Mbits/sec 0     1.07 MBytes
[ 4] 13.00-14.00 sec 1.68 MBytes 14.1 Mbits/sec 0     1.29 MBytes
[ 4] 14.00-15.00 sec 1.06 MBytes 8.86 Mbits/sec 0     1.56 MBytes
[ 4] 15.00-16.00 sec 891 KBytes 7.30 Mbits/sec 0     1.83 MBytes
[ 4] 16.00-17.00 sec 970 KBytes 7.95 Mbits/sec 0     2.12 MBytes
```

```
[ 4] 17.00-18.00 sec 1.24 MBytes 10.4 Mbits/sec 0     2.58 MBytes
[ 4] 18.00-19.00 sec 885 KBytes 7.24 Mbits/sec 0     2.65 MBytes
[ 4] 19.00-20.00 sec 1.55 MBytes 13.0 Mbits/sec 0     3.10 MBytes
[ 4] 20.00-21.00 sec 820 KBytes 6.71 Mbits/sec 0     3.10 MBytes
[ 4] 21.00-22.00 sec 1.72 MBytes 14.4 Mbits/sec 6     2.42 MBytes
[ 4] 22.00-23.00 sec 0.00 Bytes 0.00 bits/sec 5     2.30 MBytes
[ 4] 23.00-24.00 sec 256 KBytes 2.10 Mbits/sec 0     1.35 MBytes
[ 4] 24.00-25.00 sec 1.56 MBytes 13.1 Mbits/sec 237     1.83 MBytes
[ 4] 25.00-26.00 sec 1.90 MBytes 15.9 Mbits/sec 0     2.17 MBytes
[ 4] 26.00-27.00 sec 382 KBytes 3.12 Mbits/sec 61     1.95 MBytes
[ 4] 27.00-28.00 sec 0.00 Bytes 0.00 bits/sec 0     1.39 MBytes
[ 4] 28.00-29.00 sec 3.35 MBytes 28.1 Mbits/sec 0     1.52 MBytes
[ 4] 29.00-30.00 sec 954 KBytes 7.82 Mbits/sec 0     1.58 MBytes
[ 4] 30.00-31.00 sec 1018 KBytes 8.34 Mbits/sec 0     1.64 MBytes
[ 4] 31.00-32.00 sec 1.24 MBytes 10.4 Mbits/sec 0     1.71 MBytes
[ 4] 32.00-33.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.76 MBytes
[ 4] 33.00-34.00 sec 1.61 MBytes 13.5 Mbits/sec 0     1.80 MBytes
[ 4] 34.00-35.00 sec 1.46 MBytes 12.2 Mbits/sec 0     1.82 MBytes
[ 4] 35.00-36.00 sec 1.18 MBytes 9.89 Mbits/sec 0     1.83 MBytes
[ 4] 36.00-37.00 sec 1.36 MBytes 11.4 Mbits/sec 0     1.84 MBytes
[ 4] 37.00-38.00 sec 1.36 MBytes 11.4 Mbits/sec 0     1.84 MBytes
[ 4] 38.00-39.00 sec 1.24 MBytes 10.4 Mbits/sec 0     1.84 MBytes
[ 4] 39.00-40.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.85 MBytes
[ 4] 40.00-41.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.86 MBytes
[ 4] 41.00-42.00 sec 1.40 MBytes 11.8 Mbits/sec 0     1.88 MBytes
[ 4] 42.00-43.00 sec 1.12 MBytes 9.37 Mbits/sec 0     1.91 MBytes
[ 4] 43.00-44.00 sec 1.12 MBytes 9.40 Mbits/sec 0     1.96 MBytes
[ 4] 44.00-45.00 sec 1.20 MBytes 10.1 Mbits/sec 0     2.02 MBytes
[ 4] 45.00-46.00 sec 1.27 MBytes 10.7 Mbits/sec 0     2.11 MBytes
[ 4] 46.00-47.00 sec 1.30 MBytes 10.9 Mbits/sec 0     2.22 MBytes
[ 4] 95.00-96.00 sec 1.48 MBytes 12.4 Mbits/sec 0     1.82 MBytes
[ 4] 96.00-97.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.83 MBytes
[ 4] 97.00-98.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.83 MBytes
[ 4] 98.00-99.00 sec 1.49 MBytes 12.5 Mbits/sec 0     1.84 MBytes
[ 4] 99.00-100.00 sec 1.25 MBytes 10.5 Mbits/sec 0     1.86 MBytes
[ 4] 100.00-101.00 sec 1.21 MBytes 10.2 Mbits/sec 0     1.89 MBytes
[ 4] 101.00-102.00 sec 1.34 MBytes 11.2 Mbits/sec 0     1.94 MBytes
[ 4] 102.00-103.00 sec 1.25 MBytes 10.5 Mbits/sec 0     2.01 MBytes
[ 4] 103.00-104.00 sec 1.30 MBytes 10.9 Mbits/sec 0     2.09 MBytes
[ 4] 104.00-105.00 sec 1.25 MBytes 10.5 Mbits/sec 0     2.17 MBytes
[ 4] 105.00-106.00 sec 1.39 MBytes 11.6 Mbits/sec 0     2.33 MBytes
[ 4] 106.00-107.00 sec 1.01 MBytes 8.47 Mbits/sec 0     2.46 MBytes
[ 4] 107.00-108.00 sec 526 KBytes 4.31 Mbits/sec 0     2.54 MBytes
[ 4] 108.00-109.00 sec 0.00 Bytes 0.00 bits/sec 0     2.54 MBytes
[ 4] 109.00-110.00 sec 0.00 Bytes 0.00 bits/sec 0     2.54 MBytes
[ 4] 110.00-111.00 sec 0.00 Bytes 0.00 bits/sec 0     2.54 MBytes
[ 4] 111.00-112.00 sec 0.00 Bytes 0.00 bits/sec 1     1.41 KBytes
[ 4] 112.00-113.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 113.00-114.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 114.00-115.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 115.00-116.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 116.00-117.00 sec 0.00 Bytes 0.00 bits/sec 1     1.41 KBytes
[ 4] 117.00-118.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 118.00-119.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 119.00-120.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 120.00-121.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 121.00-122.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 122.00-123.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 123.00-124.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 124.00-125.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 125.00-126.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 126.00-127.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 127.00-128.00 sec 0.00 Bytes 0.00 bits/sec 1     1.41 KBytes
[ 4] 128.00-129.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
```

```
[ 4] 129.00-130.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 130.00-131.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 131.00-132.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 132.00-133.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 133.00-134.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 134.00-135.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 135.00-136.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 136.00-137.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 137.00-138.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 138.00-139.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 139.00-140.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 140.00-141.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 141.00-142.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 142.00-143.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 143.00-144.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 144.00-145.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 145.00-146.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 146.00-147.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 147.00-148.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 148.00-149.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 149.00-150.00 sec 0.00 Bytes 0.00 bits/sec 0     1.41 KBytes
[ 4] 150.00-151.00 sec 700 KBytes 5.73 Mbits/sec 847    600 KBytes
[ 4] 151.00-152.00 sec 954 KBytes 7.82 Mbits/sec 993    1.32 MBytes
[ 4] 152.00-153.00 sec 509 KBytes 4.17 Mbits/sec 0     1.79 MBytes
[ 4] 153.00-154.00 sec 1.08 MBytes 9.07 Mbits/sec 0     1.85 MBytes
[ 4] 154.00-155.00 sec 1.38 MBytes 11.6 Mbits/sec 0     1.90 MBytes
[ 4] 155.00-156.00 sec 1.55 MBytes 13.0 Mbits/sec 0     1.98 MBytes
[ 4] 156.00-157.00 sec 1.16 MBytes 9.71 Mbits/sec 0     2.04 MBytes
[ 4] 157.00-158.00 sec 1.21 MBytes 10.2 Mbits/sec 0     2.10 MBytes
[ 4] 158.00-159.00 sec 1.26 MBytes 10.6 Mbits/sec 0     2.17 MBytes
[ 4] 159.00-160.00 sec 1.14 MBytes 9.56 Mbits/sec 0     2.23 MBytes
[ 4] 160.00-161.00 sec 1.29 MBytes 10.8 Mbits/sec 0     2.27 MBytes
[ 4] 161.00-162.00 sec 1.24 MBytes 10.4 Mbits/sec 0     2.34 MBytes
[ 4] 162.00-163.00 sec 1.42 MBytes 11.9 Mbits/sec 0     2.41 MBytes
[ 4] 163.00-164.00 sec 1.11 MBytes 9.34 Mbits/sec 0     2.46 MBytes
[ 4] 164.00-165.00 sec 1.39 MBytes 11.7 Mbits/sec 0     2.56 MBytes
[ 4] 165.00-166.00 sec 995 KBytes 8.16 Mbits/sec 0     2.69 MBytes
[ 4] 166.00-167.00 sec 1.88 MBytes 15.7 Mbits/sec 0     2.94 MBytes
[ 4] 167.00-168.02 sec 950 KBytes 7.69 Mbits/sec 0     3.12 MBytes
[ 4] 168.02-169.00 sec 1.79 MBytes 15.2 Mbits/sec 0     3.12 MBytes
[ 4] 169.00-170.01 sec 1.27 MBytes 10.6 Mbits/sec 0     3.12 MBytes
[ 4] 170.01-171.00 sec 1.25 MBytes 10.5 Mbits/sec 23     1.60 MBytes
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth       Retr
[  4]   0.00-600.00 sec   704 MBytes  9.84 Mbits/sec  12069   sender
[  4]   0.00-600.00 sec   702 MBytes  9.82 Mbits/sec          receiver

iperf Done.

<!-On Router A!>
Router#show appmgr application name iperf-server-app stats
Thu Dec  3 11:45:47.790 UTC
Application Stats: iperf-server-app
   CPU Percentage: 0.00%
   Memory Usage: 816KiB / 31.23GiB
   Memory Percentage: 0.00%
   Network IO: 0B / 0B
   Block IO: 0B / 0B
   PIDs: 1
<!-On Router B!>
Router#show appmgr application name iperf-client-app stats
Thu Dec  3 11:45:59.418 UTC
Application Stats: iperf-client-app
   CPU Percentage: 0.00%
```

```
Memory Usage: 0B / 0B
Memory Percentage: 0.00%
Network IO: 0B / 0B
Block IO: 0B / 0B
PIDs: 0
```

Stop iPerf Applications

Stop the iPerf applications on Router A and Router B using the **appmgr application stop name** *app_name* command. The **application stop** command can only be used for applications that are registered, activated, and are currently running. The **application stop** command stops only the application and does not clean up the resources used by the application.

You can verify the status of the application using the **show appmgr application-table** command. The **Status** is displayed as **Exited** if the application has been stopped successfully.

```
Router#appmgr application stop name iperf-server-app
Mon Nov 30 13:38:36.202 UTC
Router#show appmgr application-table
Mon Nov 30 13:38:36.999 UTC
Name                 Type    Config State  Status
--------             ------- ------------- -------------------------
iperf-server-app     Docker    Activated   Exited (1) Less than a se
Router#
```

Start iPerf Applications

Start or restart an application that has been stopped (and not deactivated) using the **appmgr application start name** *app_name* command.

```
Router#appmgr application start name iperf-server-app
Tue Dec 1 13:06:21.996 UTC
Router#show appmgr application-table
Mon Nov 30 13:38:36.999 UTC
Name                 Type    Config State  Status
--------             ------- ------------- -------------------------
iperf-server-app     Docker    Activated   UP(1) Less than a second
Router#
```

Deactivate iPerf Applications

Step 1 Deactivate the iPerf applications using the **no appmgr application** *app_name* command. You deactivate the installed application when you want to release all resources used by the application.

```
Router#config
Router(config)#no appmgr application iperf-server-app
Router(config)#commit
```

Step 2 Verify the status of the application by using the **show appmgr application-table** *app_name* **stats** command.

```
Router#show appmgr application-table
Mon Nov 30 13:39:51.197 UTC
Router#
```

Note You can activate a deactivated application using the **appmgr application** *app_name* **activate type docker source** *source_name* command.

Uninstall iPerf Applications

Uninstall the applications using the **appmgr package uninstall package** *package_name* command.

After the application is successfully uninstalled, executing the **show appmgr source-table** command displays no result.

```
Router#appmgr package uninstall package iperf
table
Mon Nov 30 13:41:05.155 UTC
Router#show appmgr source-table
Mon Nov 30 13:41:05.936 UTC
Router#
```