SD-WAN

This chapter describes the SD-WAN capabilities supported in the management center.

SD-WAN Capabilities

Software-Defined WAN (SD-WAN) solutions replace traditional WAN routers and are agnostic to WAN transport technologies. SD-WAN provides dynamic, policy-based, application path selection across multiple WAN connections and supports service chaining for additional services such as WAN optimization and firewalls.

As organizations expand their operations across multiple branch locations, ensuring secure and streamlined connectivity becomes paramount. Deploying a secure branch network infrastructure involves complex configurations, which can be time-consuming and prone to configuration errors if not handled properly. However, organizations can overcome these challenges by leveraging the Cisco Secure Firewall Management Center (management center) and the Cisco Secure Firewall Threat Defense (threat defense) devices for a simplified and secure branch deployment.

In this guide, we explore the concept of simplifying secure branch deployment using a robust firewall solution. By integrating a secure firewall as a foundational component of the branch network architecture, organizations can establish a strong security baseline while simplifying the deployment process. This approach enables organizations to enforce unified security policies, optimize traffic routing, and ensure resilient connectivity.

Some of the SD-WAN capabilities supported on the Cisco Secure Firewall are:

- **Simplified management:**
  - SD-WAN Wizard
  - SASE: Umbrella auto tunnel deployment
  - Dynamic VTI (DVTI) hub spoke topology simplification
- **Application awareness:**
  - Direct Internet Access (DIA) for public cloud and guest user

- Policy based routing (PBR) using applications as a match criteria
- Local tunnel ID support for Umbrella

- **Increased usable bandwidth:**
  - ECMP support for load balancing across multiple ISPs and VTIs
  - Application-based load balancing using PBR

- **High availability with near zero network downtime:**
  - Dual ISP configuration
  - Optimal path selection based on application-based interface monitoring.

- **Secure Elastic Connectivity:**
  - Route-based (VTI) VPN tunnels between headquarters (hub) and branches (spokes)
  - IPv4 and IPv6 BGP, IPv4 and IPv6 OSPF, and IPv4 EIGRP over VTI
  - DVTI hubs that support spokes with static or dynamic IP

Features

The following table lists some commonly used SD-WAN features:

Feature	Introduced in	More Information
Configure settings to carry SGT over the SD-WAN tunnels using SD-WAN wizard.	Release 10.0	Using SD-WAN Wizard for Secure Branch Network Deployment, on page 4
Support for ECMP in hubs and BFD for SVTI and DVTI.	Release 10.0	Using SD-WAN Wizard for Secure Branch Network Deployment, on page 4
Use PBR to handle traffic based on advanced custom application detector.	Release 10.0	Policy Based Routing
Management of Remote Branch (HA) with Dual WAN Support	Release 7.7	SD-WAN Summary Dashboard, on page 19
PBR Support for Custom Applications	Release 7.7	Policy Based Routing
SD-WAN Wizard	Release 7.6	Using SD-WAN Wizard for Secure Branch Network Deployment, on page 4

Feature	Introduced in	More Information
Application monitoring using SD-WAN Summary dashboard	Release 7.4.1	SD-WAN Summary Dashboard, on page 19
SD-WAN Summary Dashboard	Release 7.4	SD-WAN Summary Dashboard, on page 19
Policy-based routing with user identity and SGTs	Release 7.4	Policy Based Routing
Policy-based routing using HTTP path monitoring	Release 7.4	Policy Based Routing
Loopback interface support for VTIs	Release 7.3	About Loopback Interfaces
Support for dynamic VTI (DVTI) with site-to-site VPN	Release 7.3	Dynamic VTI
Umbrella auto tunnel	Release 7.3	Deploy a SASE Tunnel on Umbrella
Support for IPv4 and IPv6 BGP, IPv4 and IPv6 OSPF, and IPv4 EIGRP for VTIs	Release 7.3	BGP OSPF EIGRP
Route-based site-to-site VPN with hub and spoke topology	Release 7.2	Create a Route-based Site-to-Site VPN
Policy-based routing with path monitoring	Release 7.2	Policy Based Routing
Site to Site VPN Monitoring Dashboard	Release 7.1	Monitor Site-to-Site VPNs Using Site-to-Site VPN Dashboard
Direct Internet Access/Policy Based Routing	Release 7.1	Policy Based Routing
Equal-Cost-Multi-Path (ECMP) zone with WAN interfaces	Release 7.1	ECMP
ECMP zone with VTI interfaces	Release 7.1	ECMP
Backup VTI for route-based site-to-site VPN	Release 7.0	Route Traffic Through a Backup VTI Tunnel
Support for static VTI (SVTI) with site-to-site VPN	Release 6.7	Static VTI

Using SD-WAN Wizard for Secure Branch Network Deployment

Management Center allows you to easily configure VPN tunnels and routing configuration between your centralized headquarters (hubs) and remote branch sites (spokes) using the new SD-WAN wizard.

What are Hubs and Spokes?

Hubs: Devices that enable secure VPN connectivity to and from one or more remote branch devices or spokes. Hubs also act as a gateway for spokes to communicate with each other.

Spokes: Devices in remote branches that connect over VPN to a hub to securely access the corporate resources behind the hub. Spokes communicate with each other through the hub.

Benefits of Using SD-WAN Wizard

- Simplifies and automates the VPN and routing configuration of your SD-WAN network.
- Creates route-based VPN tunnels and simplifies the configuration process by automating tasks such as:
  - Generating tunnel interfaces of the branches.
  - Assigning IP addresses to the tunnel interfaces.
  - Configuring BGP for the SD-WAN overlay network. These configurations ensure seamless connection between hubs and spokes, and spoke to spoke through the hub.
- Provides seamless routing because hubs act as route reflectors and enable the following:
  - Provide connectivity between the spokes.
  - Determine the best routing path based on the spokes' active and backup tunnels.
- Requires minimal user input.
- Easily add multiple branches at a time.
- Provides easy dual ISP configurations.
- Enables network scaling.

Guidelines and Limitations for Using SD-WAN Wizard

Guidelines

- When you configure the DVTIs of two hubs, ensure that they have the same IPsec tunnel mode (IPv4 or IPv6).
- In a dual-hub SD-WAN topology, the hubs can be in different geographic locations and have different protected networks behind them. To ensure direct communication between these networks, ensure that you configure the following:
  - A point-to-point route-based VPN topology between the two hubs (**Secure Connections** > **Site-to-Site VPN & SD-WAN**, and click **Add** > **Route-Based VPN**).

  - A dynamic routing protocol between the hubs (**Devices** > **Device Management**, click the device name and click **Routing**).

- When you configure IP address pools for spokes, ensure the following:
  - The **Allow Overrides** check box must be unchecked.
  - If you are using multiple pools, the IP addresses of the pools must not overlap.
  - IP addresses must not overlap with any of the interfaces on the spoke.
- When you create security zones or interface groups, choose **Routed** as the **Interface Type**.
- Use the spoke security zone to configure an access control policy that allows tunnel traffic to and from the spokes.
- Configure the spokes' static VTIs in an ECMP zone to load balance the application traffic. If you do not configure the ECMP zone, the remaining paths act as backup paths when the primary path goes down. Note that you must configure the spokes' static VTIs and not the physical interfaces in the ECMP zone. This configuration is not part of the SD-WAN wizard.
- In SD-WAN topologies with dual ISPs on spokes, the tunnel identity and the tunnel source of the spokes must be unique.
- If a spoke is part of multiple SD-WAN topologies, ensure that you use the same local community tag and learned route community tag in each SD-WAN topology. Note that the local community tags and learned route community tags must be different from each other.
- If a device has only IPv6 address configurations, you must configure the BGP router ID with a loopback or physical interface that has an IPv4 address (**Devices** > **Device Management**, and click **Routing** > **General Settings** > **BGP**).
- Configure unique local IKE identity for all tunnels across all your SD-WAN VPN topologies.
- Ensure that the spokes in an SD-WAN topology do not have the same protected network.
- Use distinct DVTIs for SD-WAN and route-based VPNs to avoid IPsec profile conflicts and errors.
- Ensure that you shutdown a DVTI virtual template before you change the IP address of a DVTI's numbered interface.

Limitations

- You can configure a maximum of two hubs in an SD-WAN topology using the SD-WAN wizard.
- For each spoke, you can use only one WAN interface per topology. However, for dual-ISP setups, you can configure a second SD-WAN topology with the second WAN interface. For more information, see Sample Configurations for Dual ISP Deployment Using SD-WAN Wizard, on page 12.
- SD-WAN wizard does not support the following:
  - IKEv1
  - Cluster devices are not supported on the hub and spoke because VTI is not supported on cluster devices.

- Extranet hubs and spokes such as ASA, Cisco IOS, Cisco Viptela, Umbrella, Meraki, or vendor devices.

License Requirements for Configuring an SD-WAN Topology

Ensure that export-controlled features are enabled in your Smart License to configure an SD-WAN topology in Firewall Management Center.

To verify if export-controlled functionality is enabled for your Smart License account, choose **Administration** > **Licenses** > **Smart Licenses**.

Prerequisites for Using the SD-WAN Wizard

- You must be an Admin user.
- Hub devices must be Version 7.6.0 and later.
- Spoke devices must be Version 7.3.0 and later.
- The Firewall Threat Defense devices must have an internet-routable public IP address. The IP address can be static or dynamic.
- Assign appropriate logical names and IP addresses to the interfaces of the Firewall Threat Defense devices. For example, use *inside* for the interface connected to the LAN, and *outside* for the interface connected to the internet or WAN.
- If you are using certificate-based authentication, you must enroll the certificates in the hub and spokes.
- Configure routing, NAT, and AC policies to ensure underlay connectivity between the devices.
- Hub devices must be Version 10.0 and later to enable ECMP on the virtual access interfaces associated with the hub's dynamic VTI.
- Firewall Threat Defense devices must be Version 10.0 and later to enable BFD routing protocol on SVTIs and DVTIs.

Configure an SD-WAN Topology Using the SD-WAN Wizard

The SD-WAN wizard allows you to easily configure VPN tunnels between your centralized headquarters and remote branch sites.

Before you begin

Ensure that you review Prerequisites for Using the SD-WAN Wizard, on page 6 and Guidelines and Limitations for Using SD-WAN Wizard, on page 4.

Procedure

Step 1 Choose **Secure Connections** > **Site-to-Site VPN & SD-WAN**, and click **Add**.

Step 2 Enter a name for the SD-WAN VPN topology in the **Topology Name** field.

Step 3 Click the **SD-WAN Topology** radio button and click **Create**.

Step 4 Configure a hub:

a) Click **Add Hub**.

b) From the **Device** drop-down list, choose a hub.

c) Click **+** next to the **Dynamic Virtual Tunnel Interface (DVTI)** drop-down list to add a dynamic VTI for the hub.

The **Add Virtual Tunnel Interface** dialog box is prepopulated with default configurations. However, you must configure the **Tunnel Source**, and the **Borrow IP Address**. For more information, see Add a Dynamic Virtual Tunnel Interface for a Hub, on page 11.

d) Click **OK**.

e) In the **Hub Gateway IP Address** field, enter the public IP address of the hub's VPN interface or the tunnel source of the dynamic VTI to which the spokes connect.

This IP address is auto populated if the interface has a static IP address. If hub is behind a NAT device, you must manually configure the post-NAT IP address.

f) From the **Spoke Tunnel IP Address Pool** drop-down list, choose an IP address pool or click **+** to create an address pool.

When you add spokes, the wizard auto generates spoke tunnel interfaces, and assigns IP addresses to these spoke interfaces from this IP address pool.

g) Click **Add** to save the hub configuration.

h) (Optional) To add a secondary hub, repeat Step 4a to Step 4f.

i) Check the **ECMP** check box to enable Equal Cost Multi-Path (ECMP) on the dynamic VTIs of hub devices with Version 10.0 or later.

All virtual access interfaces on the hub connecting to the same spoke are grouped into an ECMP zone. This feature load balances traffic through multiple paths to a spoke.

j) Click **Next**.

Step 5 Configure spokes:

Click **Add Spoke** to add a single spoke device, or click **Add Spokes (Bulk Addition)** to add multiple spokes to your topology.

- Click **Add Spoke**. In the **Add Spoke** dialog box, configure the following parameters:

  a. From the **Device** drop-down list, choose a spoke.

  b. From the **VPN Interface** drop-down list, choose a WAN-facing or internet-facing physical interface to establish a VPN connection with the hub.

  c. Check the **Local Tunnel (IKE) Identity** check box to enable a unique and configurable identity for the VPN tunnel from this device to the remote peer. By default, this option is enabled.

  d. Choose one of the following options from the **Identity Type** drop-down list:

  - **Key ID**—(Default value) This value is auto populated as <*sd-wan topologyname*>_<*device_IP_address*>, for example, sdwantopo1_192.168.0.200. You can also specify a key ID of your choice.
  - **Email ID**—Specify an email ID up to 127 characters.
  - **IP Address**—IP address of the spoke's VPN interface.

- **Auto**—IP address of the spoke's VPN interface for pre-shared key authentication or the certificate Distinguished Name (DN) for certificate-based authentication.
- **Hostname**—Fully qualified hostname of the spoke.

e. Click **Save** to save the spoke configuration.

- Click **Add Spokes (Bulk Addition)**. In the **Add Bulk Spokes** dialog box, configure the following parameters:

a. Choose one or more devices from the **Available Devices** list and click **Add** to move the devices to **Selected Devices**.

b. Use one of the following methods to select the VPN interfaces of the spokes:

- Click the **Interface Name Pattern** radio button and specify a string to match the logical name of the internet or WAN interface of the spokes, for example, outside*, wan*.

  If the spoke has multiple interfaces with the same pattern, the first interface that matches the pattern is selected for the topology.

- Click the **Security Zone** radio button and choose a security zone with the VPN interfaces of the spokes from the drop-down list, or click + to create a security zone.

c. Click **Next**.

The wizard validates if the spokes have interfaces with the specified pattern. Only the validated devices are added to the topology.

d. Click **Add**.

e. Click **Next**.

For each spoke, the wizard automatically selects the hub's DVTI as the tunnel source IP address.

Note
If the hub’s tunnel source IP address is an IPv6 address, the wizard automatically selects the first IPv6 address of the spokes' selected interface. To edit the IPv6 address of a spoke's tunnel source, click the edit icon next to a spoke, choose an IPv6 address from the **IP Address** drop-down list, and click **Save**.

Step 6 Configure authentication settings for the devices in the SD-WAN topology:

a) **Authentication Type**—For device authentication, you can use a manual pre-shared key, an auto-generated pre-shared key, or a certificate.

- **Pre-shared Manual Key**—Specify the pre-shared key for the VPN connection.
- **Pre-shared Automatic Key**—(Default value) The wizard automatically defines the pre-shared key for the VPN connection. Specify the key length in the **Pre-shared Key Length** field. The range is 1 to 127.
- **Certificate**—When you use certificates as the authentication method, the peers obtain digital certificates from a CA server in your PKI infrastructure, and use them to authenticate each other.

b) Choose one or more algorithms from the **Transform Sets** drop-down list.
c) Choose one or more algorithms from the **IKEv2 Policies** drop-down list.

d) Click **Next**.

Step 7 Configure the SD-WAN settings:

This step involves the auto generation of spoke tunnel interfaces, and BGP configuration of the overlay network.

a) From the **Spoke Tunnel Interface Security Zone** drop-down list, choose a security zone or click **+** to create a security zone to which the wizard automatically adds the spokes' auto-generated Static Virtual Tunnel Interfaces (SVTIs).
b) Check the **Enable BGP on the VPN Overlay Topology** check box to automate BGP configurations such as neighbor configurations between the overlay tunnel interfaces and basic route redistribution from the directly connected LAN interfaces of the hubs and spokes.
c) In the **Autonomous System Number** field, enter an Autonomous System (AS) number.

AS number is a unique number for a network with a single routing policy. BGP uses AS numbers to identify networks. The spoke's BGP neighbor configuration is generated based on the corresponding hub's AS number. Range is from 0 to 65536.

- If all the hubs and spokes are in the same region, by default, **64512** is the AS number.
- If the primary and secondary hubs are in different regions, the primary hub and the spokes are configured with **64512** as the AS number, and the secondary hub is configured with a different AS number.

d) In the **Community Tag for Local Routes** field, enter the BGP community attribute to tag connected and redistributed local routes. This attribute enables easy route filtering.
e) Check the **Redistribute Connected Interfaces** check box and choose an interface group from the drop-down list or click **+** to create an interface group with connected inside or LAN interfaces for BGP route redistribution in the overlay topology.
f) Check the **Enable Multiple Paths for BGP** check box to allow multiple BGP routes to be used at the same time to reach the same destination. This option enables BGP to load-balance traffic across multiple links.

Note that when you enable this option, BGP multipath is enabled only for spokes.

g) (Optional) Check the **Secondary Hub is in Different Autonomous System** check box. This check box appears only if you have a secondary hub in this topology.
h) In the **Autonomous System Number** field, enter the AS number for the secondary hub.
i) In the **Community Tag for Learned Routes** field, enter the BGP community attribute to tag routes learned from other SD-WAN peers over the VPN tunnel. This attribute is required only for eBGP configuration when the secondary hub has a different AS number. This field appears only if you have configured two hubs in the SD-WAN topology.
j) Click **Next**.

Step 8 Configure **Advanced Settings**.

a) From the **Identity Sent to Peers** drop-down list, choose the identity that the peers will use to identify themselves during IKE negotiations.

- **autoOrDN**—(Default value) Determines IKE negotiation by connection type: IP address for preshared key, or Cert DN for certificate authentication.
- **IP Address**—Uses the IP addresses of the hosts exchanging ISAKMP identity information.
- **Hostname**—Uses the fully qualified domain name of the hosts exchanging ISAKMP identity information. This name comprises the hostname and the domain name.

b) Configure **TrustSec (SGT) Settings**.

Enable SGT propagation over Virtual Tunnel Interfaces—Cisco TrustSec uses Security Group Tags (SGTs) to control access and enforce traffic on a network. This option enables SGT propagation over SVTIs and DVTIs of the VPN topology. To enable SGT propagation on a specific SVTI or DVTI, configure it in individual devices. Note that the Firewall Threat Defense device must be Version 10.0.0 and later.

c) Configure **Bidirectional Forwarding Detection (BFD) Settings**.

Enable Bidirectional Forwarding Detection Routing—BFD is a protocol for detecting forwarding path failures. This option enables BFD routing protocol on the SVTIs and DVTIs. When BFD detects a path failure, traffic is rerouted over the newly identified path. Note that the Firewall Threat Defense device must be Version 10.0.0 and later.

1. From the **Interval** drop-down list, choose the unit of interval, microseconds or milliseconds, at which BFD control packets are sent.
2. In the **Multiplier** field, enter the number of consecutive missed BFD control packets allowed before declaring that the peer is unavailable. The range is 3 to 50 packets.
3. In the **Minimum Transmit and Receive Interval** field, enter the minimum transmit and receive interval of the BFD control packets. The range is 50 to 999 milliseconds or 50000 to 999000 microseconds.

Step 9 Click **Finish** to save and validate the SD-WAN topology.

You can view the topology in the **Site-to-Site VPN Summary** page (**Secure Connections** > **Site-to-Site VPN & SD-WAN**). After you deploy the configurations to all the devices, you can see the status of all the tunnels in this page.

What to do next

- View the auto-generated spoke SVTIs and their IP addresses—Click the edit icon next to the spoke configuration and click **View Generated Tunnel Interfaces**.
- We recommend that you enable ECMP on the spoke SVTIs. Choose **Devices** > **Device Management**, and click **Routing** > **ECMP**. Note that when you enable ECMP on the hubs, it is not enabled on the spoke SVTIs, you must manually enable ECMP on the SVTIs.
- Deploy the configurations on the hub and spokes. Choose **Deploy**. Select devices and click **Deploy**.
- Verify the SD-WAN topology tunnel statuses. For more information, see Verify Tunnel Statuses of an SD-WAN Topology, on page 16.
- Configure ACLs for the spokes' tunnel interface security zones. Choose **Policies** > **Security policies** > **Access Control**.
- We recommend that you enable BGP multipath on hubs. To enable BGP multipath on hubs:
  1. Choose ECMP **Devices** > **Device Management**, and click **Routing**.
  2. Under **General Settings**, click **BGP**.
  3. Check the **Enable BGP** check box to enable BGP.
  4. In the **AS Number** field, enter the AS number that you configured in the SD-WAN topology.

5. Click **Save**.
6. In the left pane, choose **BGP > IPv4 or IPv6**, and click the **General** tab.
7. In the **Forward Packets over Multiple Paths** section, click the edit icon.
8. Configure values for **Number of Paths** and **IBGP number of paths**. We recommend that you configure these values as 8.

- For more information about configuration examples using SD-WAN wizard, see Sample Configurations for Dual ISP Deployment Using SD-WAN Wizard, on page 12
- Configure a PBR policy on each spoke for application-aware routing based on the application performance metrics of the WAN interfaces. For more information, see Route Application Traffic from the Branch to the Internet Using Direct Internet Access (DIA).

Add a Dynamic Virtual Tunnel Interface for a Hub

In the SD-WAN wizard, you must configure a DVTI for each hub. DVTI uses a virtual template to dynamically generate a unique virtual access interface for each VPN session.

Before you begin

In the SD-WAN wizard, click **Add Hub**, and choose a hub from the **Device** drop-down list.

Procedure

Step 1 Click + next to the **Dynamic Virtual Tunnel Interface (DVTI)** drop-down list to add a DVTI for the hub.

The **Add Virtual Tunnel Interface** dialog box appears with the following prepopulated default configurations.

a. **Tunnel Type**: Dynamic.

b. **Name**: <*tunnel_source_interface_logical name*>_dynamic_vti_<*tunnel_ID*>. For example, outside_dynamic_vti_1.

c. **Enabled** check box: Checked by default.

d. **Template ID**: Unique ID for the DVTI.

e. **Tunnel Source**: Physical interface that is the source of the DVTI and is auto populated by default.

f. **IPsec Tunnel Mode**: IPv4, by default.

Step 2 Choose a security zone for the dynamic VTI from the **Security Zone** drop-down list.

Step 3 Choose a physical or loopback interface from the **Borrow IP** drop-down list, the dynamic VTI interface inherits this IP address.

Ensure that you use an IP address different from the tunnel source IP address. We recommend that you use a loopback IP address.

Step 4 Click **OK** to save the dynamic VTI.

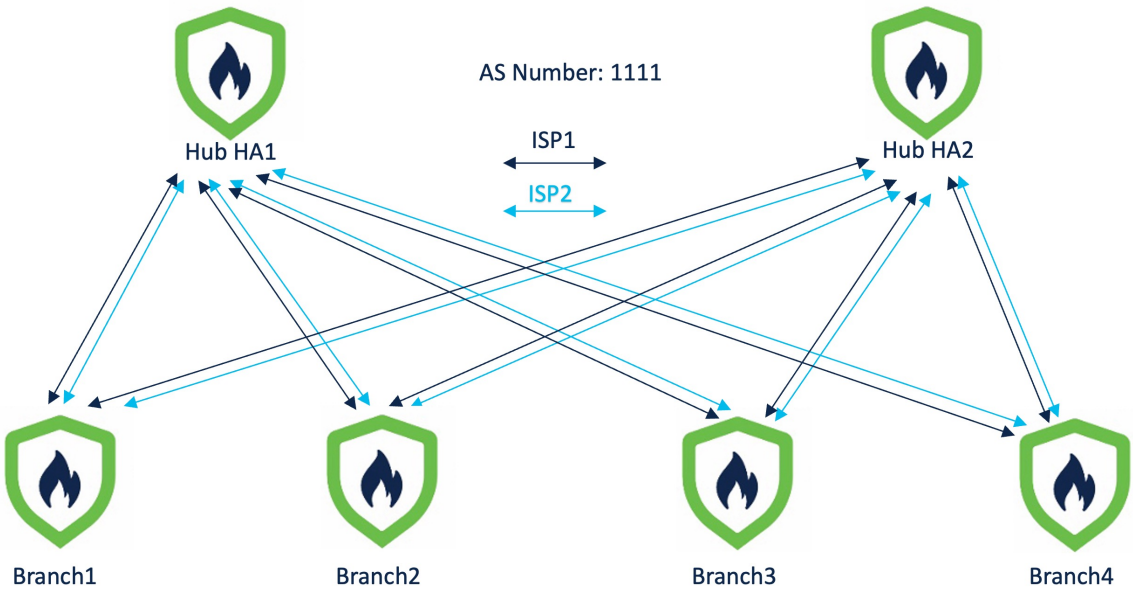
Sample Configurations for Dual ISP Deployment Using SD-WAN Wizard

Dual ISP Deployment: Two Hubs and Four Spokes in the Same Region

In the following dual ISP topology, the hubs and the spokes are in a single region, with AS number as 1111. The hubs and spokes use Internal Border Gateway Protocol (iBGP) as the routing protocol to exchange routing information.

- Hub HA1 and Hub HA2 are hub threat defense devices at the headquarters.
- Branch1, Branch2, Branch3, and Branch4 are spoke threat defense devices at the branches.
- ISP1 is the VPN interface of each spoke to ISP1.
- ISP2 is the VPN interface of each spoke to ISP2.

Figure 1: Dual ISP Topology with Two Hubs and Four Spokes in the Same Region



To configure this topology, you must create the following two SD-WAN topologies using the SD-WAN wizard:

SD-WAN Topology 1

Parameter	Value
Primary Hub	Hub HA1
Secondary Hub	Hub HA2
Spokes	Branch1, Branch2, Branch3, Branch4
AS Number	1111
VPN Interface (Spoke Tunnel Source)	ISP1

Parameter	Value
Number of Tunnels	8

The total number of tunnels in SD-WAN Topology 1 is 8.

SD-WAN Topology 2

Parameter	Value
Primary Hub	Hub HA1
Secondary Hub	Hub HA2
Spokes	Branch1, Branch2, Branch3, Branch4
AS Number	1111
VPN Interface (Spoke Tunnel Source)	ISP2
Number of Tunnels	8

The total number of tunnels in SD-WAN Topology 2 is 8.

The total number of VPN tunnels for this dual ISP deployment is 16.

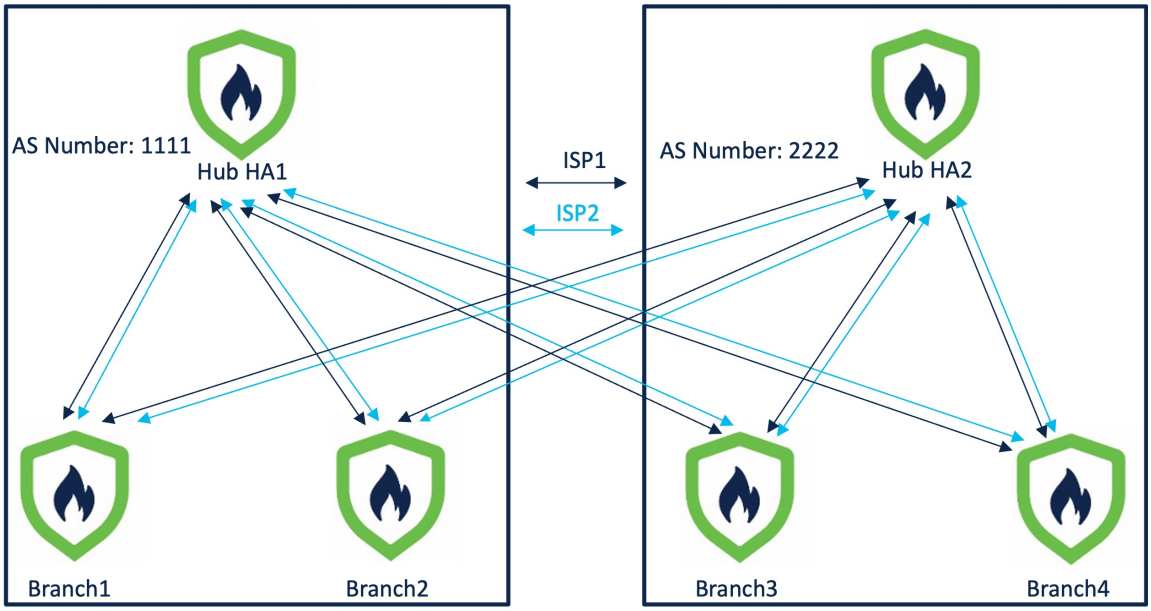
Note If the hubs are in different geographic locations and have different protected networks behind them, to ensure direct communication between these networks, configure a point-to-point route-based VPN topology between the two hubs using the route-based VPN wizard.

Dual ISP Deployment: Two Hubs and Four Spokes in Different Regions

In the following dual ISP topology, the hubs are in different regions, and have two directly connected spokes each. The hubs and their directly connected spokes use Internal Border Gateway Protocol (iBGP) as the routing protocol, and the hubs use External Border Gateway Protocol (eBGP) to exchange routing information.

- Hub HA1 and Hub HA2 are hub threat defense devices at the headquarters.
- Branch1, Branch2, Branch3, and Branch4 are spoke threat defense devices at the branches.
- HQ1, Branch1, and Branch2 are in a single region with AS number as 1111.
- HQ2, Branch3, and Branch4 are in a single region with AS number as 2222.
- ISP1 is the VPN interface of each spoke to ISP1.
- ISP2 is the VPN interface of each spoke to ISP2.

Figure 2: Dual ISP Topology with Two Hubs and Four Spokes in Different Regions



To configure this topology, you must create the following four SD-WAN topologies using the SD-WAN wizard:

SD-WAN Topology 1

Parameter	Value
Primary Hub	Hub HA1
Secondary Hub	Hub HA2
Spokes	Branch1, Branch2
AS Number	1111
Secondary AS Number	2222
VPN Interface (Spoke Tunnel Source)	ISP1

The number of tunnels in SD-WAN Topology 1 is 4.

SD-WAN Topology 2

Parameter	Value
Primary Hub	Hub HA1
Secondary Hub	Hub HA2
Spokes	Branch1, Branch2
AS Number	1111

Parameter	Value
Secondary AS Number	2222
VPN Interface (Spoke Tunnel Source)	ISP2

The number of tunnels in SD-WAN Topology 2 is 4.

SD-WAN Topology 3

Parameter	Value
Primary Hub	Hub HA2
Secondary Hub	Hub HA1
Spokes	Branch3, Branch4
AS Number	2222
Secondary AS Number	1111
VPN Interface (Spoke Tunnel Source)	ISP1

The number of tunnels in SD-WAN Topology 3 is 4.

SD-WAN Topology 4

Parameter	Value
Primary Hub	Hub HA2
Secondary Hub	Hub HA1
Spokes	Branch3, Branch4
AS Number	2222
Secondary AS Number	1111
VPN Interface (Spoke Tunnel Source)	ISP2

The number of tunnels in SD-WAN Topology 4 is 4.

The total number of VPN tunnels for this dual ISP deployment is 16.

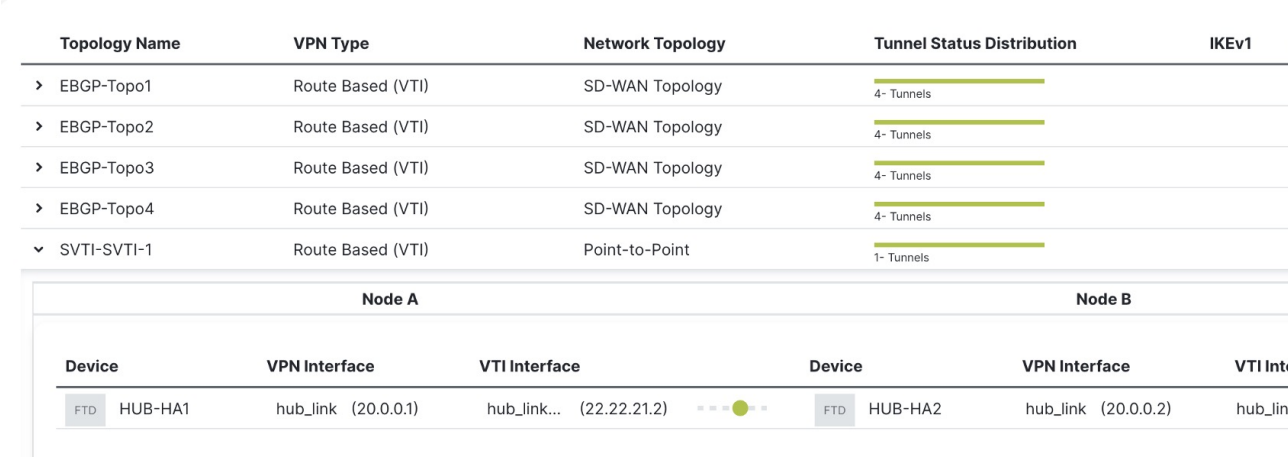
Note If the hubs are in different geographic locations and have different protected networks behind them, to ensure direct communication between these networks, configure a point-to-point route-based VPN topology between the two hubs using the route-based VPN wizard.

Verify Tunnel Statuses of an SD-WAN Topology

Verify Tunnel Statuses on the Site-to-Site VPN Summary Page

To verify if the VPN tunnels of the SD-WAN topologies are up, choose **Secure Connections** > **Site-to-Site VPN & SD-WAN**.

Following are the five SD-WAN topologies with two hubs and four spokes in different regions that are connected to dual ISPs:



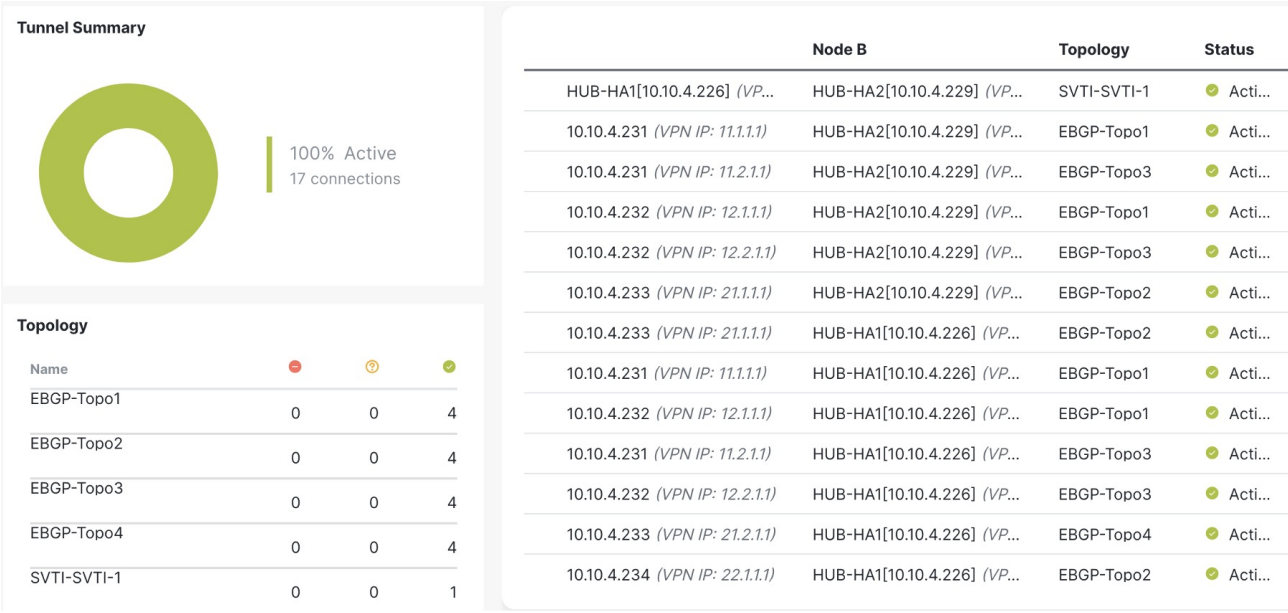
Topology Name	VPN Type	Network Topology	Tunnel Status Distribution	IKEv1
EBGP-Topo1	Route Based (VTI)	SD-WAN Topology	4- Tunnels	
EBGP-Topo2	Route Based (VTI)	SD-WAN Topology	4- Tunnels	
EBGP-Topo3	Route Based (VTI)	SD-WAN Topology	4- Tunnels	
EBGP-Topo4	Route Based (VTI)	SD-WAN Topology	4- Tunnels	
SVTI-SVTI-1	Route Based (VTI)	Point-to-Point	1- Tunnels	

Node A				Node B			
Device	VPN Interface	VTI Interface		Device	VPN Interface		VTI Int
FTD HUB-HA1	hub_link (20.0.0.1)	hub_link... (22.22.21.2)		FTD HUB-HA2	hub_link (20.0.0.2)		hub_lin

Verify Tunnel Statuses on the Site-to-Site VPN Dashboard

To view details of the SD-WAN VPN tunnels, choose **Insights & Reports** > **VPN dashboards** > **Site-to-Site VPN**.

Following are the VPN tunnels for an SD-WAN topology with two hubs and four spokes in different regions that are connected to dual ISPs:



Tunnel Summary

100% Active
17 connections

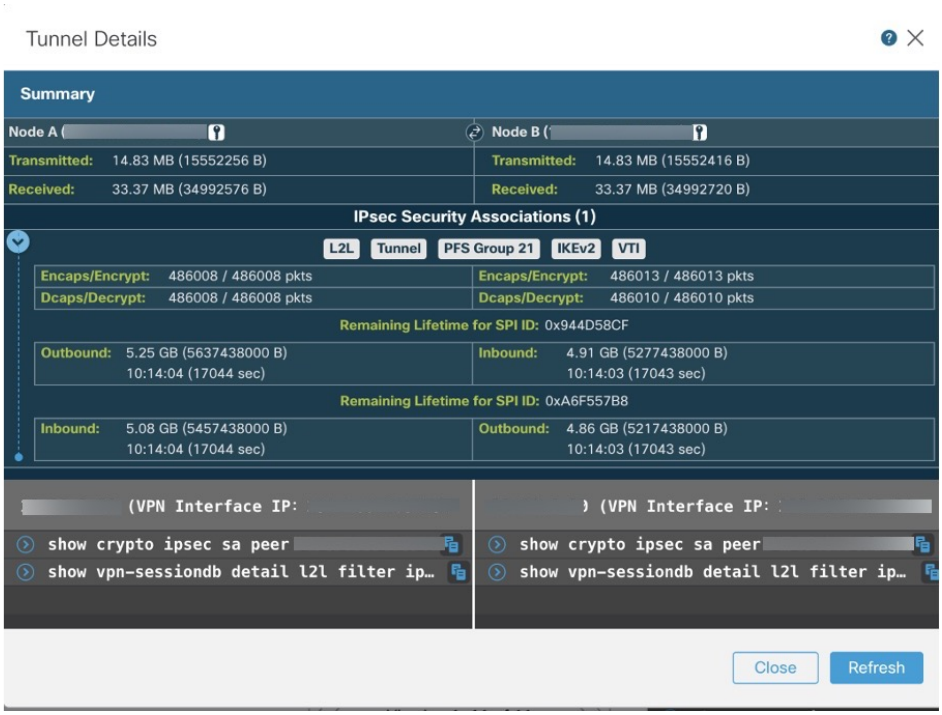
Topology

Name			
EBGP-Topo1	0	0	4
EBGP-Topo2	0	0	4
EBGP-Topo3	0	0	4
EBGP-Topo4	0	0	4
SVTI-SVTI-1	0	0	1

	Node B	Topology	Status
HUB-HA1[10.10.4.226] (VP...	HUB-HA2[10.10.4.229] (VP...	SVTI-SVTI-1	Acti...
10.10.4.231 (VPN IP: 11.1.1.1)	HUB-HA2[10.10.4.229] (VP...	EBGP-Topo1	Acti...
10.10.4.231 (VPN IP: 11.2.1.1)	HUB-HA2[10.10.4.229] (VP...	EBGP-Topo3	Acti...
10.10.4.232 (VPN IP: 12.1.1.1)	HUB-HA2[10.10.4.229] (VP...	EBGP-Topo1	Acti...
10.10.4.232 (VPN IP: 12.2.1.1)	HUB-HA2[10.10.4.229] (VP...	EBGP-Topo3	Acti...
10.10.4.233 (VPN IP: 21.1.1.1)	HUB-HA2[10.10.4.229] (VP...	EBGP-Topo2	Acti...
10.10.4.233 (VPN IP: 21.1.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo2	Acti...
10.10.4.231 (VPN IP: 11.1.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo1	Acti...
10.10.4.232 (VPN IP: 12.1.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo1	Acti...
10.10.4.231 (VPN IP: 11.2.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo3	Acti...
10.10.4.232 (VPN IP: 12.2.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo3	Acti...
10.10.4.233 (VPN IP: 21.2.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo4	Acti...
10.10.4.234 (VPN IP: 22.1.1.1)	HUB-HA1[10.10.4.226] (VP...	EBGP-Topo2	Acti...

To view more details of each VPN tunnel:

1. Hover over a tunnel.
2. Click the **View Full Information** ( ) icon. A pane with tunnel details and more actions appears.
3. Click the **CLI Details** tab in the side pane to view the show commands and details of the IPsec security associations.



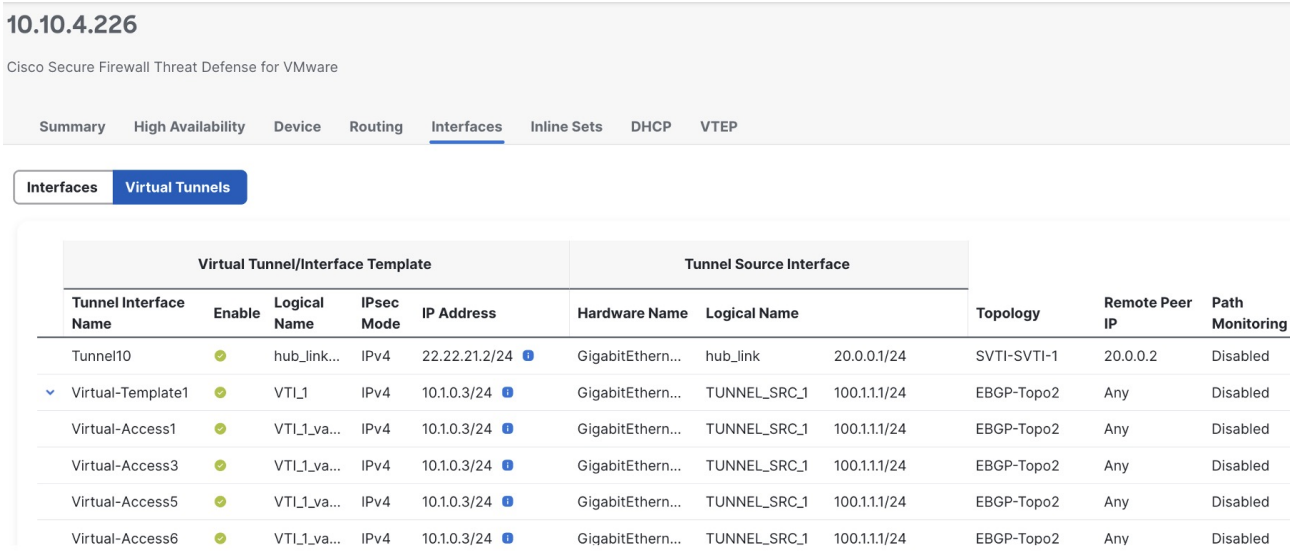
View Virtual Tunnel Interfaces of the Devices

To view the dynamic VTIs of hubs and static VTIs of spokes:

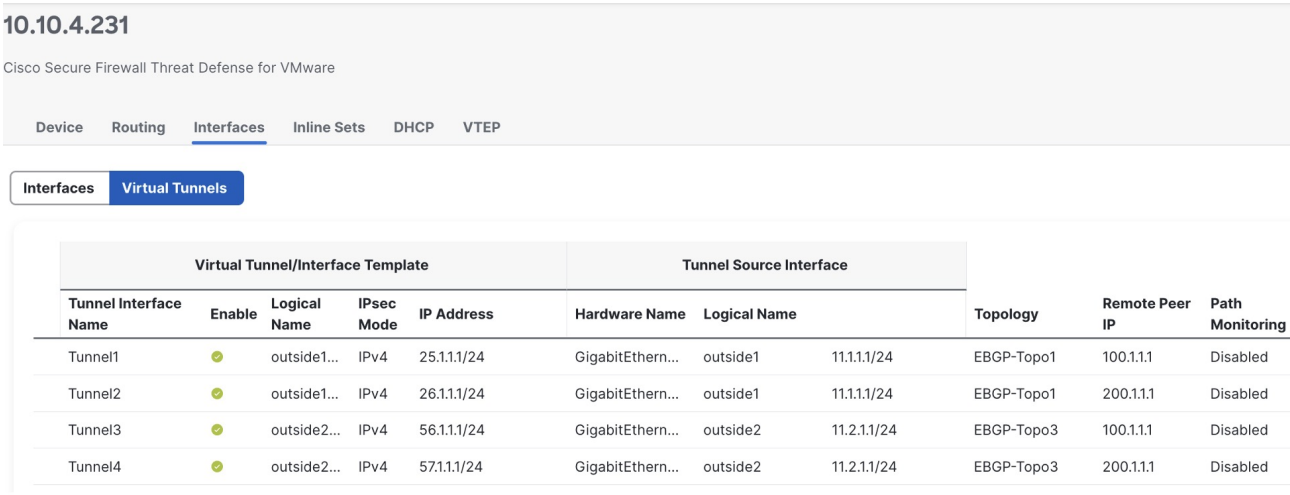
1. Choose **Devices** > **Device Management**.
2. Click the edit icon for a hub or a spoke device.
3. Click the **Interface** tab.
4. Click the **Virtual Tunnels** tab.

   For each VTI, you can view details such as name, IP address, IPsec mode, tunnel source interface details, topology, and remote peer IP.

Following image shows an example of the virtual access interfaces created dynamically by a hub's DVTI:



Following image shows an example of the static tunnel virtual interfaces (SVTIs) created on a spoke by the SD-WAN wizard:



The SD-WAN wizard assigns IP addresses to these tunnel interfaces from the IP address pool of the hub.

Verify Routing on the Hub and Branches

To verify the BGP configuration of the hubs and spokes of the SD-WAN topologies:

1. Choose **Devices** > **Device Management**.
2. Click the edit icon for a hub or a spoke device.
3. Click the **Device** tab.
4. Click **CLI** in the **General** card. The **CLI Troubleshoot** window appears.
5. Enter the following commands in the **Command** field and click **Execute**:
    - **show route**

- **show bgp summary**

Use Cases for SD-WAN Capabilities

Use the Cisco Secure Firewall Threat Defense SD-WAN Design and Deployment Guide to design and deploy SD-WAN architectures using Firewall Threat Defense and Firewall Management Center. This guide explains design principles, configuration workflows, and best practices.

Use these guides for detailed instructions for the primary use cases leveraging the SD-WAN capabilities supported by Cisco Secure Firewall.

- Simplify Branch to Hub Communication using Dynamic Virtual Tunnel Interface (DVTI)
- Route Application Traffic from the Branch to the Internet Using Direct Internet Access (DIA)
- Secure Internet Traffic Using Umbrella Auto Tunnel
- Empower Remote Workers with Secure Connectivity: DIA, Umbrella Auto Tunnel, and DVTI in Action
- Set Up SD-WAN Branch Office with Dual ISPs Using Registration Key and Device Templates
- Set Up SD-WAN Branch Office with Dual ISPs Using Serial Numbers and Device Template

Monitoring SD-WAN Topologies

-

SD-WAN Summary Dashboard

The SD-WAN Summary dashboard (**Insights & Reports** > **VPN dashboards** > **SD-WAN Summary**) provides a snapshot of your WAN devices and their interfaces. This dashboard helps you to:

- Identify issues with the underlay and overlay (VPN) topologies.
- Troubleshoot VPN issues using the existing **Health Monitoring**, **Device Management**, and **Site-to-Site Monitoring** pages.
- Monitor application performance metrics of WAN interfaces. The threat defense steers application traffic based on these metrics.

A WAN device must meet one of the following criteria:

- The device must be a VPN peer.
- The device must have WAN interface.

A WAN interface must meet one of the following criteria:

- The interface has IP address-based path monitoring enabled on it.
- The interface has a Policy Based Routing (PBR) policy with at least one application configured to monitor it.

For more information about PBR policy and path monitoring, see Policy Based Routing.

Click **Uplink Decisions** to view the **VPN Troubleshooting** page. You can view syslogs with ID: 880001. These syslogs show the threat defense interfaces through which it steers traffic based on the configured PBR policy.

To view the above syslogs and to view the data on this dashboard, ensure that you review Prerequisites for Using SD-WAN Summary Dashboard, on page 20.

For clusters, this dashboard displays application performance metrics of only the control node and not the data nodes.

Prerequisites for Using SD-WAN Summary Dashboard

- You must be an Admin, Security Analyst, or Maintenance user to view this dashboard.
- Threat defense devices must be Version 7.2 or later.
- Enable IP-based path monitoring and HTTP-based application monitoring on the WAN interfaces.
  1. Choose **Devices** > **Device Management**.
  2. Click the edit icon adjacent to the device that you want to edit.
  3. Click the edit icon adjacent to the interface that you want to edit.
  4. Click the **Path Monitoring** tab.
  5. Check the **Enable IP based Monitoring** check box.
  6. Check the **Enable HTTP based Application Monitoring** check box.
  7. Click **OK**.
- Configure a PBR policy with at least one application configured to monitor it:
  1. Choose **Devices** > **Device Management**.
  2. Click the edit icon adjacent to the device that you want to edit.
  3. Click **Routing**.
  4. In the left pane, click **Policy Based Routing**.
  5. Click **Add**.
  6. From the **Ingress Interface** drop-down list, choose an interface.
  7. Click **Add** to configure a forwarding action.
  8. Configure the parameters.
  9. Click **Save**.
- To view the application performance metrics for the WAN interfaces, you must:
  - Threat defense devices must be Version 7.4.1.
  - Enable data collection from the SD-WAN module in the health policy.
    1. Choose **Troubleshooting** > **+ Show more** > **Health** > **Policies**.

2. Click the **Edit health policy** icon.
3. In the **Health Modules** tab, under **SD-WAN**, click the **SD-WAN Monitoring** toggle button.

- Configure applications for the PBR policies.
  1. Choose **Objects** > **Access List** > **Extended**.
  2. Click the edit icon adjacent to the access list and add the applications for the PBR policy.
- Configure the forwarding action for the policy with one of the four application metrics.
  1. Choose **Devices** > **Device Management**.
  2. Click the edit icon adjacent to the device that you want to edit.
  3. Click **Routing**.
  4. In the left pane, click **Policy Based Routing**.
  5. Click the edit icon adjacent to the policy that you want to edit.
  6. In the **Edit Policy Based Route** dialog box, click the edit icon adjacent to the corresponding ACL.
  7. In the **Edit Forwarding Actions** dialog box, from the **Interface Ordering** drop-down list, choose one of the following options:
     - **Minimal Jitter**
     - **Maximum Mean Opinion Score**
     - **Minimal Round-Trip Time**
     - **Minimal Packet Loss**

     If you choose **Interface Priority** or **Order**, application monitoring is not enabled on the interface.
- Configure ECMP on the WAN interfaces:
  1. Choose **Devices** > **Device Management**.
  2. Click the edit icon adjacent to the device that you want to edit.
  3. Click **Routing**.
  4. In the left pane, click **ECMP**.
  5. Click **Add** and specify a name for the ECMP zone.
  6. Click **Add** to move interfaces from **Available Interfaces** to **Selected Interfaces**.
  7. Click **OK**.
- Ensure that traffic passes through the interface.
- Enable DNS inspection on each WAN device so that the threat defense device can do DNS snooping, and configure the trusted DNS servers:
  1. Choose **Devices** > **Platform Settings**.

2. Click the edit icon adjacent to the threat defense policy that you want to edit.
3. In the left pane, click **DNS**.
4. Click the **DNS Settings** tab.
5. Check the **Enable DNS name resolution by device** check box.
6. Click the **Trusted DNS Servers** tab.
7. Do one of the following:
    - Click the **Trust Any DNS server** toggle button.
    - Under **Specify DNS Servers**, click **Edit** to add trusted DNS servers.

- To view syslogs when you click **Uplink Decisions**, you must:
    - Choose **Devices** > **Platform Settings** and create or edit a threat defense policy.
    - In the left pane, click **Syslog**.
    - Click the **Logging Setup** tab.
    - Check the **Enable Logging** check box to turn on the data plane system logging for the threat defense device.
    - Click the **All Logs** radio button to enable logging of all the troubleshooting syslog messages.

      or

      Click the **VPN Logs** radio button to enable logging of only the VPN troubleshooting messages.
    - Click **Save**.

Monitor WAN Devices and Interfaces Using the SD-WAN Summary Dashboard

The SD-WAN Summary dashboard has the following widgets under the **Overview** tab:

Top Applications

This widget displays the top 10 applications ranked according to throughput.

You can choose a time range for the widget data from the **Show Last** drop-down list. The range is 15 minutes to two weeks.

WAN Connectivity

This widget provides a summary of the WAN interfaces statuses. It shows the number of WAN interfaces that are in the **Online**, **Offline** or **No Data** states. Note that you cannot monitor subinterfaces using this widget.

Click **View All Interfaces** to view more details about the interfaces in the health monitor page.

If a WAN interface is in the **Offline** or **No Data** state, you can troubleshoot it from the health monitor page:

1. In the **Monitoring** pane, expand **Devices**.
2. Click the corresponding WAN device to view the device-specific health details.
3. Click the **Interface** tab to view the interface status and aggregate traffic statistics for a specific time.

   Alternatively, you can click **View System & Troubleshoot Details**. The health monitor page is displayed with all the necessary details.

VPN Topology

This widget provides a summary of the site-to-site VPN tunnel statuses. It shows the number of **Active**, **Inactive**, and **No Active Data** VPN tunnels.

Click **View All Connections** to view the VPN tunnel details in the **Site-to-site VPN Monitoring** dashboard.

If the tunnels are in the **Inactive** or **No Active Data** state, you can troubleshoot using the **Site-to-site VPN Monitoring** dashboard. In the **Tunnel Status** widget, hover your cursor over a topology, click **View** ( ) and do one of the following:

- Click the **CLI Details** tab to view the details of the VPN tunnels.
- Click the **Packet Tracer** tab to use the packet tracer tool for the topology.

WAN Interface Throughput

This widget monitors the average throughput of the WAN interfaces during the chosen time period.

The interface throughput is classified into four bands. These details aid in cost planning and resourcing. You can choose a time range for the widget data from the **Show Last** drop-down list. The range is from 15 minutes to two weeks.

Click **View Health Monitoring** to view more details about the interface in the health monitor page.

Device Inventory

This widget lists all the managed WAN devices and groups them according to the model.

Click **View Device Management** to view more details about the device in the **Device Management** page.

WAN Device Health

This widget displays the device count according to the health of the WAN devices. You can view the number of devices with errors, warnings, or those that are in **Disabled** state.

Click **View Health Monitoring** to view the alarms, and quickly identify, isolate, and resolve issues.

If the health of a device is affected, you can troubleshoot it from the health monitor page.

1. In the **Monitoring** pane, expand **Devices**.

2. Click the corresponding WAN device to view the device-specific health details.
3. Click **View System & Troubleshoot Details**. The health monitor page is displayed with all the necessary details.

A device can be in **Disabled** state for multiple reasons, including the following:

- Management interface is disabled.
- Device is powered off.
- Device is being upgraded.

Monitor Application Performance Metrics of WAN Interfaces Using the SD-WAN Summary Dashboard

Under the **Application Monitoring** tab, you can select a WAN device and view the application performance metrics for the corresponding WAN interfaces. These metrics include Jitter, Round Trip Time (RTT), Mean Opinion Score (MOS), and Packet Loss.

By default, the metrics data is refreshed every 5 minutes. You can change the refresh time; the range is from 5 to 30 minutes. You can view the metrics in tabular and graphical formats. For each WAN interface, the latest metric value appears in the table. For graphical data, you can choose a time interval of up to 24 hours to view the metrics data for the corresponding WAN interfaces.