Extended Enterprise Implementation Guide for Cisco SD-WAN Deployments

This *Extended Enterprise Implementation Guide for Cisco SD-WAN Deployment*s describes the implementation of the design defined in the *Extended Enterprise SD-WAN Design Guide*. This guide incorporates a broad set of technologies, features, and applications for helping customers extend the enterprise information technology (IT) services to outdoor spaces.

Cisco Validated Designs (CVDs) provide the foundation for systems design and deployment and are based on common use cases or engineering system priorities. Each guide details the methodology for building solutions, and more importantly, the recommendations have been comprehensively tested by Cisco engineers to help ensure a faster, more reliable, and predictable deployment.

Extended Enterprise CVD

An enterprise has production, storage, distribution, and outdoor facilities. IT reach extends beyond the traditional carpeted space to non-carpeted spaces as well. IT can now extend network connectivity, security policy, and management to the outside, warehouses, and distribution centers with the same network operating systems and network management that offer automation, policy enforcement, and assurance inside. Cisco Software-Defined WAN (SD-WAN) is a secure architecture that is open, programmable, and scalable. Managed through the Cisco vManage console you can quickly establish an SD-WAN overlay fabric to connect data centers, branches, campuses, and remote sites to improve network speed, security, and efficiency.

This CVD outlines the steps for both IT and operations teams to accomplish business goals by digitizing the operations in the outdoor spaces of an enterprise. It includes guidance for implementing Extended Enterprise use cases with the customer's existing Cisco SD-WAN architecture.

References

To learn more about Extended Enterprise solutions, please visit:

- https://www.cisco.com/go/extendedenterprise
- https://www.cisco.com/go/iotcvd

Scope and Audience for this Document

This implementation document provides deployment guidance for an Extended Enterprise network design. It is a companion to the associated design and deployment guides for enterprise networks, which provide guidance on how to deploy the most common implementations of Cisco SD-WAN. This guide discusses the extended enterprise implementation for Cisco SD-WAN deployments.

For the associated deployment guides, design guides, and white papers, refer to the following documents:

- Cisco Enterprise Networking design guides:
  - https://www.cisco.com/go/designzone

- Cisco IoT Solutions validated design guides:
  - https:/www.cisco.com/go/iotcvd
- Cisco Extended Enterprise Solutions Overview:
  - https://www.cisco.com/go/extendedenterprise
- *CVD SD-WAN Design Guide* at the following URL:
  - https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/EE/DG/ee-WAN-dg.html
- *Cisco Extended Enterprise Cisco SD-WAN End-to-End Deployment Guide:*
  - https://www.cisco.com/c/dam/en/us/td/docs/solutions/CVD/SDWAN/CVD-SD-WAN-Deployment-2018OCT.pdf

What is in this Guide?

This document is organized in the following sections:

Implementation Overview, page 8	Discusses overall network topology and considerations
Network Planning, page 13	Detailed list explaining required network planning activities
Polcies, page 14	Details configuration of centralized and localized policies needed for extended enterprise implementation
Template Configuration, page 34	Explains feature templates and device templates. It provides a blueprint for feature template configuration and shows how to integrate them into a device template.
Device Onboarding, page 63	Provides steps to add Cisco IR1101 running IOS XE SD-WAN image to the SD-WAN overlay
Device Management, page 74	Shows how to perform operational actions on Cisco IR1101 using vManage
Monitor, page 76	Explains how to use vManage to monitor and troubleshoot SD-WAN network
Caveats and Limitations, page 87	Lists known caveats and limitations

Implementation Overview

The Cisco SD-WAN for an Extended Enterprise deployment is based on the *Cisco SD-WAN End-to-End Deployment Guide* and expands its scope to non-carpeted spaces using Cisco 1100 Series Industrial Integrated Services Routers as the SD-WAN edge router. This implementation supports controllers running on the Cisco cloud-managed service or on customer premises.

Prerequisites

- This guide assumes that the user has already installed Cisco SD-WAN controllers. For more details on installation see the following resources:
  - On-premises deployments: https://www.cisco.com/c/en/us/td/docs/routers/sdwan/configuration/sdwan-xe-gs-book/cisco-sd-wan-overlay-network-bringup.html
  - Cloud deployments: https://www.cisco.com/c/en/us/td/docs/routers/sdwan/knowledge-base/cloudops.html

- Data center and enterprise branch sites are already configured per *Cisco SD-WAN End-to-End Deployment Guide.*
- Cisco WAN Edge routers are installed and ready to be configured. The IOS XE SD-WAN routers should already be converted from IOS XE to SD-WAN code. See **Appendix A - Upgrade Cisco IR1101 with IOS XE SD-WAN Image** for information on the conversion.
- Devices adjacent to the Cisco WAN Edge routers are configured.

The Cisco SD-WAN solution and its associated concepts are understood, although no deployment experience is required. See the **Extended Enterprise SD-WAN Design Guide** for background information.

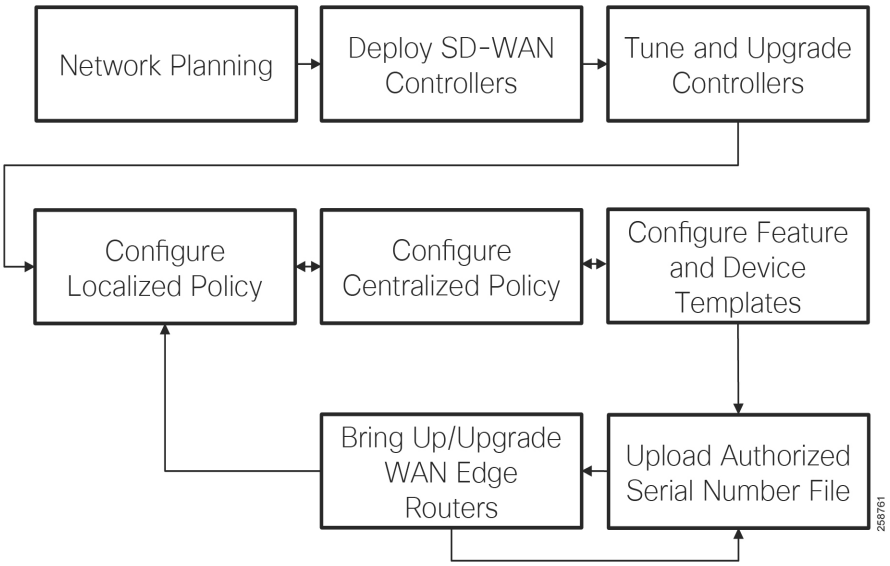
- vBond IP address or hostname must be configured under the vManage administration settings.
- vSmart is attached to a template.

Deployment Steps

As explained in the accompanying design guide, in order to have a fully functional SD-WAN overlay, there are a number of steps that need to be taken. The following image illustrates one example workflow that can be used as a reference. The order on the workflow for configuring policies and templates is flexible, the diagram shows the order followed in this guide.

For Extended Enterprise deployment, it is assumed that these steps are already implemented for enterprise devices as explained in the prerequisites. This guide will focus on the details pertaining to the addition of a non-carpeted remote site such as network planning considerations for extended enterprise, template and policies configuration, and onboarding of Cisco IR1101. In addition, this guide will cover management, monitoring, and troubleshooting for the Cisco IR1101.

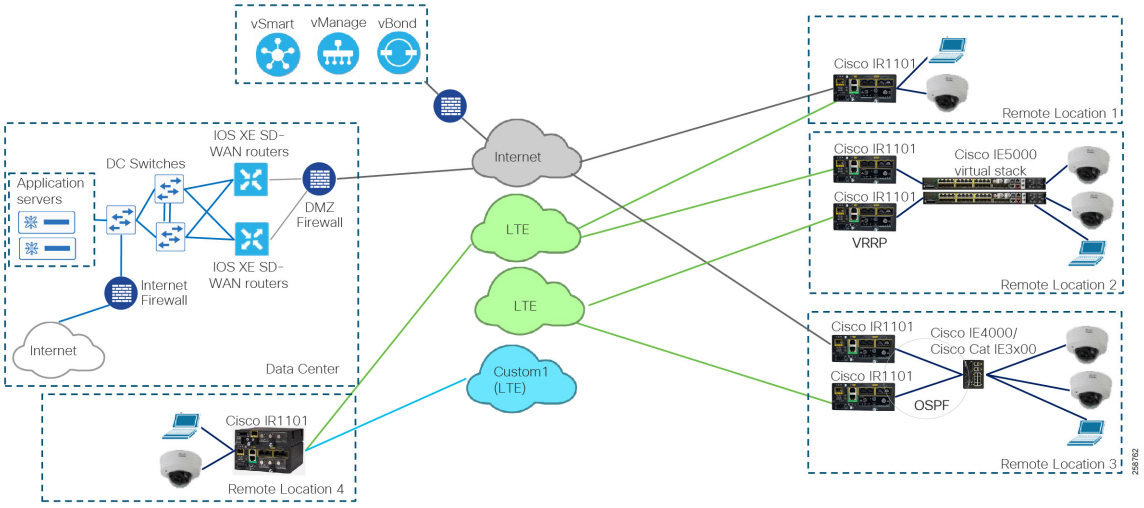
Figure 1 Deployment Flow Chart



Deployment Example

The following diagram shows the validated topology including a data center and four remote sites. In addition to the remote sites, branches can be added to the topology as shown in the **Cisco SD-WAN End-to-End Deployment Guide**. The four remote locations shown in the topology are an extension to the enterprise design.

Figure 2 Validation Topology



The routers are connected using different transport networks. In this implementation only public transports are used: Internet and Long-Term Evolution (LTE) networks. Tunnels are created on the device to send encrypted data over a transport and each tunnel on a device uses a different color. A color is one of the Cisco SD-WAN tunnel identifiers, there are 16 available colors to assign to a specific tunnel. In this example, tunnels use three colors: biz-internet, lte, and custom1 for an optional LTE network connection on a router. In the topology diagram biz-internet is shown as gray, lte as green and custom1 as blue. The tunnels are created without using the “restrict” setting, allowing you to establish inter-color tunnels. This means that remote site tunnels using biz-internet color can establish tunnels to other locations using the LTE or custom1 color as an example.

The SD-WAN controllers are deployed on premises, but the Cisco cloud-managed service is also supported. Controllers are reachable via the Internet transport. There is one vManage, one vSmart controller, and one vBond orchestrator; redundancy for the controllers is not covered in this guide.

Each IOS XE SD-WAN router attempts to make a connection to the controllers over each transport. It will initially connect to a vBond and will then connect to the vSmart controllers over each transport. Only one vManage connection is made from the IOS XE SD-WAN router, and it will depend on which transport first connected to it, but this preference is configurable.

Remote Site Connections

The design considers IOS XE SD-WAN router network connectivity as follows:

- Control connections: secure connectivity between the router and the SD-WAN controllers using Datagram Transport Layer Security (DTLS). It is established on the transport VPN (VPN0).
- Transport connections: secure tunnels between IOS XE SD-WAN routers. It is established using the transport VPN (VPN 0).
- Service VPNs: carry service-side data for devices connected to the IOS XE SD-WAN routers. Multiple service VPNs can be configured to provide traffic segmentation.

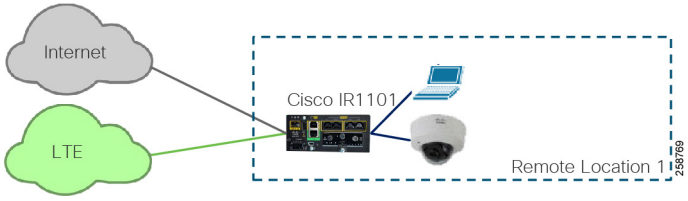
Note: the out-of-band management network (VPN 512) is not used for remote sites because it requires an additional connection.

Remote Site Examples

Each of the remote locations is an example of implementation:

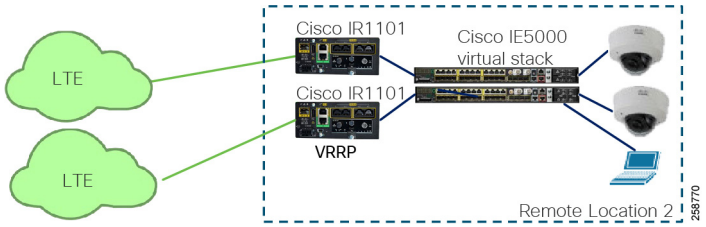
- Remote location 1 shows a single router with two WAN connections, one wired and one LTE.

Figure 3 Remote Location 1



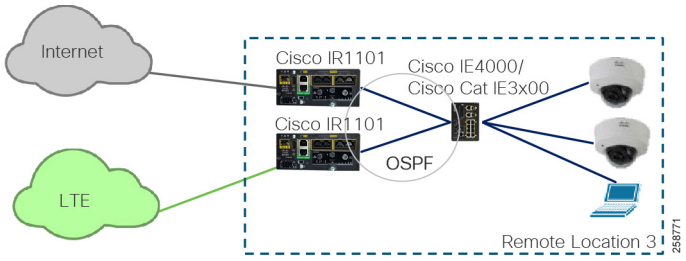
- Remote location 2 shows a site with two routers running Virtual Router Redundancy Protocol (VRRP) for hardware redundancy. Optionally, the routers may be connected to a virtual stack of switches to provide redundancy on the access switch too. Note that the switches need to be in a stack configuration because currently there is no support for channel or spanning tree protocol. Additionally, the connected switch can provide Power over Ethernet (PoE) to devices connected to it.

Figure 4 Remote Location 2



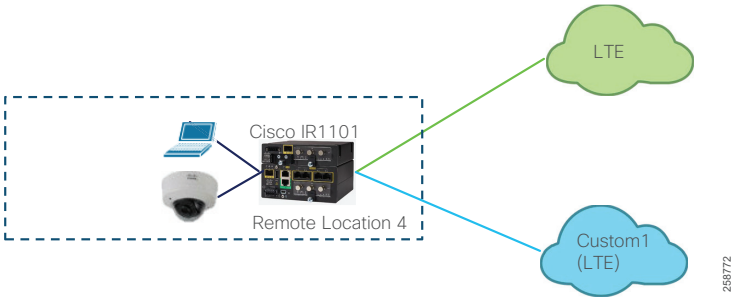
- Remote location 3 shows a site with two routers connected to a switch using Layer 3 connections and running Open Shortest Path First (OSPF) as the routing protocol to provide hardware redundancy for the Cisco IR1101. The router interfaces are configured for OSPF network point-to-point for each interface connected to the switch. As previous stated, the connected switch could be a stack of switches or a single switch. In this example, a single switch is used. The access switch is also used to provide PoE to devices.

Figure 5 Remote Location 3



- Remote location 4 shows a Cisco IR1101 with an expansion module. In this configuration the router can have dual LTE connections. A wired connection in addition to this is also possible but not shown in this example.

Figure 6 Remote Location 4



In all cases, static default routes pointing to the next-hop gateways are configured for tunnel establishment on all transports. Also, transport interfaces are configured for DHCP in order to dynamically obtain an IP address and gateway address. Nevertheless, an example of static configuration will be shown for reference.

Service-side configuration in this deployment has three service VPNs: shared services (VPN 1), IoT devices (VPN 10), and employee (VPN 11). This is to showcase how to configure segmentation on the service side, and by using the service-side segmentation IoT devices can be isolated from employee services for security. As an example, IP cameras connected to the IoT devices VPN are completely isolated from employee devices.

Service networks on the Cisco IR1101 are configured using Switched Virtual Interface (SVI). An SVI must belong to only one VPN but multiple SVIs can belong to same VPN. For example, IP Cameras and Badge readers can use different IP ranges but belong to the IoT VPN at the same time. The switchports on the Cisco IR1101 can be configured as trunks carrying multiple SVIs when connecting to a switch as in remote locations 2 and 3. Alternatively, they can be configured as access ports for directly connected devices as in remote locations 1 and 4.

It is not necessary that every remote site is configured with all service VPNs. Templates for a specific location can be customized to exclude service VPNs not needed at a site. For example, a site with only IoT endpoints does not need employee or shared services VPNs.

Validated Hardware and Software Matrix

The following table contains a list of the verified hardware and software components.

Table 1 Validated Components

Role	Cisco Platform	Version
Extended enterprise remote site WAN routers	IR1101	IOS XE SD-WAN 16.12.1d
Extended enterprise remote site WAN routers expansion module	IRM-1100-SPMI	NA
Cellular Modules for Cisco IR1101	P-LTEA-EA P-LTEA-US P-LTEA-VZ	NA
Extended enterprise Service Side Switch/Router	IE4000 / IE5000	15.2(7)E0
	Catalyst IE3200 / IE3300 / IE3400	16.12.1
SD-WAN controller	vBond, vSmart, vManage	19.2
Data center WAN routers	ISR4321	IOS XE SD-WAN 16.12.1d

Network Planning

As part of network planning it is important to consider the following items when deploying templates and policies:

- Device placement, system IP addresses, and site IDs; For site ID, consider using 32 bits for site identification as shown in the table. This numbering system allows for scale.

Table 2 Recommended for Site ID

Continent	Country	Site Number
1-7	1-999	1-9999

- Define transports and colors: Which devices will be connected to which transport? This will influence which interface templates are needed on the device.
- Define services for a site: What service networks do you need? What is the desired Segmentation? Which sites need access to which services?
- Plan for LAN networks: Do you need switch ports or access ports on the local site? Is the IOS XE SD-WAN router connected to a switch?
- Define redundancy options for a site: Are you using a routing protocol such as OSPF? Are you using VRRP for hardware?
- Is there a preferred path for devices with multiple transports? Deep Packet Inspection (DPI) may require selecting a preferred path for traffic symmetry as explained later in the document.

Consider policies that may be needed. Policies can be created as part of planning or during day-n operations, but it is recommended to determine policy items before deployment. The policy wizard guides you through complete policy configuration, so knowing beforehand what policy elements are important for your deployment may simplify the process. Moreover, local policies need to be applied to device and feature templates; for this reason, configuring policies before templates eliminates the need to edit templates later.

For centralized policies consider:

- What is the desired topology or connectivity among WAN Edge routers? Is the topology applicable to all VPNs?
- What are SLA classes and requirements?
- What traffic needs to be classified and how?
- Do you need policers for incoming traffic?
- Do you need to restrict any applications?

For localized policies consider:

- Do you require any access control lists (ACLs)?
- What is the bandwidth distribution for different types of traffic?
- Is there a need for different scheduling policies depending on interface, for example LTE versus wired interfaces?
- Do you need any policies that affect local routing?

Polcies

Policy influences the flow of data traffic among the IOS XE SD-WAN routers in the overlay network. There is a clear separation between control and data plane policies. Control policies affect the flow of routing information in the network control plane while data policies affect the flow of data traffic in the network data plane.

Policies are configured either centrally or locally. Centralized policy is provisioned on the centralized vSmart controllers in the overlay network, and localized policy is provisioned on the IOS XE SD-WAN routers. Centralized policies affect network wide while localized policies affect local network and interfaces.

Some results can be achieved using either policy, and this guide provides an example for a centralized policy as well as a local policy both affecting data and control planes. An explanation of key policy components and objective is provided in addition to steps for configuration.

The examples provided showcase a subset of use cases, but it is not a comprehensive guide to SD-WAN policies. For more information and options please refer to https://www-author4.cisco.com/c/en/us/support/routers/sd-wan/products-installation-and-configuration-guides-list.html

In this deployment we describe the policies in the following table:

Table 3 Policy examples used in the implementation

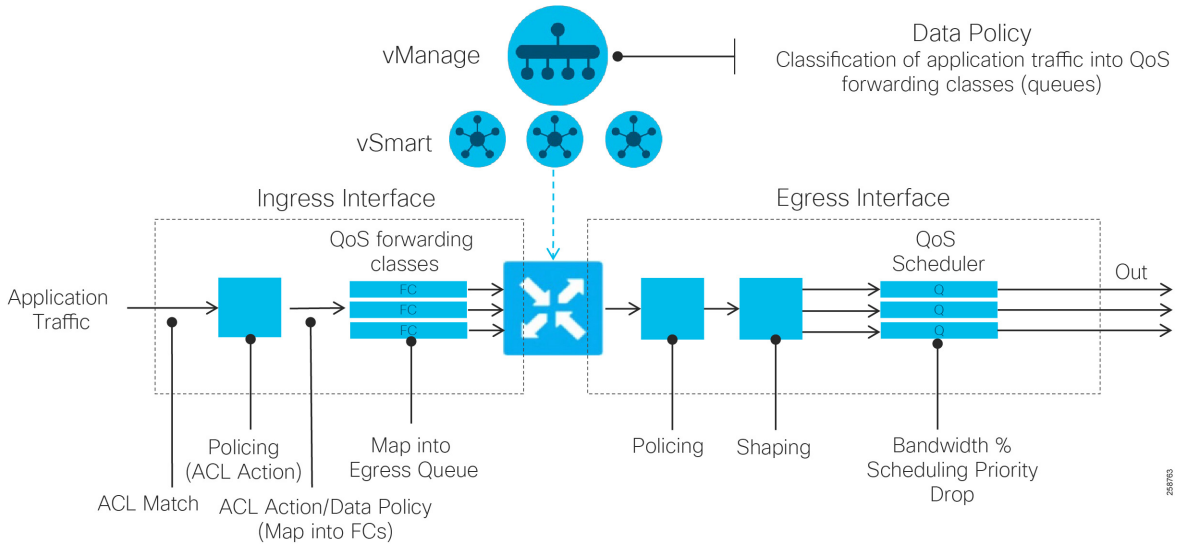
Use case	Description	Type of policy used	Implementation
Configurable VPN Topology	A VPN topology is configured mirroring ***Cisco SD-WAN End-to-End Deployment Guide***, using hub and spoke topology for low bandwidth sites and mesh for high bandwidth sites. Alternatively, different topologies can be applied per VPN.	Centralized control	Configured in vManage Applied to vSmart affecting OMP routing information sent to IOS XE SD-WAN routers
Ensure SLA compliance	Application Aware Routing policies ensure SLA compliant path through the SD-WAN fabric. The SLA class defines loss, latency and jitter thresholds.	Centralized Application aware routing	Configured on vManage, enabled on vSmart controllers and enforced on IOS XE SD-WAN routers
Consistent classification and policing	Classify incoming data packets into multiple forwarding classes based on importance. Police incoming traffic. Match could be done based on application, DSCP, packet properties, source or destination. Localized policies could also be used, but note that localized policies do classification using up to layer 4 parameters. Centralized policies provide layer 7 visibility.	Centralized data policy	Configured on vManage, enabled on vSmart controllers and enforced on IOS XE SD-WAN routers
Schedule traffic based on importance	QoS map is defined to specify bandwidth and loss priority for every forwarding class. This enables you to determine how to prioritize data packets for transmission to the destination.	Localized data policy	Configured on vManage and applied to IOS XE SD-WAN router. Associated to a WAN interface on the router.
Influence local routing	Is used to influence routing decisions on the local site. On this implementation, it is used in the following cases: ■ To establish a preferred route for OSPF in a redundant router configuration. ■ To guarantee VRRP switchover when the primary loses connection to the transport.	Localized control policy	Configured on vManage and applied to IOS XE SD-WAN router. Associated to features templates.
Create policies that restrict undesired communication	ACLs can be created to limit communication. It is possible to configure as centralized policy too.	Localized data policy	Configured on vManage and applied to IOS XE SD-WAN router. Associated to a WAN interface on the router.

QoS deployment

The following diagram shows how quality of service (QoS) works on IOS XE SD-WAN routers. At the service side traffic is classified according to a data policy, marked, re-marked, policed, and mapped into a forwarding class. On the transport side, traffic is policed, shaped, and scheduled. For this implementation, classification and ingress policing is done using centralized policies. Centralized policies are preferred instead of localized policies because it allows for application-aware classification, and it can be applied to all routers consistently from vSmart and eliminates the need to configure the policy on the specific interface templates.

On the other hand, scheduling and shaping can only be done in localized policies. Policing at the egress side is not covered in this document but it may be desired when there is a significant bandwidth difference between transports. Also, re-marking is not covered in this document but it is covered in the Cisco SD-WAN End-to-End Deployment Guide; the guide describes how to rewrite the DSCP values in the tunnel header in the event that the service provider supports less DSCP classes in use.

Figure 7 XE SD-WAN QoS



The following is an example of configuring a six-class QoS model. The table illustrates the bandwidth percentage and buffer percentage, the congestion avoidance algorithm. This is provided as an example; implementation parameters will depend of specific network requirements. In XE SD-WAN, the QoS configuration is limited to a maximum of eight classes.

Note: Queue 0 is always priority or Low-Latency Queuing (LLQ) and is used for Bidirectional Forwarding Detection (BFD) and SD-WAN control traffic. In this implementation voice traffic shares the low latency queue with SD-WAN control traffic.

Table 4 QoS Deployment Example

Class	DSCP	Scheduling Type	Bandwidth (Wired interface)%	Bandwidth (LTE interface)%	Congestion Avoidance Algorithm	Queue	Policer
Voice	EF/46	Priority Queuing (PQ)	10	10	Tail	0	
Broadcast-Video	CS5/40	Weighted Round Robin Queueing (WRR)	20	60	Tail	1	Policer-HD-Camera-4MB-drop
Network-Control	CS6/48	WRR	5	5	Tail	2	
OAM	CS2/16	WRR	10	10	Tail	3	OneMB-drop
Signaling	CS3/24	WRR	5	5	Tail	4	
Scavenger	CS1/8	WRR	50	10	Random Early Drop (RED)	5	

The following table describes the policer used.

Table 5 Policer List Example

Name	Burst	Exceed	Rate
Policer-SD-Camera-1MB-drop	20000000	Drop	1000000
Policer-HD-Camera-4MB-drop	80000000	Drop	4000000
OneMB-drop	20000000	Drop	1000000

Steps to configure the policies will be described in the Localized Policies and Centralized Policy. Centralized Policy sections, and will cover the following topics:

1. Map each QoS forwarding class to an output queue (localized policy).
2. Configure the QoS scheduler, which assigns the scheduling method, bandwidth percentage, and drop algorithm for each forwarding class (localized policy).
3. Create a QoS map, where all of the QoS schedulers are grouped (localized policy).
4. Define an access list to match traffic and assign to forwarding classes (centralized policy). Apply policer if desired.
5. Apply the classification access list to an interface (localized or centralized policy). In localized policy, this is accomplished by referencing the access list in the VPN Interface template. For centralized policy, this is accomplished by applying the QoS data policy to a site and VPN list.
6. Apply the QoS map to an egress interface (configured in the VPN Interface Ethernet template).

Localized policies

Localized policies are configured on vManage and provisioned directly on the IOS XE SD-WAN routers. Localized control policy examples are route policies, which can affect OSPF routing behavior on the local site network and affect routing into or out of that specific site. Localized data policy controls the data traffic into and out of interfaces and interface queues on a WAN Edge router. Examples include access lists, which allows you to classify traffic and map the traffic to different classes, or traffic mirroring, policing, and QoS.

Note that only one localized policy can be applied per device, but one policy can be shared across many devices. It is possible to create a localized policy that applies to all remote sites, or to create smaller policies and apply different ones to different site types. Localized policy is attached to a device template. Once the policy is attached to the template and deployed to the device, the route policies, access lists, and other components in the policy can be referenced in any of the feature templates attached to the device template. You will not be able to configure a feature template in a device template that contains a policy element without having a policy attached to the device template. If a device template has been attached to a device and you try to update one of the referenced feature templates with a policy element, but a policy has not yet been attached, the configuration update will fail.

In this section we will create a local policy that has the elements described in the table. Those elements are:

- QoS map to allocate bandwidth to queues. A queue is previously linked to a configured forwarding class.
- Route policy for OSPF route preference when there are redundant routers as the example shown in Remote location 3. Setting a preference is needed to guarantee traffic symmetry needed for DPI as explained later in this section.
- Route policy to track route for sites running VRRP. A prefix list containing a route in order for VRRP to track on it. When the OMP prefix route disappears, the primary router gives up VRRP primary status.
- ACLs to restrict unwanted traffic. In this implementation a policy is created to restrict traffic among IP cameras. IP cameras should only communicate with video server, so restricting IP camera to IP camera traffic could prevent a malicious device to be connected to a camera port and reach or infect other devices.
- Flow visibility.
- Application visibility, or Deep Packet Inspection (DPI) is used to classify applications and put them on different SLA classes.

Traffic Symmetry for DPI on Dual Router Scenarios

In order for DPI on a WAN Edge router to be able to classify most application traffic, it is important that the WAN Edge router sees network traffic in both directions. To ensure symmetry at dual WAN Edge router sites, traffic should prefer one router in both directions, from the LAN to the WAN and from the WAN to the LAN over the overlay.

In this implementation traffic is influenced by:

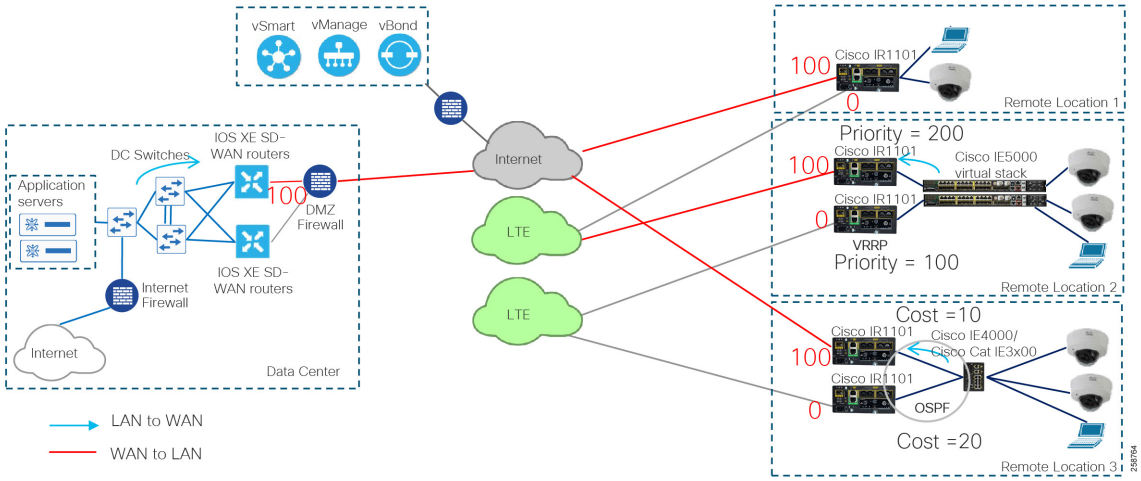
Table 6 Determining Traffic Path on Dual Router Scenario

Direction	Parameter
WAN to LAN	Tunnel preference is one way to control WAN to LAN direction. This parameter is contained within the Tunnel section of the interface templates, and a variable was already created for it when the feature templates were created. When attaching a device to a template, select preference values to achieve desired topology.
LAN to WAN (applies only to redundant sites)	For sites running VRRP as remote location 2 in the diagram, the preferred path is defined by VRRP priority. For sites running OSPF as remote location 3 shown in the diagram, route is influenced by localized route policy. On Data center running BGP, route is influenced by localized route policy as explained on *Cisco SD-WAN End-to-End Deployment Guide.*

Note that there are other ways to influence traffic path such as application aware routing. Make sure to think about traffic symmetry for DPI on dual router scenarios when designing your network.

The following diagram shows preferred path for each router in this implementation in red, the numbers next to the tunnels indicate tunnel preference. 100 is configured for higher preference, other tunnels are configured with default value of zero.

Figure 8 Symmetric Traffic Configuration for DPI

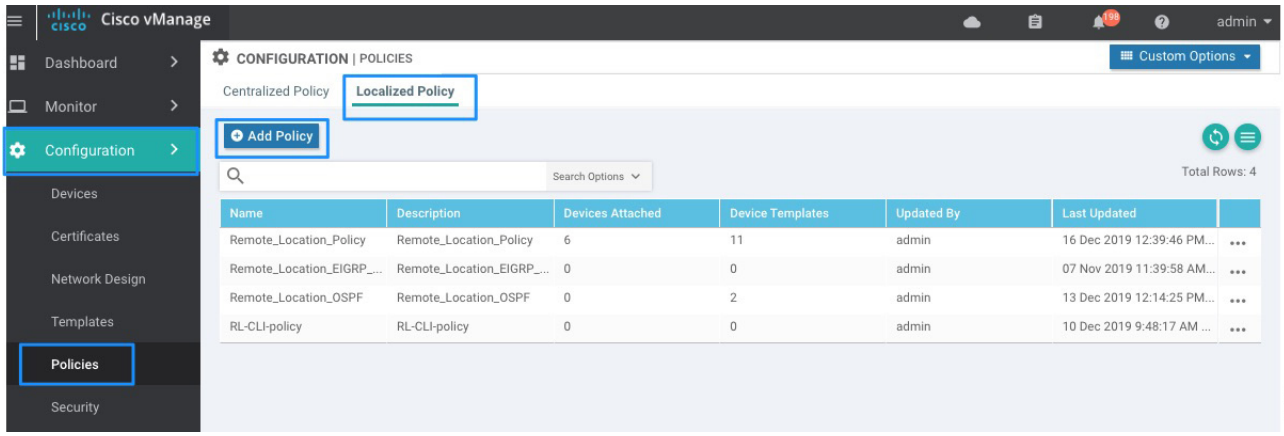


Configure Localized Policy

To configure the localized policy complete the steps below.

1. Go to **Configuration > Policies**.

Figure 9 Local Policy Creation



2. Select the **Localized Policy** tab.
3. Click on **Add Policy** to open the policy wizard.

Create Groups of Interest

The first step is to create groups of interest that will be used for matching or to perform actions later in the policy.

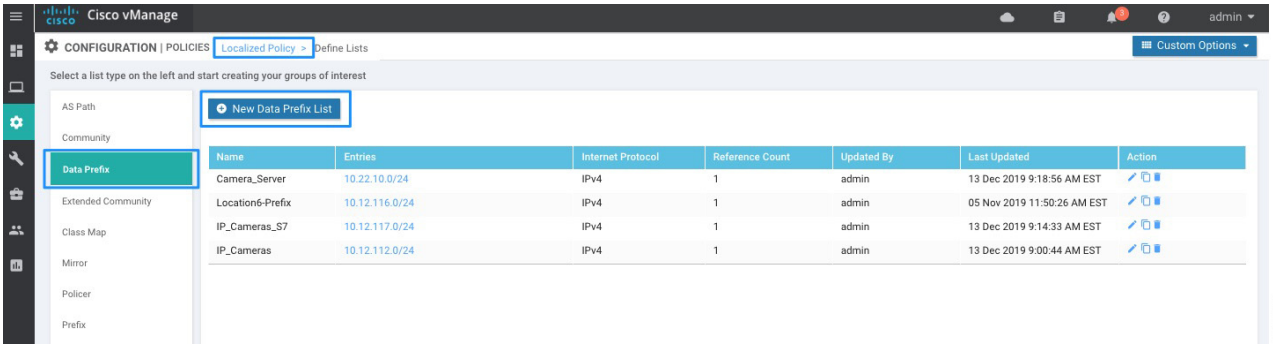
4. Select **Data Prefix** from the left panel. In this implementation data prefixes are created to use in ACLs. Click **New Data Prefix List**.

5. Enter a name, select **IPv4** radio button, and add the data prefix with network mask. Click **Add** and repeat for every data prefix. Use the following example as reference.

Table 7 Data Prefix List Example

Name	Data Prefix
IP_Cameras_S7	10.12.0.0/16
Camera Server	10.22.10.0/24

Figure 10 Define Lists Example



6. Another group of interest is the class map to be used for QoS scheduler. These provide a mapping from the Forwarding Class to an output queue. Select **Class Map** from the left panel.

7. To add a new entry, click **New Class List**. Enter a class name and select an option from the Queue drop-down list. Click **Save**. Table 4 QoS Deployment Example can be used as an example. Note that there is no need to create a class for queue 0 since this class is always created. Class 0 is used for Bidirectional Forwarding Detection (BFD) and SD-WAN control traffic.

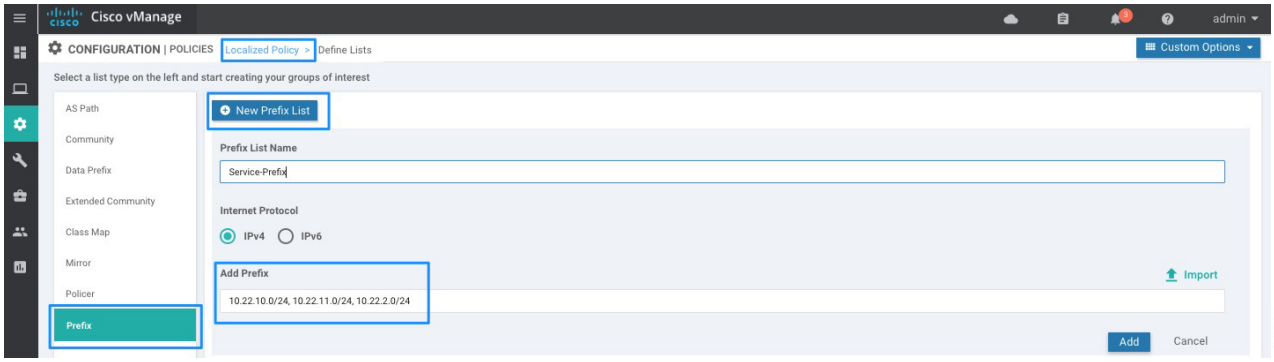
Table 8 Class List Example

Class	Queue
Broadcast-Video	1
Network-Control	2
OAM	3
Signaling	4
Scavenger	5

8. Next, create prefixes. The prefix in the example will be used to track a route on a remote site for VRRP switchover when transport is unavailable on the primary router. Click **Prefix** on left panel and then click **New Prefix List**.

9. Enter a list name, click the **IPv4** radio button, and enter the prefix with network mask; make sure the prefix is available on a remote site or data center, otherwise the VRRP router will not become active. The prefix could define the default route if available. It is possible to add more than one prefix separated by comma. Click **Add**.

Figure 11 Add a Prefix List



Configure Forwarding Classes/QoS

10. After all groups of interest are created, click **Next** on the wizard to move to the **Configure Forwarding Classes/QoS** step. This will define the Queue type, drop type (tail or random early), and bandwidth allocation per queue.

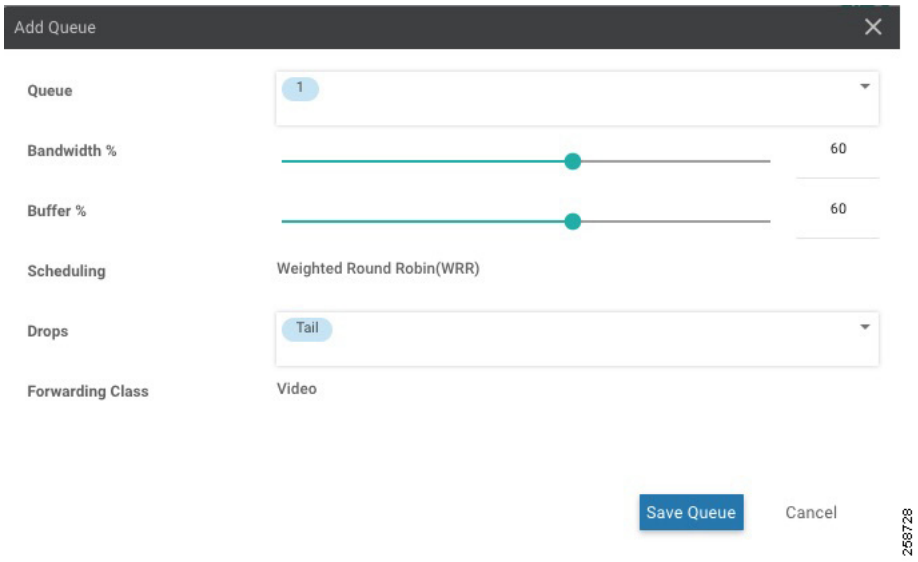
11. On the **QoS Map** tab, click **Add QoS Map**; a drop-down list with **Create New** or **Import Existing** appears. Choose **Create New**. Note that the **Import Existing** option could be used if a QoS Map was already created.

12. Add a name and description to the QoS map policy.

13. Click **Add Queue**.

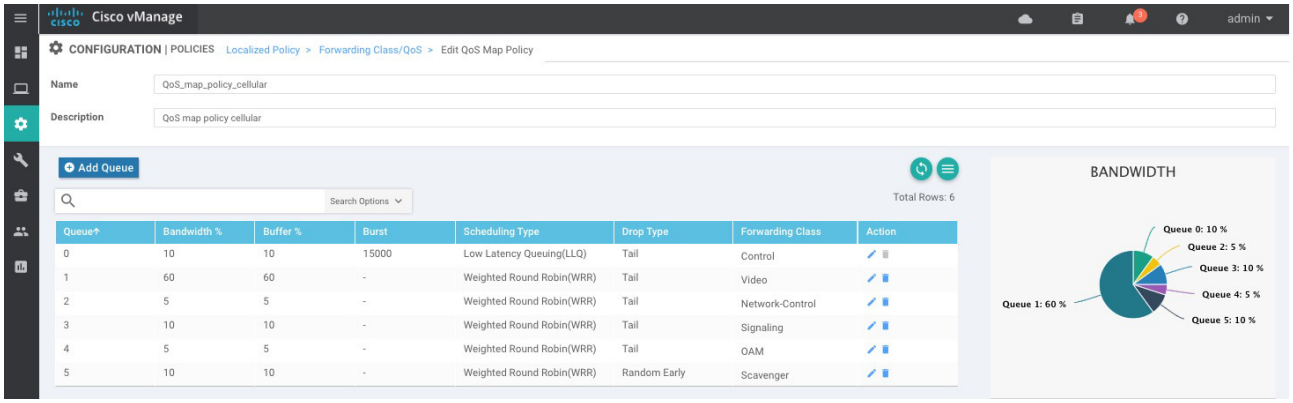
14. Select a queue and the bandwidth percentage using the slider. Select buffer percentage, scheduling type, and drop type. Note that the buffer percentage value does not apply to IOS XE SD-WAN routers at this release. Click **Save Queue**.

Figure 12 Add Queue



15. Repeat steps 13-14 for every queue configured on Step 7. Bandwidth for Queue 0 will be calculated automatically. Use Table 4 QoS Deployment Example for reference.

Figure 13 QoS Map Policy



16. Click **Save Policy**.

17. (Optional) Create another QoS Map repeating Steps 11 to 16. This will allow you to define different scheduler for interfaces where different bandwidth is expected, for example cellular versus Internet links. Each policy will allow traffic to be treated differently as shown in Table 4 QoS Deployment Example.

Configure Access Control Lists

ACLs are created to control data traffic. In this example, traffic among IP cameras is restricted. IP cameras need to reach the camera server only, and creating the ACL will prevent a malicious endpoint being connected to a camera port and accessing or infecting IP cameras.

18. Click **Next** to configure Access Control Lists.

19. Click **Add Access Control List Policy** and then select **Add IPv4 ACL Policy** from list. Alternatively, an already existing policy can be associated by selecting **Import Existing**.

20. Add a name (Camera-To-Camera-Deny) and description to the policy.

21. Click **Add ACL Sequence** on the left panel.

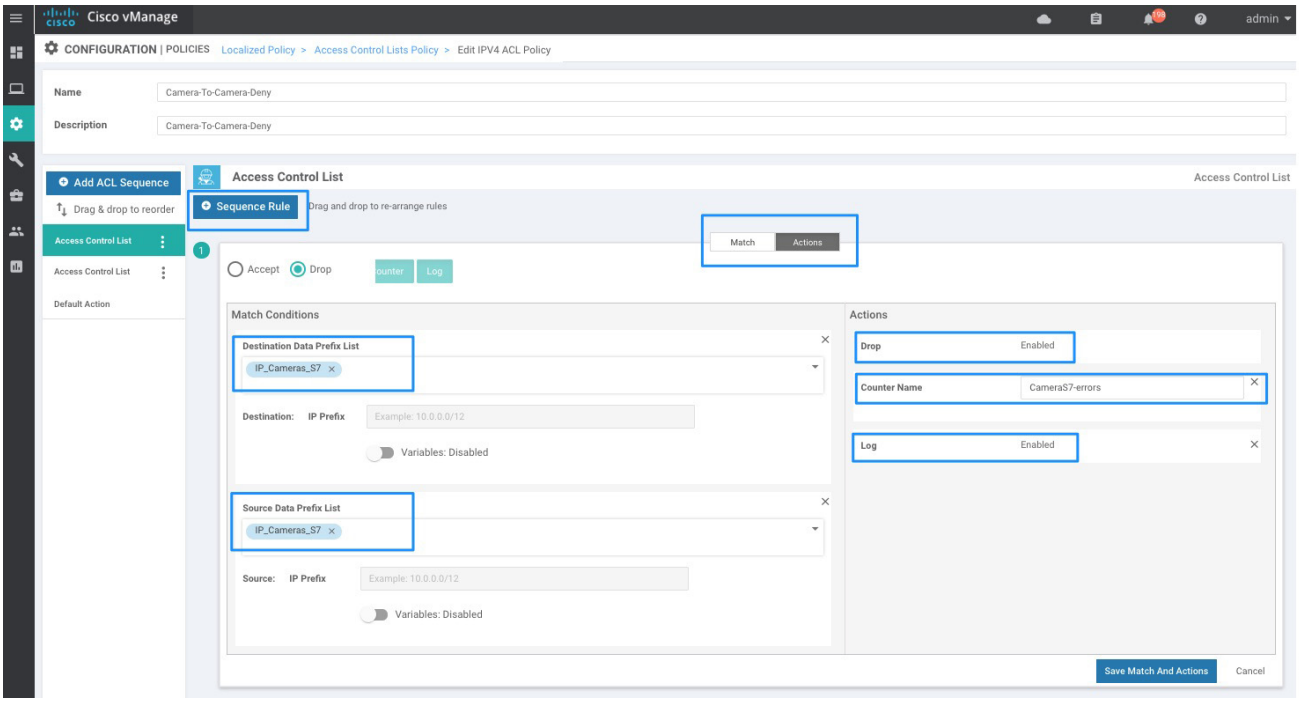
22. Click **Add Sequence Rule**. On the match tab, select **Source Data Prefix** and select a prefix from the list created at Step 5. Use Figure 9 for reference.

23. On the **Match** tab, select **Destination Data Prefix** and choose a prefix from the list created at Step 5.

24. On the **Actions** tab click the **Drop** radio button.

25. Optionally add a counter. Enter a name in the **Counter Name** field and set the **Log** field to **Enabled**.

Figure 14 Access Control List



26. Click **Save Match And Actions**.
27. Repeat Steps 21 to 26 if more entries are required.
28. Click **Default Action** on the left panel. Click the pencil icon to edit and select the **Accept** action. Click **Save**.
29. Click **Save ACL Policy**.

Configure Route Policy

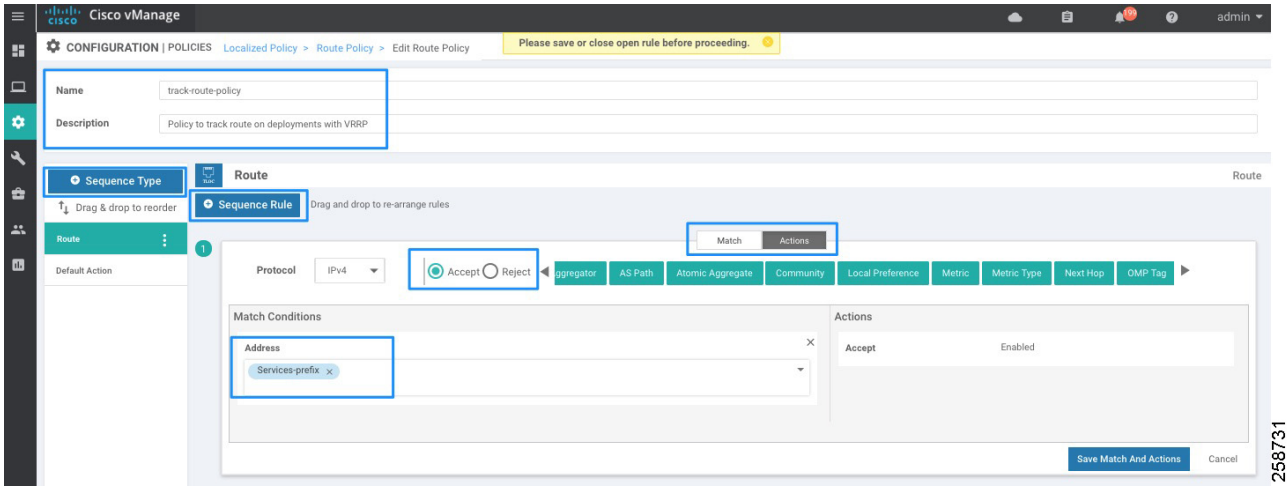
Three policies are created as explained in the Policy examples used in the implementation, page 15 table.

30. Select **Next** to move to **Configure Route Policy**. Click **Add Route Policy** and then select **Create New**.
31. Enter a name and description. For the policy used to track routes on deployments with VRRP redundant routers we are using:

    Name: track-route-policy

    Description: Policy to track routes on deployments with VRRP
32. Select **Sequence Type** on the left panel. Click **Sequence Rule**.
33. On the **Match** tab, select **Address**.
34. Select the prefix created on Step 9.
35. On the Actions tab, click the **Accept** radio button.
36. Click the **Save Match And Actions** button.

Figure 15 Local routing Policy Creation

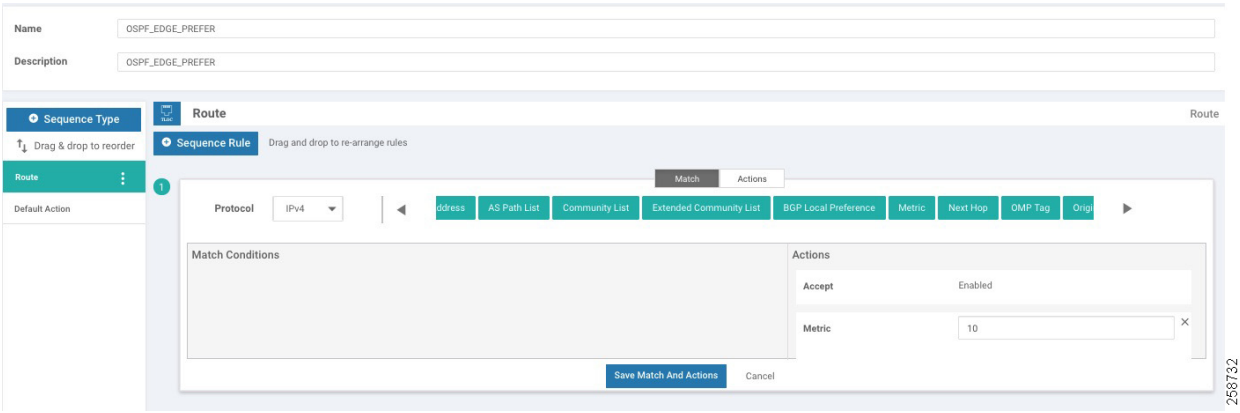


37. Select **Default Action** on the left panel. Click the pencil icon to edit, then click **Accept**. Click **Save**.
38. If creating policy for OSPF preferred route, repeat Steps 30 and 31 with settings:

    Name: OSPF_EDGE_PREFER

    Description: Policy to set OSPF routing preference to preferred router
39. Select **Sequence Type** on the left panel. Click the **Sequence Rule** button.
40. On the Actions tab, click the **Accept** radio button.
41. On the Actions tab, click **Metric** and then enter **10** in the Metric field.

Figure 16 Route Policy for OSFP preference



42. Click **Save Match And Actions**.
43. Select **Default Action** on the left panel. Click the pencil icon to edit, then click **Accept**. Click **Save**.
44. Repeat Steps 38 to 43 with the following parameters:

    Name: OSPF_EDGE_SEC

    Description: Policy to set OSPF routing preference to secondary router

Metric: 20

45. Click **Next** to go to Policy Overview.

46. Enter the policy name (**Remote_Location_Policy**) and description.

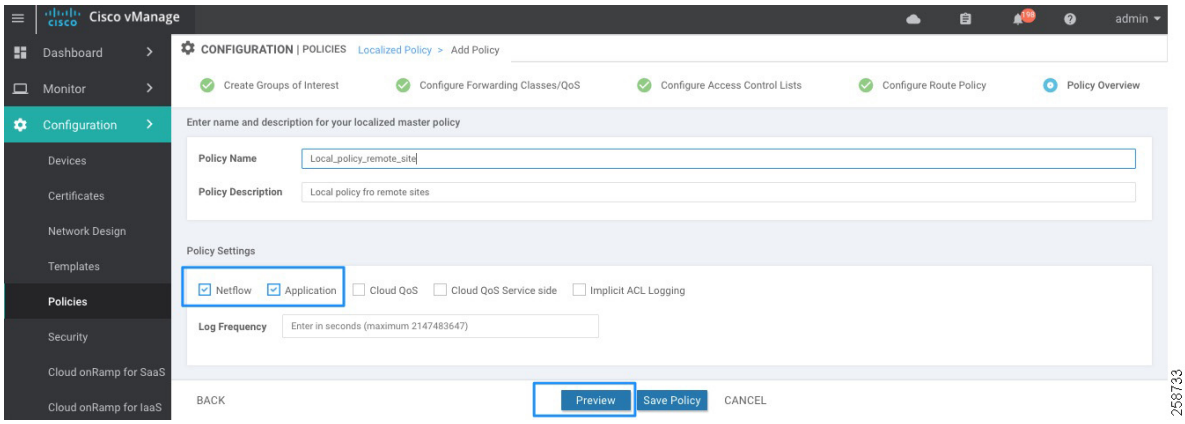
Enable DPI and NetFlow

In order to enable Deep Packet Inspection (DPI) and traffic monitoring follow these steps. These settings were configured but not validated as part of the scope of this CVD.

47. Check the **NetFlow** check box so the WAN Edge router can do traffic flow monitoring and send the information to vManage.

48. Check the **Application** check box to turn on DPI, or application visibility. DPI will allow a WAN Edge router to discover, monitor, and track the applications running on the LAN. This enhances the application information that appears within the vManage GUI.

Figure 17 Local Policy Preview



49. Click **Preview** to see generated CLI configuration output.

50. Click **Back** to make changes or click **Save Policy** to finish.

Tip: When saving a policy that has been already applied to devices, the wizard will continue to a Configuration Templates screen to show devices that will be updated. Click **Next** to preview changes and then click **Configure Devices** when you are ready to push the configuration. Confirm that you want to proceed.

Centralized Policy

Centralized policies are configured on vManage and downloaded to vSmart nodes. They use lists such as network prefixes, colors, and SLAs for defining targets of policy application and matching. Policy application is applied to a set of sites configured on a site list.

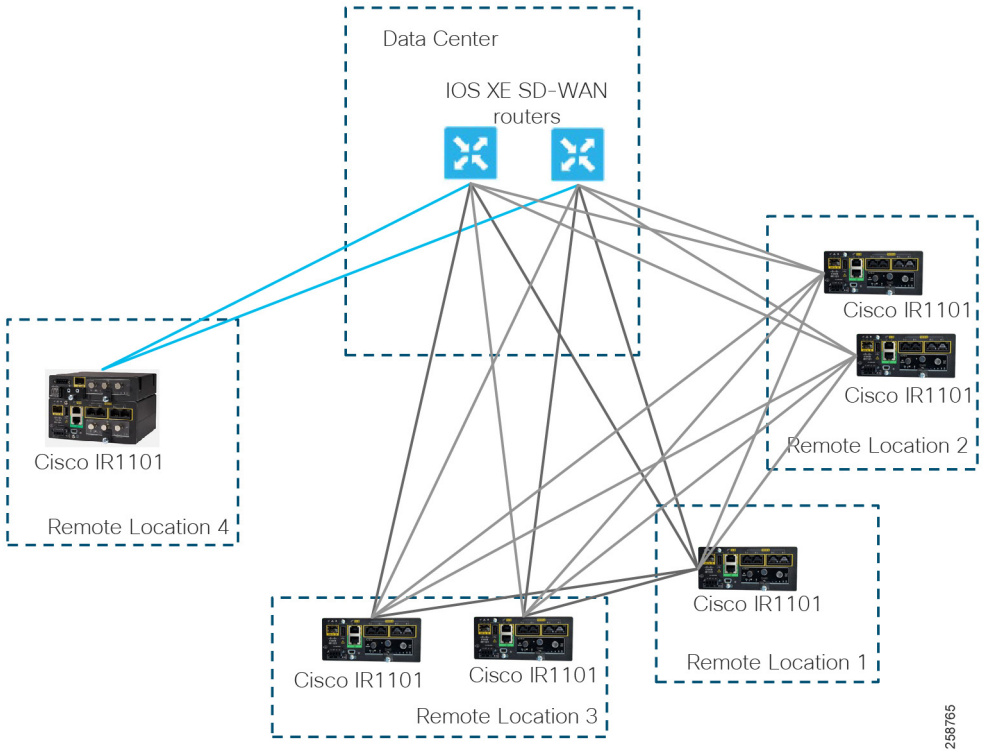
Centralized policies can be used to select the traffic path based on application SLA (application-aware routing), provide a consistent centralized data policy at the ingress on the service side (traffic policing, admission control, classification, marking and re-marking, path selection, service chaining), and affect traffic behavior for the entire SD-WAN fabric with control policies. Control policies are used for flexible VPN topology configurations, service chaining, traffic engineering, service and path affinity, and so on. Control policies act on OMP routing advertisements, whereas data policies act on application traffic characteristics.

Only one centralized policy can be downloaded to a vSmart controller at a time. The policy contains a series of control or data policy definitions inside the centralized policy that are applied to site and VPN lists. Once saved, the centralized policy will be downloaded to the vSmart controllers.

The centralized policy showcased in this implementation has the following objectives:

- Defines overlay topology. This example uses configuration from the *Cisco SD-WAN End-to-End Deployment Guide* in which low-bandwidth sites could use a hub-and-spoke topology to save bandwidth while higher bandwidth sites use a full-mesh topology. Control connections are depicted in Figure 18. Remote Site 4 is a low bandwidth site, only forming IPSec tunnels with the data center. This is accomplished by filtering routes and TLOC routes.
- Defines an application-aware routing policy. It affects traffic flowing from the service (LAN) side to the transport tunnel (WAN) side. Traffic is matched and placed into an SLA class, with certain loss, jitter, and delay values. The routing behavior is as follows:
  - Traffic will be load-balanced across all tunnels meeting the SLA class. If no tunnels meet the SLA, the traffic is sent through any available tunnel unless SLA is configured as “strict”. If the SLA is strict, traffic will only be forwarded if the SLA is met.
  - If preferred colors are specified in the policy, then traffic will be sent through the preferred color tunnels as long as the SLA is met. If no tunnels meet the SLA, the traffic is sent through any available tunnel.
  - If a backup-SLA preferred color is specified, then that tunnel is used when there are no paths that meet the SLA. Another path is used if the backup tunnel is unavailable.
  - The policy can be configured with no default action, meaning, if traffic does not match any sequence in the list, it is routed normally according to the routing protocol. Alternatively, this default traffic can be placed into an SLA class.
- Configure an access list to match traffic and assign to the forwarding class.
- Creates and applies policer for incoming traffic.

Figure 18 Customized Topology



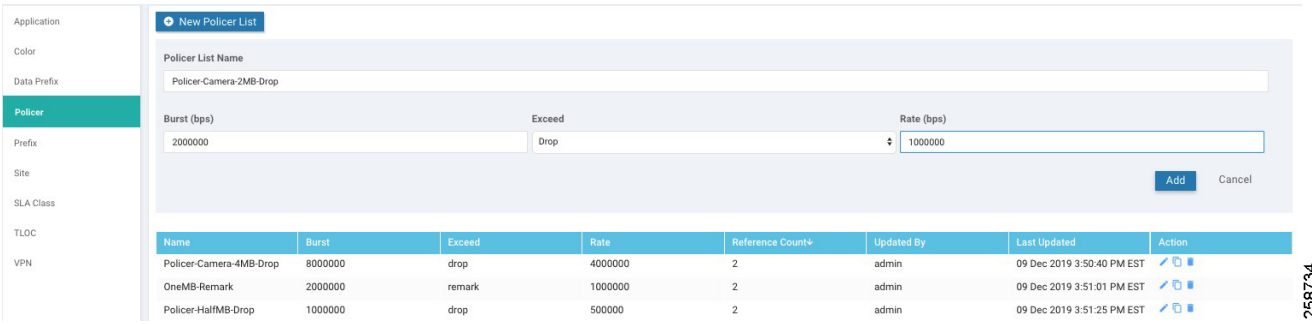
Configuration of a Centralized Policy

Create Groups of Interest

Similar to the local policy creation, the first step is to create lists that will be used in the policy, such as application, color, data prefixes, policer, prefix, site, SLA class, TLOC, and VPN lists. At a minimum, a list of site IDs is required to apply the individual policy definitions. Additionally, a list of the Service VPNs to which the policy may apply may be required.

1. (Optional) Create any application lists to match traffic based on application characteristics. This allows you to group applications so that you can reference the group as a whole. Refer to the **Cisco SD-WAN End-to-End Deployment Guide** for steps and an example.
2. Select **Policer** on the left panel to create a policer list. Use Policer List Example, page 17 for reference. Click **New Policer List**.
3. Enter a name in the Policer List Name field and a bits per second (bps) value in the Burst field. In the Exceed menu, choose Drop or Remark actions. Enter a bps value in the Rate field.
4. Click **Add**.

Figure 19 Add New Policer List



5. Repeat Steps 2–4 as required.

6. Select **Site** on the left panel to create the site lists that will be used in the control policy. Click **New Site List**. The following lists are required for the example topology.

Table 9 Site List Example

Name	Entries	Purpose
Remote_Locations	10010200-10010400	Group all remote locations with Cisco IR1101
DC	10010100-10010199	Group all routers on data center
HB_Remote_locations	10010200-10010299	Apply a customized control policy to high bandwidth sites filtering low bandwidth sites
LB_Remote_Locations	10010300-10010399	Create hub and spoke topology for low bandwidth sites

7. Add name for the site list and sites. Click the **Add** button.

8. Select **SLA Class** on the left panel. Click **New SLA Class List** to add an SLA Class List for application-aware routing. There is a limit of four SLA classes that can be used by an application route policy. Use the following table for reference.

Table 10 SLA Class List Example

SLA Class list Name	Traffic type	Loss (%)	Latency (ms)	Jitter (ms)
SLA-Voice	Voice	1	150	30
SLA-Streaming-Video	Video	2	300	500
SLA-Operations	Network-Control	3	500	500
	Signaling			
	Network-Management			
SLA-Scavenger	Scavenger	5	500	500

9. Add an **SLA Class List Name**, and enter **Loss (%), Latency (ms)** and **Jitter (ms)** values. Click the **Add** button.

10. Select **VPN** on the left panel and click the **New VPN List** button. This list will be used to define where a policy may apply. It may be useful to create separate list if you want granularity. In this example a single list is created for all the service VPNs.

11. Add a name (service_VPN_all) and a VPN list or range.

12. (Optional) Select **Data Prefix** on the left panel. Click **New Data Prefix List** to add a prefix to use in match conditions for policies. For example, create a prefix for IP Camera Servers to be used for traffic classification. Enter a name, select IPv4 and enter prefixes. Click the **Add** button.

13. Click **Next** to configure Topology and VPN membership.

Configure Topology and VPN Membership

This is the control policy definition; it can be a predefined full-mesh or hub-and-spoke policy, or a customized route and TLOC policy. Optionally, it is possible to allow or restrict VPNs in certain sites (not covered in this document). As depicted in Figure 18 Customized Topology, Remote Site 4 is a low bandwidth site, only forming IPSec tunnels with the data center. If no policy is applied, the default configuration is a full mesh.

14. On the Topology tab, select the **Add Topology** button. Select one of the options from the drop-down list: Hub-and-Spoke, Mesh, Custom Control or Import Existing. To create a hub-and-spoke topology for low bandwidth sites, choose **Hub-and-Spoke**.

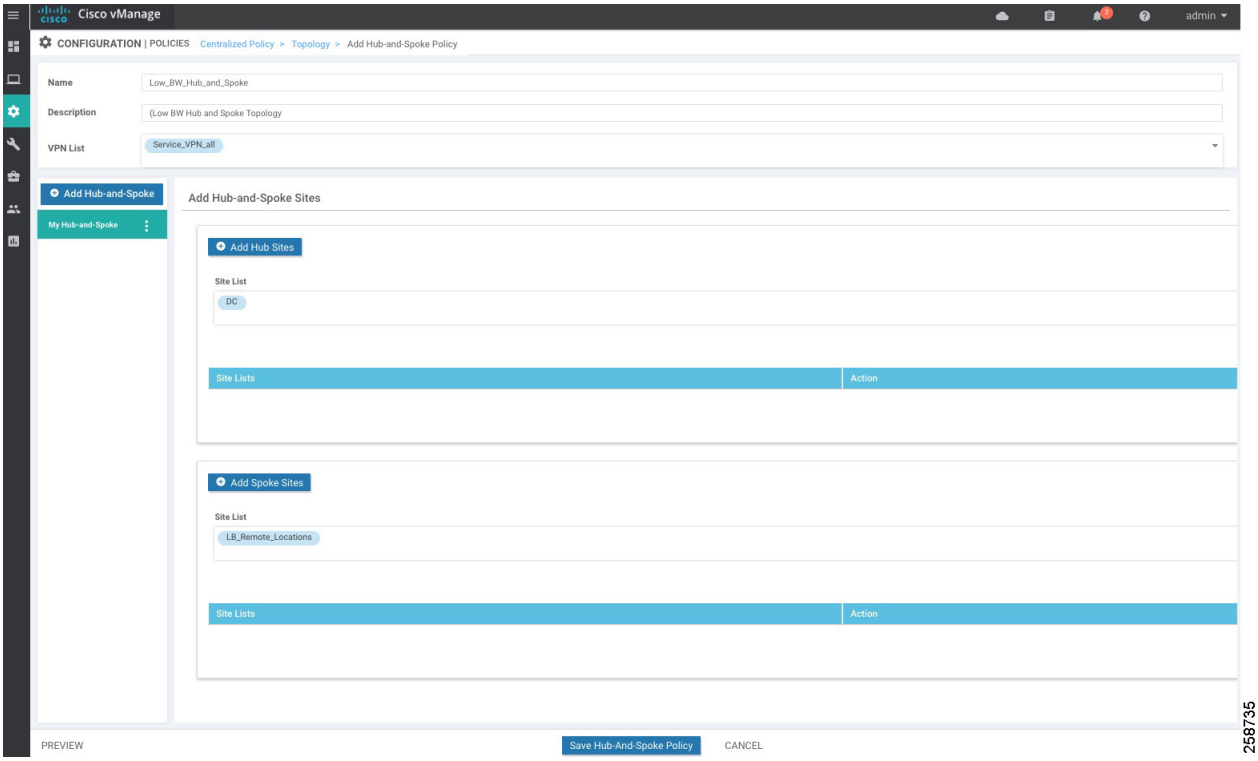
15. Provide a name, description, and select a VPN list.

16. Click the **Add Hub Sites** button. Choose **DC**.

17. Click the **Add Spoke Sites** button. Choose **LB_Remote_Locations**.

18. Click the **Save Hub-And-Spoke Policy** button at the bottom of the page. You have just finished a policy definition that needs to be applied to a site list.

Figure 20 Hub and Spoke Topology for Low Bandwidth Sites



At this point, a hub-and-spoke topology will apply to low bandwidth sites, but high-bandwidth sites still have route and TLOC information for those sites and will attempt to form IPSec tunnels, resulting in partial WAN connectivity on the dashboard. To avoid partial connectivity an additional topology can be created to filter low bandwidth sites. Follow Steps 19 to 29 to create an additional topology.

19. On the Topology tab, click the **Add Topology** button and select **Custom Control (Route & TLOC)**.
20. Fill out name and description fields for the policy.
21. Select **Sequence Type** on the left panel. On the Add Control Policy pop-up window, select **Route**.
22. Select **Sequence Rule**.
23. Select **Match**, then select **Site** and under Site List, select **LB_Remote_Locations**. Under Actions, the default is already set to **Reject**.
24. Click the **Save Match and Actions** button.
25. Select **Sequence Type** on the left panel. On the Add Control Policy pop-up window, select **TLOC**.
26. Select **Sequence Rule**. Select **Match**, select **Site** and under Site List, select **LB_Remote_Locations**. Under Actions, the default is already set to Reject.
27. Click the **Save Match and Actions** button.
28. Select **Default Action** from the left panel. Click the edit symbol. Click the **Accept** radio button, then click the **Save Match and Actions** button.
29. Click the **Save Control Policy** button to save the policy definition.

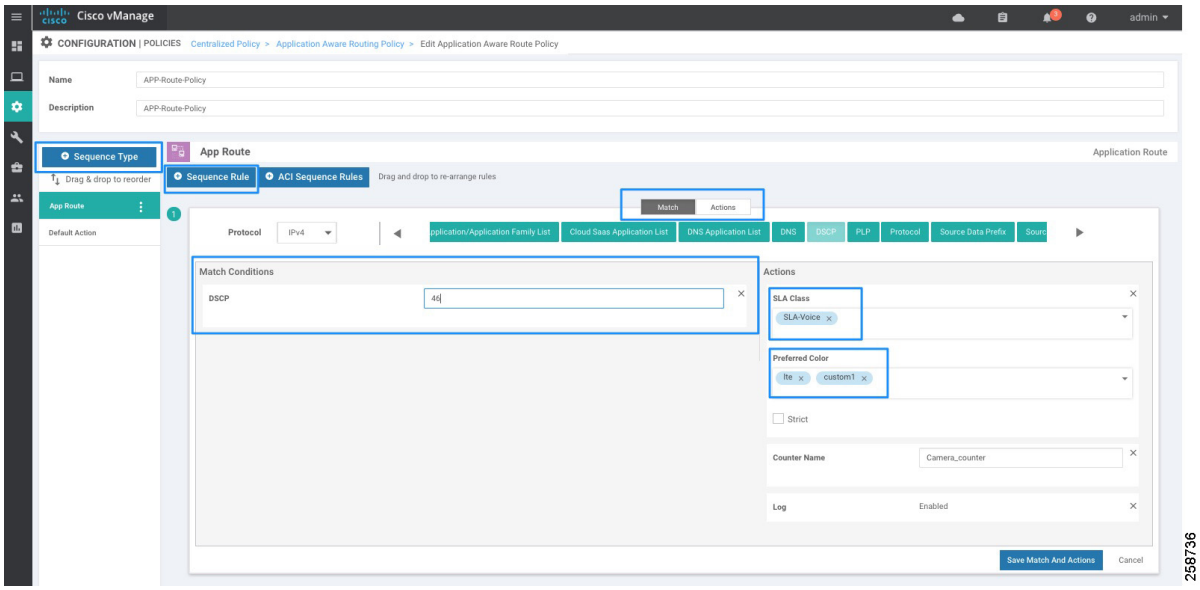
Tech tip: When you use the Predefined Hub-and-Spoke topology policy, only TLOCs and routes from the data center site are distributed to the low-bandwidth sites specified. Ensure a summary or default route is distributed from the data center if you want the low-bandwidth sites to reach other remote sites through the hub when using this policy.

Configure Traffic Rules

This section is used to create the data policy. In this example we will configure application-aware routing and traffic data.

30. To create an application-aware routing policy click the **Add Policy** button on the Application Aware Routing tab.
31. Fill out the **Name** and **Description** fields.
32. Click the **Sequence Type** button.
33. Click the **Sequence Rule** button.
34. Under the Match tab, select the condition to be evaluated, for example DSCP.
35. Under the **Action** tab, select **SLA Class and Preferred Color** options. You can select a backup color, enable logs, and create a counter variable for occurrences. If the **Strict** check box is checked, the policy will restrict the traffic class to selected colors and drop the traffic if the SLA is not met. This could increase convergence times after a transport failover because a poll interval has to be completed after tunnel is back to make sure the SLA is met in strict condition.
36. Click the **Save and Match Actions** button.

Figure 21 Application Aware Route Policy



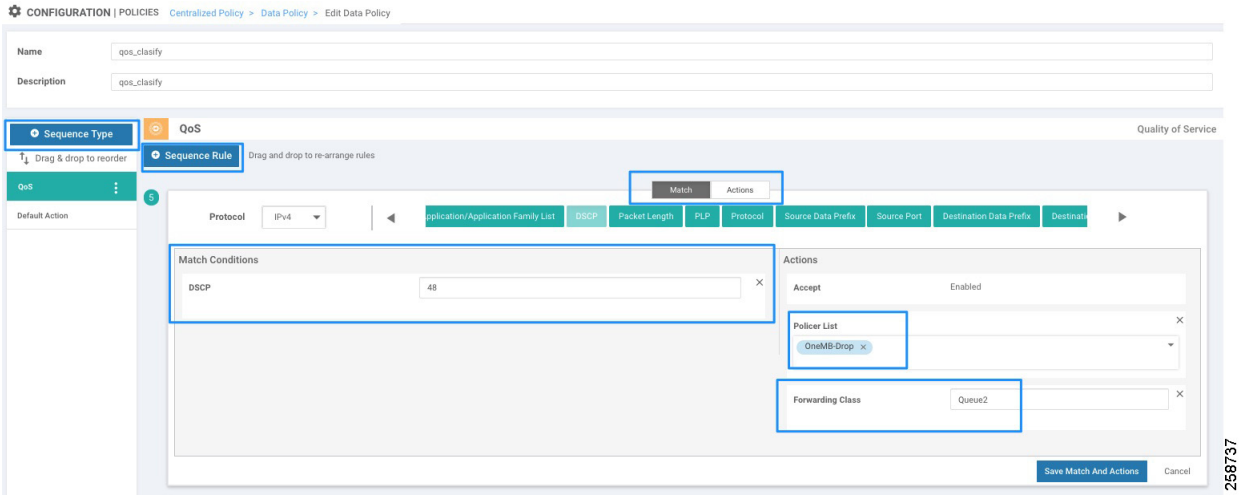
37. Repeat Steps 33 to 36 for every desired rule. The following table contains an example:

Table 11 Match Parameters for SLA example

Match Parameters	Application list name
DSCP: 46	SLA-Voice
DSCP: 40	SLA-Video
Destination Data Prefix: video_server	SLA-Video
DSCP: 48	SLA-Operations
DSCP: 16	SLA-Operations
DSCP: 24	SLA-Operations
DSCP: 8	SLA-Scavenger

38. Select **Default Action** in the left menu, and click the edit symbol. **None** is the default. Select the **SLA Class List** box, and select SLA-Scavenger from the SLA Class drop-down list. Click the **Save Match and Actions** button.
39. To create a Traffic Data policy to classify traffic on QoS forwarding classes, select **Traffic Data** tab and select **Add Policy > Create New**.
40. Provide a name and description.
41. Click the **Sequence Type** button on the left panel and then select **QoS**.
42. Click the **Sequence Rule** button.
43. Under the Match tab, select the condition to be evaluated, for example **DSCP**.
44. Under the Actions tab, select **Forwarding Class** and fill with values Queue0, Queue1, Queue2, Queue3, Queue4, Queue5, Queue6 or Queue 7 that matches the requirement.
45. (Optional) Select **Policer List** and apply a policer if required for specific rule.
46. Click the **Save and Match Actions** button.

Figure 22 QoS Centralized Data Policy



47. Repeat Steps 42-46 for every entry. The following table provides an example.

Table 12 Data Policy for QoS Classification and Policer Example

Traffic Type	Match Parameters	Forwarding Class	Policer
Voice	DSCP: 46	Queue0	
Voice	Destination Port:5060	Queue0	
Video	DSCP: 40	Queue1	Policer-HD-Camera-4MB-drop
Video	Destination Data Prefix: video_server	Queue1	
Network-Control	DSCP: 48	Queue2	
OAM	DSCP: 16	Queue3	OneMB-drop
Signaling	DSCP: 24	Queue4	
Scavenger	DSCP: 8	Queue5	
Scavenger	Any	Queue5	

48. Select **Default Action** in the left menu, then click the edit symbol. Click the **Accept** radio button. Click the **Save and Match Actions** button.
49. (Optional) Select **Sequence Type** on the left panel to add other data policies such as application firewall, service chaining, or traffic engineering. For more information on those polices refer to https://www.cisco.com/c/en/us/support/routers/sd-wan/products-installation-and-configuration-guides-list.html
50. Click **Next** to continue to apply policies to sites and VPNs.

Apply policies to sites and VPNs

51. Fill out name and description fields for the centralized policy.
52. Click on the Application-Aware Routing tab. Click the **New Site List** and **VPN List** button.
53. In the Select Site List drop-down list choose **Remote_Locations** and **DC** sites.
54. Select the **VPN List** (Service_VPN_all)
55. Click the **Add** button.
56. Click on the **Traffic Data** tab.
57. Click the **New Site List and VPN List** button, then click the **From Service** radio button, and repeat Steps 53-55.
58. (Optional) Click the **Preview** button to see policy configuration.
59. Click the **Save Policy** button.

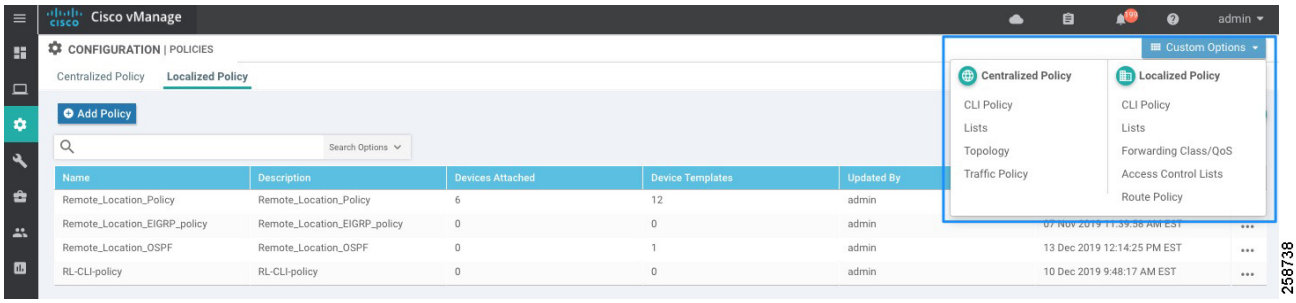
Activate Policy

60. Go to **Configuration > Policies**.
61. On the Centralized Policy tab all centralized policies are shown and the Activated column shows the active policy. Click on more actions (**...**) at the end of the row of the policy you want to activate and select **Activate** from the displayed options.
62. A dialogue box will appear and states that the policy will be applied to the reachable vSmart controllers. Click **Activate**. The policy will be pushed to the vSmart controllers and the status will indicate success.

Editing Policy Elements

The configuration steps provided in previous section show how to configure a complete policy with multiple elements in a single process. This is useful for initial implementation since it simplifies the process. If more elements need to be added or existing ones need to be modified after the policy has been created, use the **Custom Options** menu at the top right. It provides a **Lists** shortcut for both centralized and localized policies.

Figure 23 Edit Policy Elements

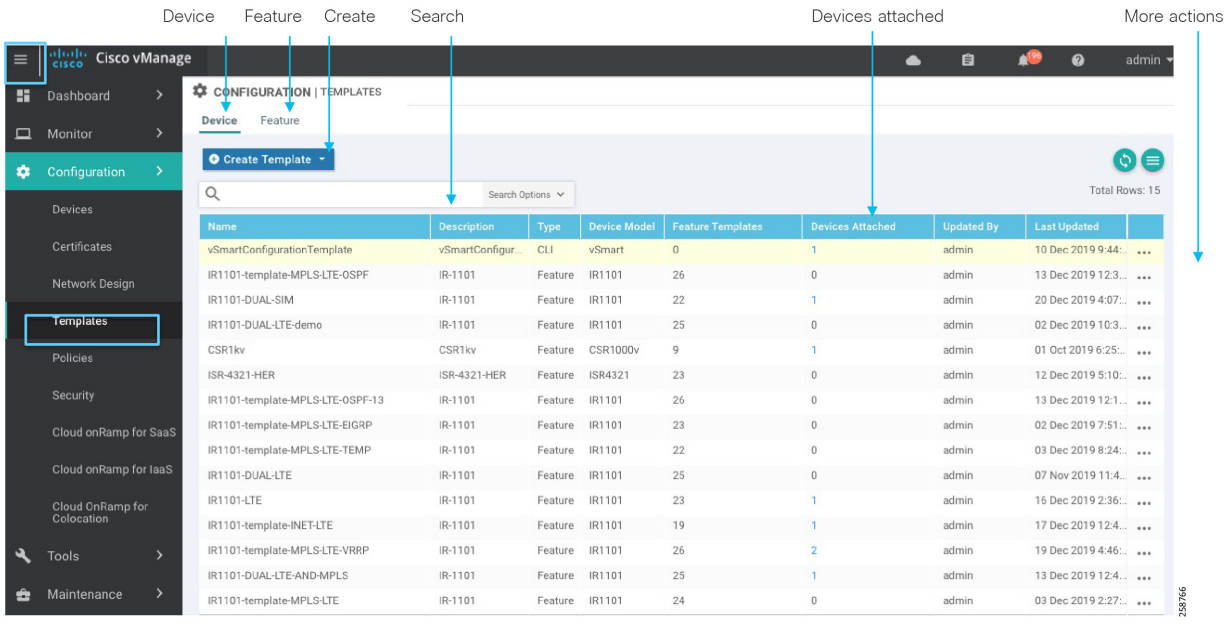


Template Configuration

The router device configuration is defined by templates created in vManage. A device template defines a device's complete operational configuration. It is possible to create device templates by consolidating together individual feature templates. Alternatively, they can be created by entering a CLI text-style configuration directly in vManage. Only feature templates are covered in this implementation guide. A feature template defines the configuration for an SD-WAN software feature; vManage comes with default feature templates but more can be created for customization.

The following image shows screen elements for template configuration that will be used in the rest of the section.

Figure 24 Template Screen Elements



Configuring Feature Templates

Before creating a device template, you must create individual feature templates that will be needed to create the device template.

Feature templates fall into three categories:

1. Basic information: includes settings for authentication, authorization, and accounting (AAA), BFD, global and system settings, Network Time Protocol (NTP), Overlay Management Protocol (OMP), and security.
2. VPN: used to create VPNs, WAN interfaces, and LAN interfaces
3. Other templates: includes miscellaneous templates such as banner, cellular controllers and profiles, DHCP server, routing protocols, Global Positioning System (GPS), logging, and switch ports.

For this implementation basic information, banner, logging and SNMP templates are leveraged from the *Cisco SD-WAN End-to-End Deployment Guide*; refer to Appendix B for template values. This is to be used as an example, but it can be customized to meet specific needs. For example, BFD templates can be edited to change multiplier values for specific colors in order to reduce tunnel failover times. For more information on specific settings for a feature template refer to: https://www.cisco.com/c/en/us/td/docs/routers/sdwan/command/sdwan-cr-book/config-cmd.html.

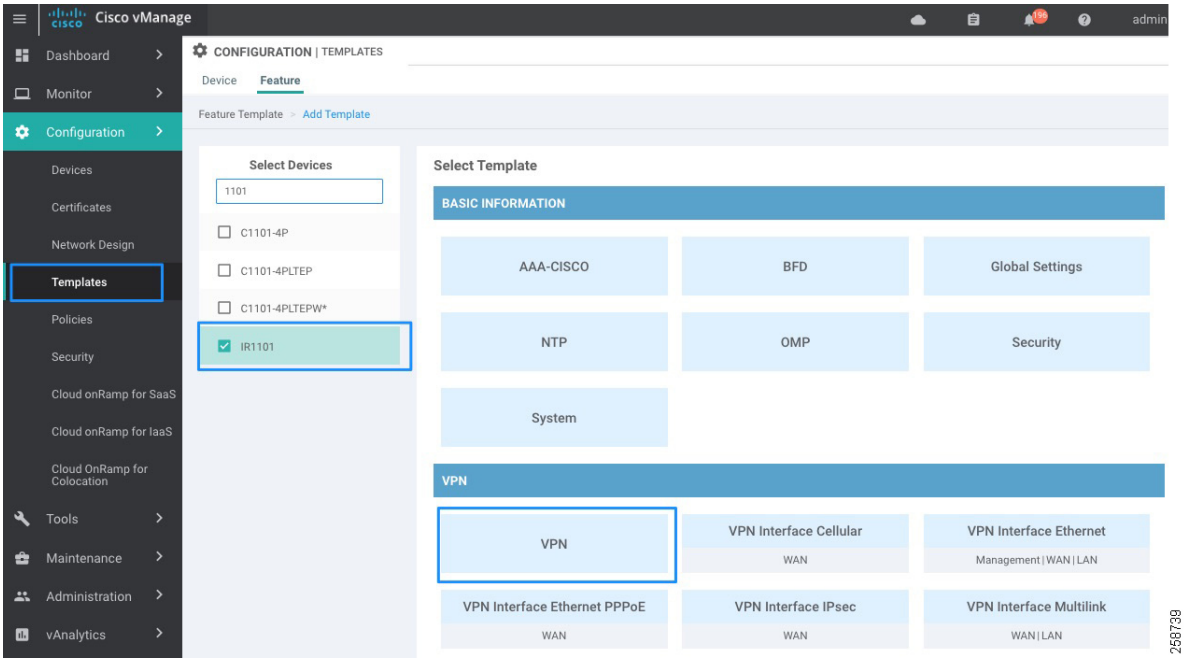
The following sections will cover the creation of templates required for extended enterprise, in addition to the ones referenced in Appendix B - Cisco SD-WAN End-to-End Deployment Guide Templates Used. First, we will explain how to create a template, and later we will provide blueprints to create specific templates needed.

Create a Feature Template

Before providing guidance to create specific feature templates for the Cisco IR1101, this section walks you through how to create a feature template.

1. In the vManage GUI, Select **Configuration > Templates**, and choose the **Feature** tab.
2. Click the **Add Template** button.
3. In the left pane, from Select Devices, select the type of device for which you are creating a template. You can create a single feature template for features that are available on multiple device types. You must, however, create separate feature templates for software features that are available only on the device type you are configuring.
4. In the right pane, select the feature template.

Figure 25 Feature Template Creation



5. The template form is displayed. The top of the form contains fields for naming the template, and the bottom contains fields for defining required parameters. If the feature has optional parameters, the bottom of the template form shows a plus sign (+) after the required parameters.

6. In the Template Name field, enter a name for the feature template, and in the Description field, enter a description for the feature template. These fields are mandatory.

7. For each parameter that needs to be customized, choose the desired value, and if applicable, select the scope of the parameter. The scope is selected from the drop-down menu to the left of each parameter value box. The available options are:

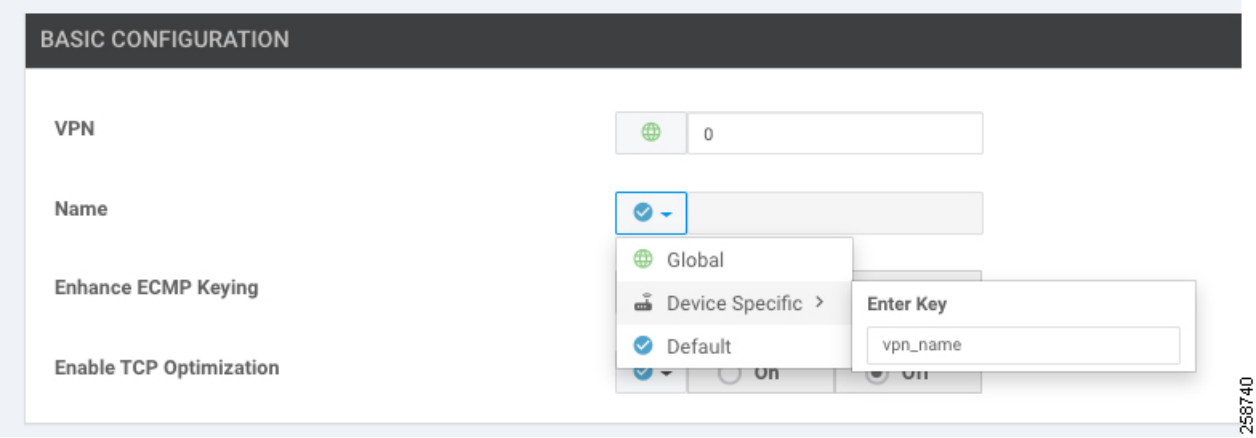
   a. Global parameters will apply to all devices using the template, for example VPN number.

   b. Device-specific parameters create a variable to be set when the device is attached to the profile. An example of a device-specific parameter is static IP address. The name of the variable can be edited as shown in the following image.

   c. Default parameters set the feature option to default configuration. When you first open a feature template, for each parameter that has a default value, the scope is set to Default (indicated by a check mark), and the default setting or value is shown. To change the default or to enter a value, select global or device specific from the Scope drop-down list.

   Click the plus sign (**+**) below the required parameters to set the values of optional parameters.

Figure 26 Scope of the Parameter



8. Click the **Save** button.

Note: Some configuration parameters can be marked as optional by checking the Mark as Optional row check box. This allows you to apply the feature template to devices with slightly different configurations. Values are entered when you attach a device to a device template. Optional values do not need to be provided.

Feature Templates for Transport VPN

For the remote sites, the transport VPN, or VPN 0 feature template, needs to be created. In the VPN template, you configure Equal-Cost Multipath (ECMP) keying, DNS, and static routes. You then define the physical interfaces for each of the transports, in other words the cellular and Internet interfaces. In those templates, you configure interface names, IP addresses, and IPSec tunnel characteristics.

The following steps create a feature template using the guidelines described in the Create a Feature Template section.

VPN 0 Template Reference

This template creates a VPN template for transport.

Feature Template type: VPN: VPN

Feature template name: RL_VPN0

Description: Remote Location VPN 0

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 13 VPN0 Feature Template

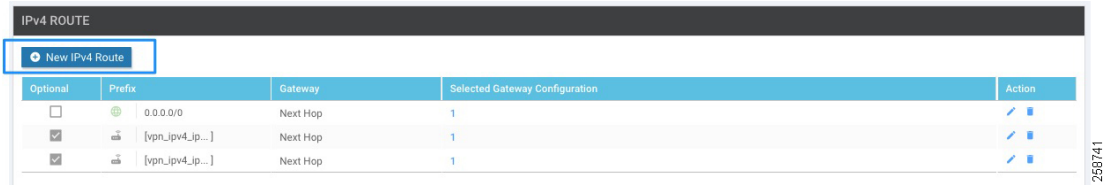
Section	Parameter	Type	Variable/value	Optional
Basic Configuration	VPN	Global	0	NA
	Name	Global	Transport VPN	NA
	Enhance ECMP Keying	Global	On	NA
DNS	Primary DNS Address	Global	64.102.6.247	NA
	Secondary DNS Address	Global	64.102.6.248	NA
IPv4 Route	Prefix	Global	0.0.0.0/0	No
	Gateway	Radio button	Next Hop	No
	Next Hop	Device Specific	vpn0_next_hop_ip_address_1	No
IPv4 Route (2)	Prefix	Device Specific	vpn_ipv4_ip_prefix2	Yes
	Gateway	Radio button	Next Hop	Yes
	Next Hop	Device Specific	vpn0_next_hop_ip_address_2	Yes
IPv4 Route (3)	Prefix	Device Specific	vpn_ipv4_ip_prefix3	Yes
	Gateway	Radio button	Next Hop	Yes
	Next Hop	Device Specific	vpn0_next_hop_ip_address_3	Yes

Note that IPv4 Route is repeated three times, the purpose of this is to allow a static route per transport interface. For a Cisco IR1101, three transport interfaces can be created–two cellular and one wired interface. In the suggested configuration, only one route is mandatory since at least one connection to transport is required.

To add each route:

1. Click the **New IPv4 Route** button as shown in the figure.

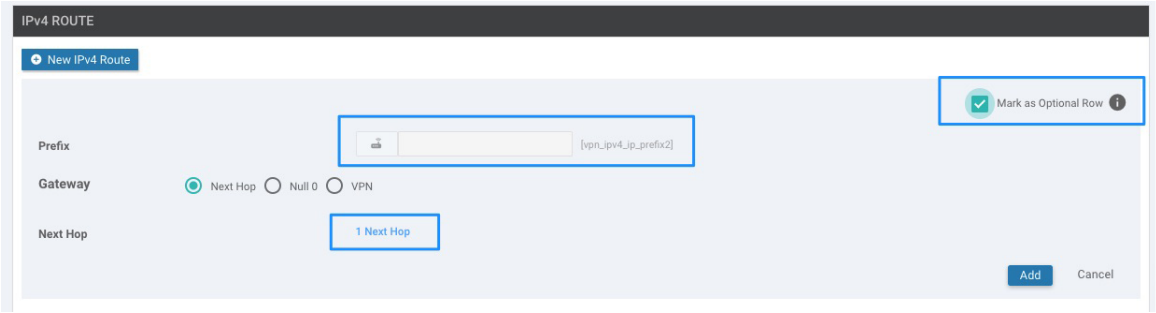
Figure 27 New IPv4 Route



2. If adding one of the optional routes, change the prefix to device specific and provide a variable name; otherwise, select **Global**.
3. If adding an optional route, check the **Mark as Optional Row** check box. See figure below.
4. Click **Add Next Hop**, then in the dialog box click **Add Next Hop**.
5. Change the address to device specific and provide the variable name.

Click the **Add** button and the dialog box will close. The Next Hop field will show 1 Next Hop, as shown in figure below.

Figure 28 New IPv4 Route Details



6. Click the **Add** button.
7. If all other fields on the feature template are configured, click **Update**.

VPN Internet Interface Template Reference

This template is used to associate the interface to the VPN 0 template. Its purpose is to define interface settings for the wired transport. This template allows for dynamic IP address assignment for WAN interface GigabitEthernet0/0/0. Additionally, an IPSec tunnel is defined with color biz-internet for control and transport connections. The Restrict setting on the tunnel is disabled to allow inter-color communication. Finally, this template defines a preference variable that will determine if the interface is selected for directing traffic to the tunnel. A higher value is preferred over a lower one, and when two or more tunnels to the destination have the same preference value, the traffic is distributed among them.

Feature Template type: VPN: VPN interface Ethernet

Feature template name: RL_INET_INT

Description: Default DHCP interface for Internet connection

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 14 Interface Ethernet Feature Template for Internet Transport

Section	Parameter	Type	Variable/value
Basic Configuration	Shutdown	Device Specific	vpn0_inet_int_shutdown
	Interface Name	Global	GigabitEthernet0/0/0
	Description	Global	Internet Interface
IPv4 Configuration	IPv4 Address	Radio button	Dynamic
Tunnel	Tunnel Interface	Global	On
	Color	Global	biz-internet
	Restrict	Global	Off
	Allow Service>NTP	Global	On
Tunnel>Advanced Options>Encapsulation	IPsec	Global	On

	Preference	Device Specific	vpn0_inet_tunnel_ipsec_preference
ACL/QoS	Shaping Rate (Kbps)	Device Specific	vpn_inet_qos_shaping-rate
	QoS Map	Global	qos_class_wired

Note: If a static IP address assignment is desired, the following IPv4 configuration can be used.

Table 15 Interface Ethernet Additional Settings for Static IP Address

Section	Parameter	Type	Variable/value
IPv4 Configuration	IPv4 Address	Radio button	Static
	IPv4 Address	Device specific	vpn0_inet_int_ip_addr|maskbits

VPN Cellular Interface Template Reference

This template is used to associate the interface to the VPN 0 template. Its purpose is to define interface settings for the cellular interface 0/1/0. This template allows for dynamic IP address assignment and defines an IPSec tunnel with color lte for control and transport connections. The Restrict setting on the tunnel is disabled to allow inter-color communication. It also defines a preference variable that will determine if the interface is selected for directing traffic to the tunnel as explained in VPN Internet Interface Template Reference, page 39.

Feature Template type: VPN: VPN interface Cellular

Feature template name: RL_CELL_INT

Description: Default cellular interface 0/1/0

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 16 Interface Cellular Feature Template for LTE Transport on Expansion Module

Section	Parameter	Type	Variable/value
Basic Configuration	Shutdown	Device Specific	vpn0_cell1_int_shutdown
	Interface Name	Global	Cellular0/1/0
	Description	Global	Cellular interface
IPv4 Configuration	IPv4 Address	Radio button	Dynamic
Tunnel	Tunnel Interface	Global	On
	Color	Global	lte
	Restrict	Global	Off
	Allow Service>NTP	Global	On
Tunnel>Advanced Options>Encapsulation	IPsec	Global	On

	Preference	Device Specific	vpn0_cell0_1_0_tunnel_ipsec_preference
ACL	Shaping Rate (Kbps)	Device Specific	vpn_cell1_qos_shaping-rate
	QoS Map	Global	qos_class_cellular

VPN Cellular Interface for Expansion Module Template Reference

This template is used to associate the expansion module cellular interface to the VPN 0 template. This template is needed for dual LTE since the same interface template cannot be attached twice to the same VPN. Parameters are similar to the ones described in VPN Cellular Interface Template Reference but it applies to a different cellular interface and associates the tunnel to a different color custom1 as shown in Figure 2 Validation Topology.

Feature Template type: VPN: VPN interface

Cellular Feature template name: RL_CELL_INT_EM

Description: Default cellular interface 0/3/0

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 17 Interface Cellular Feature Template for LTE Transport on Expansion Module

Section	Parameter	Type	Variable/value
Basic Configuration	Shutdown	Device Specific	vpn0_cell3_int_shutdown
	Interface Name	Global	Cellular0/3/0
	Description	Global	Cellular interface EM
IPv4 Configuration	IPv4 Address	Radio button	Dynamic
Tunnel	Tunnel Interface	Global	On
	Color	Global	Custom1
	Restrict	Global	Off
	Allow Service>NTP	Global	On
Tunnel>Advanced Options>Encapsulation	IPsec	Global	On
	Preference	Device Specific	vpn0_cell0_3_0_tunnel_ipsec_preference
ACL	Shaping Rate (Kbps)	Device Specific	vpn_cell3_qos_shaping-rate
	QoS Map	Global	qos_class_cellular

Feature Templates for Service VPN

These templates configure the local service-side, or LAN-facing, network. This network will be used by the endpoints to access services in the data center or establish endpoint-to-endpoint connectivity. In the extended enterprise example deployment multiple service VPNs are created: shared services (VPN 1), IoT devices (VPN 10), and employee (VPN 11). One template is required for each. Services VPNs have to be created also on the data center side; for specific steps refer to the Cisco SD-WAN End-to-End Deployment Guide.

On the IR110, service-side interfaces are configured using SVIs. In the following example two SVI templates are created to be used on a single VPN (VPN 11) because you cannot use the identical feature template under a single VPN more than once. These templates can be reused in the different VPNs; for example, a single SVI template can be used for VPN 10 and VPN 11.

For the service-side a loopback0 interface template is created. The loopback interface is used for logging and SNMP it is referenced on corresponding feature templates. An OSPF template is also required to connect to the access switch in the remote location 3 example as shown in Validation Topology.

Follow the steps described in the Create a Feature Template section to create the required feature templates for the Extended Enterprise deployment.

Service VPN 1 Template Reference

This template creates service VPN 1 template.

Feature Template type: VPN: VPN

Feature template name: RL_VPN1

Description: Remote Location VPN 1 shared services

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 18 Service-Side VPN1 Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	VPN	Global	1
	Name	Global	VPN 1 shared services
	Enhance ECMP Keying	Global	On
DNS	Primary DNS Address	Global	10.22.2.4

Service VPN 10 Template Reference

This template creates service VPN 10 template.

Feature Template type: VPN: VPN

Feature template name: RL_VPN10

Description: Remote Location VPN 10 IoT devices

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 19 Service-Side VPN10 Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	VPN	Global	10
	Name	Global	VPN 10 IoT devices
	Enhance ECMP Keying	Global	On
DNS	Primary DNS Address	Global	10.22.2.4

Service VPN 11 Template Reference

This template creates service VPN 11 template.

Feature Template type: VPN: VPN

Feature template name: RL_VPN11

Description: Remote Location VPN 11 Employee

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 20 Service-Side VPN11 Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	VPN	Global	11
	Name	Global	VPN 11 Employee
	Enhance ECMP Keying	Global	On
DNS	Primary DNS Address	Global	10.22.2.4

Service VPN Interface SVI 1

This template is for the SVI, which will be reused on every service VPN. In this template VRRP is set as optional; if VRRP is not required do not include VRRP settings on the template, but if VRRP could potentially be used on any remote location the VRRP configuration can be added as optional so it can be used by sites with and without VRRP configuration.

One of the VRRP settings is called “Track Prefix List”; this list contains a prefix to a remote service route learned through OMP (default route if available). When the OMP prefix route disappears, the router gives up VRRP primary status. This is to guarantee VRRP failover in the case the primary router loses WAN connectivity. The prefix will be created in the policy section and referenced by the variable.

Most sites use DHCP relay to the data center, so an IP DHCP helper address is configured. If you want to use the router as the DHCP server, an optional DHCP template can be created as shown later.

Feature Template type: VPN: VPN Interface SVI

Feature template name: RL_SVI-SERVICE-VPN-1

Description: Remote Location service VPN SVI 1

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 21 Service-Side SVI Feature Template

Section	Parameter	Type	Variable/value	Optional
Basic Configuration	Shutdown	Device Specific	vpn_service_svi_shutdown_1	NA
	VLAN Interface Name	Device Specific	vpn_svi_if_name_SVI_1	NA
	Description	Device Specific	vpn_svi_if_description_SVI_1	NA
IPv4 Configuration	IPv4 Address	Device Specific	vpn_if_svi_if_ipv4_prefix_SVI_1	NA
	DHCP Helper	Device Specific	vpn_svi_dhcp_helper_SVI_1	NA
ACL	Ingress ACL - IPv4*	Global	On	NA
	IPv4 Ingress Access* List	Global	Camera-To-Camera-Deny	NA
VRRP	Group ID	Device Specific	vpn_if_vrrp_grpid_1	Yes
	Priority	Device Specific	vpn_if_vrrp_priority_1	Yes
	Track Prefix List**	Device Specific	vpn_if_vrrp_track_prefix_list_1	Yes
	IP Address	Device Specific	vpn_if_vrrp_vrrp_ipaddress_1	Yes

*Shows where to apply an ACL created on Localized Policy

**Variable that will point to localized policy to track on a route for VRRP switchover when transport is unavailable.

Service VPN Interface SVI 2 (Optional)

In some instances, more than one SVI is required per VPN. For example, on the employee VPN one SVI is required for data and a separate VPN is required for voice. This template creates a template for an additional interface SVI. This template may be reused on more than one service VPN. In this template VRRP is set as optional; if VRRP is not required don't include VRRP settings on the template, but if VRRP could potentially be used on any remote location the VRRP configuration can be added as optional so it can be used by sites with and without VRRP configuration.

Feature Template type: VPN Interface SVI

Feature template name: RL_ SVI-SERVICE-VPN-2

Description: Remote Location service VPN SVI 2

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 22 Service-Side Secondary SVI Feature Template

Section	Parameter	Type	Variable/value	Optional
Basic Configuration	Shutdown	Device Specific	vpn_service_svi_shutdown_2	NA
	VLAN Interface Name	Device Specific	vpn_svi_if_name_SVI_2	NA
	Description	Device Specific	vpn_svi_if_description_SVI_2	NA
IPv4 Configuration	IPv4 Address	Device Specific	vpn_if_svi_if_ipv4_prefix_SVI_2	NA
	DHCP Helper	Device Specific	vpn_svi_dhcp_helper_SVI_2	NA
VRRP	Group ID	Device Specific	vpn_if_vrrp_grpid_2	Yes
	Priority	Device Specific	vpn_if_vrrp_priority_2	Yes
	Track Prefix List**	Device Specific	vpn_if_vrrp_track_prefix_list_2	Yes
	IP Address	Device Specific	vpn_if_vrrp_vrrp_ipaddress_2	Yes

**Variable that will point to localized policy to track on a route for VRRP switchover when transport in unavailable

Switchport Template

The switchport template configures the switchport settings on the router. The following tables contain three examples.

Example 1: Cisco IR1101 with four access ports to connect 4 endpoints directly to the switch.

Feature Template type: Switch Port

Feature template name: RL_SW_Ports_4_access

Description: Remote Location switchport 4 access ports

Device type: IR1101.

Use the following settings, any value not mentioned in the list leave it as default.

Table 23 Switchport Feature Template for Access Ports

Section	Parameter	Type	Variable/value
Basic Configuration	Slot	Global	0
	Sub-Slot	Global	0
	Module	Global	4 Port
Interface 1	Interface Name	Global	FastEthernet0/0/1
	Shutdown	Device Specific	switchport_1_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_1_if_access_vlan
Interface 2	Interface Name	Global	FastEthernet0/0/2
	Shutdown	Device Specific	switchport_2_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_2_if_access_vlan
Interface 3	Interface Name	Global	FastEthernet0/0/3
	Shutdown	Device Specific	switchport_3_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_3_if_access_vlan
Interface 4	Interface Name	Global	FastEthernet0/0/4
	Shutdown	Device Specific	switchport_4_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_4_if_access_vlan

Example 2: Cisco IR1101 with three access ports to connect three endpoints directly to the switch and a trunk to be connected to an access switch.

This template is shown below.

Feature Template type: Switch Port

Feature template name: RL_SW_Ports_4_Trunk

Description: Remote Location switchport 3 access ports and a trunk

Device type: IR1101.

Use the following settings, any value not mentioned in the list leave it as default.

Table 24 Switchport Feature Template with Trunk Port

Section	Parameter	Type	Variable/value
Basic Configuration	Slot	Global	0
	Sub-Slot	Global	0
	Module	Global	4 Port
Interface 1	Interface Name	Global	FastEthernet0/0/1
	Shutdown	Device Specific	switchport_1_if_shutdown
	Switch Port	Radio button	Trunk
	Allowed VLANS	Device Specific	switchport_1_if_trunk_allowed_vlans
Interface 2	Interface Name	Global	FastEthernet0/0/2
	Shutdown	Device Specific	switchport_2_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_2_if_access_vlan
Interface 3	Interface Name	Global	FastEthernet0/0/3
	Shutdown	Device Specific	switchport_3_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_3_if_access_vlan
Interface 4	Interface Name	Global	FastEthernet0/0/4
	Shutdown	Device Specific	switchport_4_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_4_if_access_vlan

Example 3: Cisco IR1101 with expansion module

Gigabit Ethernet ports in expansion module are configured as trunk ports to be connected to the access switch. Fast Ethernet ports are configured for access ports to connect to end devices directly.

Feature Template type: Switch Port

Feature template name: RL_SW_Ports_5_EM

Description: Remote Location switchport 4 access ports and a trunk on EM

Device type: IR1101

Use the following settings, any value not mentioned in the list leave it as default.

Table 25 Switchport Feature Template for Expansion Module

Section	Parameter	Type	Variable/value
Basic Configuration	Slot	Global	0
	Sub-Slot	Global	0
	Module	Global	8 Port
Interface 1	Interface Name	Global	FastEthernet0/0/1
	Shutdown	Device Specific	switchport_1_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_1_if_access_vlan
Interface 2	Interface Name	Global	FastEthernet0/0/2
	Shutdown	Device Specific	switchport_2_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_2_if_access_vlan
Interface 3	Interface Name	Global	FastEthernet0/0/3
	Shutdown	Device Specific	switchport_3_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_3_if_access_vlan
Interface 4	Interface Name	Global	FastEthernet0/0/4
	Shutdown	Device Specific	switchport_4_if_shutdown
	Switch Port	Radio button	Access
	VLAN ID	Device Specific	switchport_4_if_access_vlan
Interface 5	Interface Name	Global	GigabitEthernet0/0/5
	Shutdown	Device Specific	switchport_5_if_shutdown
	Switch Port	Radio button	Trunk
	Allowed VLANS	Device Specific	switchport_5_if_trunk_allowed_vlans

VPN Interface Ethernet Loopback0

A loopback0 interface is created with the system IP address so that logging, SNMP, and other management traffic could be sourced from the system IP address, making correlation with vManage easier. This template can be shared across all device types.

Feature Template type: VPN Interface Ethernet

Feature template name: Loopback0

Description: Interface Loopback0

Device type: all IOS XE SD-WAN routers

Use the following settings, any value not mentioned in the list leave it as default.

Table 26 Loopback Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	Shutdown	Global	No
	Interface Name	Global	No
IPv4 Configuration	IPv4 Address	Radio button	Static
	DHCP Helper	Device Specific	lo0_int_ip_addr|maskbits

OSPF Template

The OSPF template is used on sites that require OSPF connectivity to the access switch. The router interfaces are configured for OSPF network point to point. A route policy was configured as part of the localized policy as an example. It defines the OSPF routing behavior on the local site network and affect routing into or out of that specific site. A variable is created to reference the local route policy.

Feature Template type: OSPF

Feature template name: RL_OSPF

Description: Remote location OSPF

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 27 OSPF Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	Router ID	Device Specific	ospf_router_id
Redistribute	Protocol	Global	OMP
	Route Policy*	Device Specific	ospf_redistribute_route_policy
Area	Area Number	Device Specific	ospf_area_a_num
	Interface>Interface Name	Device Specific	ospf_name_iface
	Interface>Advanced Options>OSPF Network Type	Global	point-to-point
	Range>Address	Device Specific	ospf_area_range_address_0
Advanced	Reference Bandwidth (Mbps)	Global	1000000
	Originate	Global	On

*Variable pointing to localized policy to control OSPF path metric

DHCP Template (Optional)

A DHCP server pool template is created to add DHCP server functionality to the IR1101. Once created, the template is associated under an interface template.

Feature Template type: DHCP Template

Feature template name: RL_DHCP_template

Description: Remote location DHCP server

Device type: IR1101. Optionally, include more IOS XE SD-WAN routers for remote locations if template is to be reused.

Use the following settings, any value not mentioned in the list leave it as default.

Table 28 DHCP Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	Address Pool	Device Specific	voice_dhcp_addr_pool|maskbits
	Exclude Addresses	Device Specific	voice_dhcp_addr_exclude_range
Advanced	Domain Name	Global	cisco.local
	Default Gateway	Device Specific	dhcp_default_gateway
	DNS Servers	Global	10.22.2.4

Note: TFTP Server option can be also added to the template.

4G LTE Configuration

The Cisco IR1101 offers LTE support through the use of Pluggable Modules. Cisco LTE Pluggable Module support can be found on datasheet:
https://www.cisco.com/c/en/us/products/collateral/routers/1101-industrial-integrated-services-router/datasheet-c78-741709.html.

The following table shows the relationship between Modems, SIMs, Interface, and Controller. For 4G-LTE-Advanced, the numbering on the Cisco IR1101 for slot 0, module 0, and port 0 is 0/1/0 for all commands on the base unit. On the Expansion Module, the numbering for slot 0, module 0, and port 0 is 0/3/0 for all commands.

Table 29 LTE Module Details

Router	Controller	SIM	Modem Sub Slot	PDN Interface
IR1101	0/1/0	0|1	0/1	Cellular 0/1/0 Cellular 0/1/1
IR1101 with Expansion Module	0/3/0	0|1	0/3	Cellular 0/3/0 Cellular 0/3/1

Cisco pluggable modules ship with a specific carrier provisioning file that can be found using the show cellular slot hardware command. Default profiles for the carrier are already populated and can be deployed readily. If using default profiles, such as AT&T, Sprint, and Verizon, there is no need to make any profile-related changes. In this case the router receives its IP address dynamically and is ready for PnP discovery. No feature templates are required to support default profiles.

Tip: Use the show cellular unit profile command to view the data profile. An asterisk(*) symbol is displayed against the data profile. A double asterisk(**) symbol is displayed against the attach profile.

Although profiles can be created, modified, and deleted, current versions of vManage don't allow you to change the profile attachment. For example, the P-LTE-US module comes with seven pre-configured profiles and default profile used for attach and data is 1. Even when you could create an additional eighth profile, vManage lacks the capability to select it to be used for attach and data. Therefore, if you need to use customized profiles (for example, Access Point

Name (APN) in mobile networks), you need to overwrite the default profile. In the example, you would need to overwrite profile 1 with customized value. Default profiles are shown in the table. To customize profile, use feature template cellular profile.

Table 30 LTE Default Profiles

Modem	Profile Number
P-LTE-GB (Global)	Profile 1
P-LTE-VZ (Verizon)	Both Profile 1 and Profile 3
P-LTE-US (AT&T or other SPs)	Profile 1
P-LTEA-EA	Profile 1 and Profile 3 when using Verizon SIM Profile 1 when using AT&T SIM

Tip: When using the cellular interface for router onboarding using customized cellular profiles (nondefault APNs), device onboarding has to be done using the bootstrap method. More information can be found in the Device Onboarding section.

Warning: Dual SIM cards with different APNs is not possible when using customized profiles due to a current vManage limitation. Using vManage version 19.2 (and older) it is not possible to associate a specific APN per slot using feature templates.

Cellular Controller

When a cellular interface is added to a device template, a cellular controller template is required. We will create two feature templates, one for controller 0/1/0 and one for controller 0/3/0 used for the expansion module.

Feature Template type: Cellular controller

Feature template name: RL_CELL_CONTROLLER_0_1_0

Description: Remote location cellular controller 0/1/0

Device type: Device type: IR1101.

Use the following settings, any value not mentioned in the list leave it as default.

Table 31 Cellular Controller Feature Template

Section	Parameter	Type	Variable/value
Basic Configuration	Cellular ID	Global	0/1/0

Feature Template type: Cellular controller

Feature template name: RL_CELL_CONTROLLER_0_3_0

Description: Remote location cellular controller 0/3/0 Expansion module

Device type: IR1101.

Use the following settings, any value not mentioned in the list leave it as default.

Table 32 Cellular Controller Feature Template for Expansion Module

Section	Parameter	Type	Variable/value
Basic Configuration	Cellular ID	Global	0/3/0

Cellular Profile (Optional)

This configuration is only needed if using a customized APN. Be sure to understand limitations mentioned in Caveats and Limitations before using this template.

Feature Template type: Cellular profile

Feature template name: RL_CELL_PROFILE_CUST

Description: Remote location cellular profile for customized APN

Device type: IR1101.

Use the following settings, any value not mentioned in the list leave it as default.

Table 33 Cellular Profile Feature Template

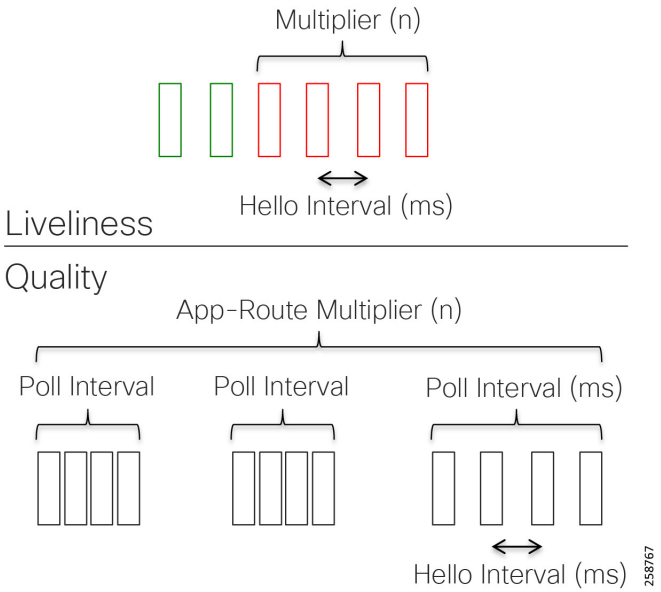
Section	Parameter	Type	Variable/value
Basic Configuration	Profile ID	Device Specific	cellular_profile_profile_id
	Access Point Name	Device Specific	cellular_profile_apn

A Note on BFD Timers and Application-Aware Routing

The BFD feature template allows for the configuration of two timers (hello interval and poll interval) that are used for application-aware routing to determine the availability of the tunnel.

- Each IOS XE SD-WAN router sends BFD hello packets using the hello interval for path quality and availability detection, and those packets are echoed back by the remote site. The hello interval and multiplier determine how many BFD packets need to be lost to declare the IPSec tunnel down. The hello interval and multiplier can be customized per color and applied per device. The default value for the hello interval is 1 sec, and in general is not recommended to edit this value. If desired, the multiplier value can be decremented to decrease the time that takes to detect a failure in the tunnel.
- The number of hello intervals that fit inside the poll interval determines the number of BFD packets considered for establishing the poll interval average path quality. The app-route multiplier determines number of poll intervals for establishing overall average path quality. The poll interval and multiplier are configured at the device level.

Figure 29 Understanding BFD Timers



To determine the SLA classification of a tunnel, application-aware routing uses the loss, latency, and jitter information from the latest poll intervals. The number of poll intervals used is determined by a multiplier. These default values have to be chosen to provide damping of sorts, as a way to prevent frequent reclassification (flapping) of the tunnel. The multiplier is user-configurable per IOS XE SD-WAN router; that is, it applies to all tunnels originating on a router. If there is a need to react quickly to changes in tunnel characteristics, you can reduce the multiplier all the way down to 1. With a multiplier of 1, only the latest poll interval loss and latency values are used to determine whether this tunnel can satisfy one or more SLA criteria. Regardless of how quickly a tunnel is reclassified, the loss, latency, and jitter information are measured and calculated continuously.

Warning: Changing the BFD timers is not recommended because it changes the scalability of tunnels that the device can provide. Timers should stay conservative if possible and if changed from the defaults, should be tested thoroughly in the customer environment.

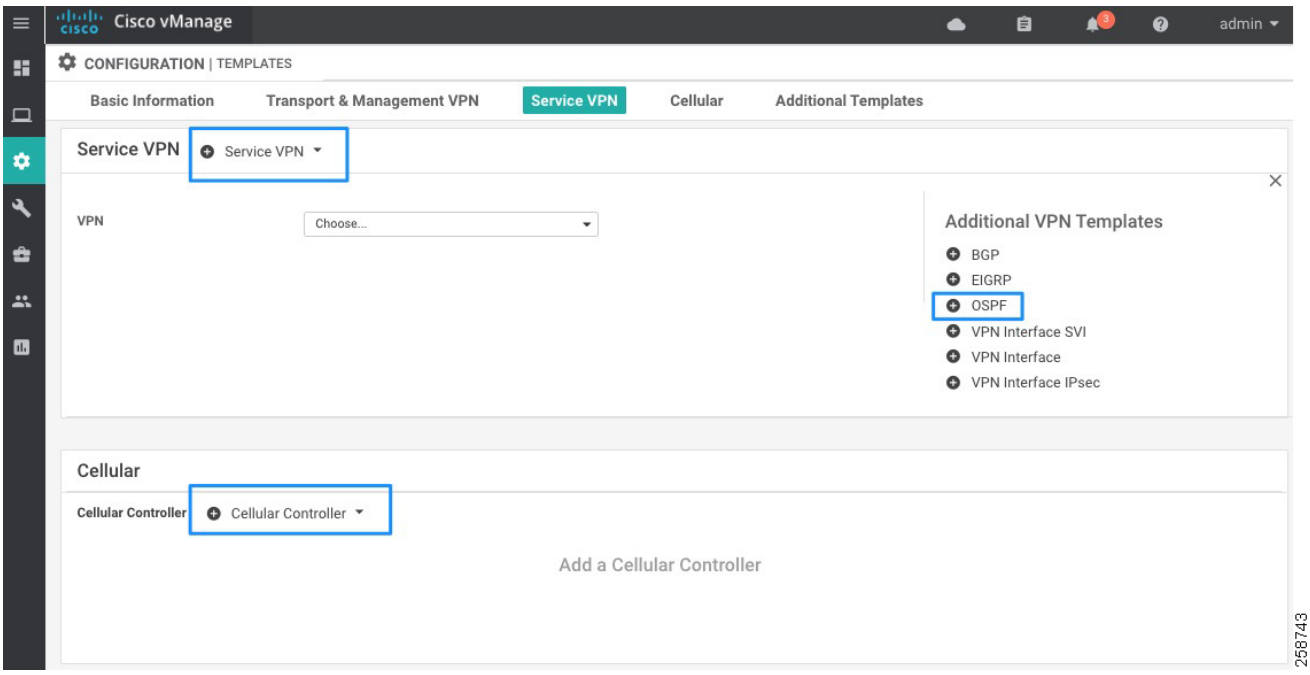
Device Templates

A device template contains a set of configurations to be applied to a device type. In this section we will explain how to create a device template, followed by some examples used during validation.

1. From the vManage GUI, go to **Configuration > Templates** and click the **Device** tab.
2. Click **Create Template** and choose **From Feature Template** from the options.
3. From the Device Model drop-down list choose the type of device for which you are creating the template. vManage displays all the feature templates for that device type. The required feature templates are indicated with an asterisk and the remaining templates are optional. The factory-default template for each feature is selected by default.
4. Enter information in the Template Name and Description fields.
5. To view the factory-default configuration for a feature template, select the desired feature template and click **View Template** text. Click the **Cancel** button to return to the Configuration Template screen. The drop-down list on each template option will show available templates for specific feature, and if templates were created previously before they will show in the list.
6. Select the desired feature template for each setting.

7. (Optional) A (+) sign indicates it is possible to add elements to the device template. The figure below illustrates options to add a service VPN, a Cellular Controller, and Additional VPN templates such as OSPF.

Figure 30 Adding Optional Elements to Device Template



8. Click the **Create** button to save the template. The new configuration template is displayed in the Device Template table. The Feature Templates column shows the number of feature templates that are included in the device template, and the Type column shows " Feature" to indicate that the device template was created from a collection of feature templates.

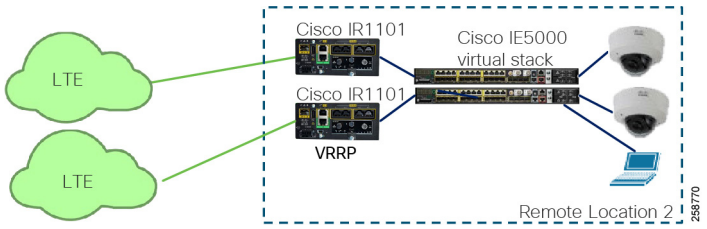
Device Templates for Extended Enterprise Remote Sites

In this guide we are creating four different device templates that match different device configurations. Note that those device templates are provided as guidance but they should be modified to match specific requirements.

IOS XE SD-WAN router with LTE Transport

Remote Location 2 on Figure 2 Validation Topology shows two routers with one cellular transport each. On the service side they are connected to a switch stack using trunk ports, and other ports are access ports to connect end devices. Note that no special device template considerations are done to support VRRP on the site because VRRP settings are added as optional parameters in the common service VPN feature templates.

Figure 31 Remote Location 2



To create a profile that matches this deployment follow steps in the Device Templates section using the following values.

Name: IR1101_CELL_with_TRUNK

Description: Template for single router with cellular connection and switchport on service side

Device Type: IR1101

Table 34 Device Template IR1101_CELL_with_TRUNK

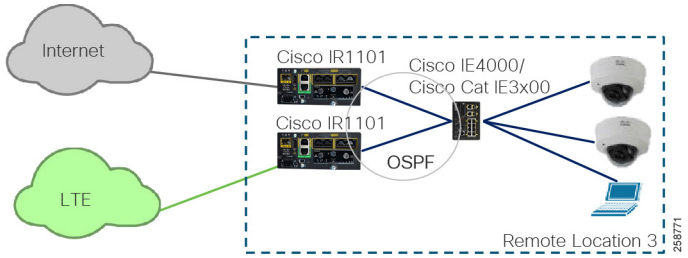
Section	Template sub-type	Template name	Note
Basic Information	System	System_Template	Blueprint on Appendix B
	Logging	Logging_Template	Blueprint on Appendix B
	NTP	NTP_Template	Blueprint on Appendix B
	AAA		Blueprint on Appendix B
	AAA-Cisco	AAA_Template	Blueprint on Appendix B
	BFD	BFD_Template	Blueprint on Appendix B
	OMP	OMP_Template	Blueprint on Appendix B
	Security	Security_Template	Blueprint on Appendix B
Transport & Management VPN (VPN0)	VPN0	RL_VPN0	
	VPN interface Cellular	RL_CELL_INT	
Service VPN (VPN1)	VPN	RL_VPN1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface Ethernet	Loopback0	
Service VPN (VPN10)	VPN	RL_VPN10	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
Service VPN (VPN11)	VPN	RL_VPN11	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-2	Optional if a second interface in same VPN is required
Cellular	Cellular Controller	RL_CELL_CONTROLLER_0_1_0	
Additional Templates	Banner	Banner_Template	Blueprint on Appendix B

	Policy	Remote_Location_Policy	Local policy
	SNMP	SNMP_Template	Blueprint on Appendix B
Switch Portxxx	Switch Port	RL_SW_Ports_4_Trunk	

IOS XE SD-WAN router with LTE Transport and OSPF

Remote location 3 on Figure 2 Validation Topology shows one router with an LTE transport and one router with an Internet transport. This section shows device template parameters for a router with LTE transport. This location has the OSPF configuration on the service side and is connected to a switch using a trunk port.

Figure 32 Remote Location 3



To create a profile that suits this deployment, follow steps in the Device Templates section using the following values.

Name: IR1101_CELL_OSPF_with_TRUNK

Description: Template for single router with cellular connection, OSPF and switchport on service side

Device Type: IR1101

Table 35 Device Template IR1101_CELL_OSPF_with_TRUNK

Section	Template sub-type	Template name	Note
Basic Information	System	System_Template	Blueprint on Appendix B
	Logging	Logging_Template	Blueprint on Appendix B
	NTP	NTP_Template	Blueprint on Appendix B
	AAA		Blueprint on Appendix B
	AAA-Cisco	AAA_Template	Blueprint on Appendix B
	BFD	BFD_Template	Blueprint on Appendix B
	OMP	OMP_Template	Blueprint on Appendix B
	Security	Security_Template	Blueprint on Appendix B
Transport & Management VPN (VPN0)	VPN0	RL_VPN0	
	VPN interface Cellular	RL_CELL_INT	
Service VPN (VPN1)	VPN	RL_VPN1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface Ethernet	Loopback0	
	OSPF	RL_OSPF	

Service VPN (VPN10)	VPN	RL_VPN10	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	OSPF	RL_OSPF	
Service VPN (VPN11)	VPN	RL_VPN11	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	OSPF	RL_OSPF	
Cellular	Cellular Controller	RL_CELL_CONTROLLER_0_1_0	
Additional Templates	Banner	Banner_Template	Blueprint on Appendix B
	Policy	Remote_Location_Policy	Local policy
	SNMP	SNMP_Template	Blueprint on Appendix B
Switch Portxxx	Switch Port	RL_SW_Ports_4_Trunk	

IOS XE SD-WAN router with Internet Transport and OSPF

Remote location 3 on Figure 2 Validation Topology shows one router with an LTE transport and one router with an Internet transport. This section shows device template parameters for router with Internet transport. This location has the OSPF configuration on the service side and is connected to a switch using a trunk port. To create a profile that suits this deployment, follow steps in the Device Templates section using the following values.

Name: IR1101_INET_OSPF_with_TRUNK

Description: Template for single router with Internet connection, OSPF and switchport on service side

Device Type: IR1101

Table 36 Table 35 Device Template IR1101_INET_OSPF_with_TRUNK

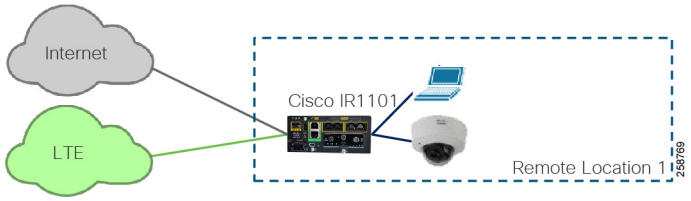
Section	Template sub-type	Template name	Note
Basic Information	System	System_Template	Blueprint on Appendix B
	Logging	Logging_Template	Blueprint on Appendix B
	NTP	NTP_Template	Blueprint on Appendix B
	AAA		Blueprint on Appendix B
	AAA-Cisco	AAA_Template	Blueprint on Appendix B
	BFD	BFD_Template	Blueprint on Appendix B
	OMP	OMP_Template	Blueprint on Appendix B
	Security	Security_Template	Blueprint on Appendix B
Transport & Management VPN (VPN0)	VPN0	RL_VPN0	
	VPN Interface	RL_INET_INT	
Service VPN (VPN1)	VPN	RL_VPN1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface Ethernet	Loopback0	

	OSPF	RL_OSPF	
Service VPN (VPN10)	VPN	RL_VPN10	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	OSPF	RL_OSPF	
Service VPN (VPN11)	VPN	RL_VPN11	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	OSPF	RL_OSPF	
Additional Templates	Banner	Banner_Template	Blueprint on Appendix B
	Policy	Remote_Location_Policy	Local policy
	SNMP	SNMP_Template	Blueprint on Appendix B
Switch Portxxx	Switch Port	RL_SW_Ports_4_Trunk	

IOS XE SD-WAN router with Cellular and Internet Transport

Remote Location 1 on Figure 2 Validation Topology shows a single router with one wired transport and one cellular transport.

Figure 33 Remote Location 1



On the service side, all switch ports are access ports. To create a profile that suits this deployment follow steps in the Device Templates section using the following values.

Name: IR1101_INET_and_CELL

Description: Template for single router with Internet and cellular transport

Device Type: IR1101

Table 37 Table 36 Device Template IR1101_INET_and_CELL

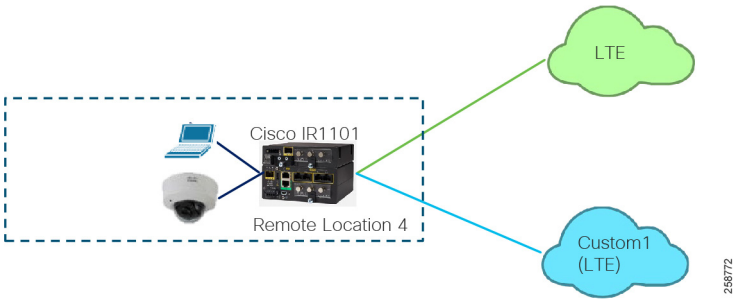
Section	Template sub-type	Template name	Note
Basic Information	System	System_Template	Blueprint on Appendix B
	Logging	Logging_Template	Blueprint on Appendix B
	NTP	NTP_Template	Blueprint on Appendix B
	AAA		Blueprint on Appendix B
	AAA-Cisco	AAA_Template	Blueprint on Appendix B
	BFD	BFD_Template	Blueprint on Appendix B
	OMP	OMP_Template	Blueprint on Appendix B

	Security	Security_Template	Blueprint on Appendix B
Transport & Management VPN (VPN0)	VPN0	RL_VPN0	
	VPN Interface	RL_INET_INT	
	VPN interface Cellular	RL_CELL_INT	
Service VPN (VPN1)	VPN	RL_VPN1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	DHCP	RL_DHCP_template	Optional if DHCP server functionality is required
	VPN Interface Ethernet	Loopback0	
Service VPN (VPN10)	VPN	RL_VPN10	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	DHCP	RL_DHCP_template	Optional if DHCP server functionality is required
Service VPN (VPN11)	VPN	RL_VPN11	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-2	Optional if a second interface in same VPN is required
Cellular	Cellular Controller	RL_CELL_CONTROLLER_0_1_0	
	Cellular profile	RL_CELL_PROFILE_CUST	Optional if non default cellular profile required**
Additional Templates	Banner	Banner_Template	Blueprint on Appendix B
	Policy	Remote_Location_Policy	Local policy
	SNMP	SNMP_Template	Blueprint on Appendix B
Switch Portxxx	Switch Port	RL_SW_Ports_4_access	

IOS XE SD-WAN router with Dual LTE

Remote Location 4 on Figure 2 Validation Topology shows a single router with an expansion module and two cellular interfaces.

Figure 34 Remote Location 4



To create a profile that suits this deployment follow steps in the Device Templates section using the following values:

Name: IR1101_DUAL_CELL_EM

Description: Template for single router with expansion module and two cellular transports

Device Type: IR1101

Table 38 Table 37 Device Template IR1101_DUAL_CELL_EM

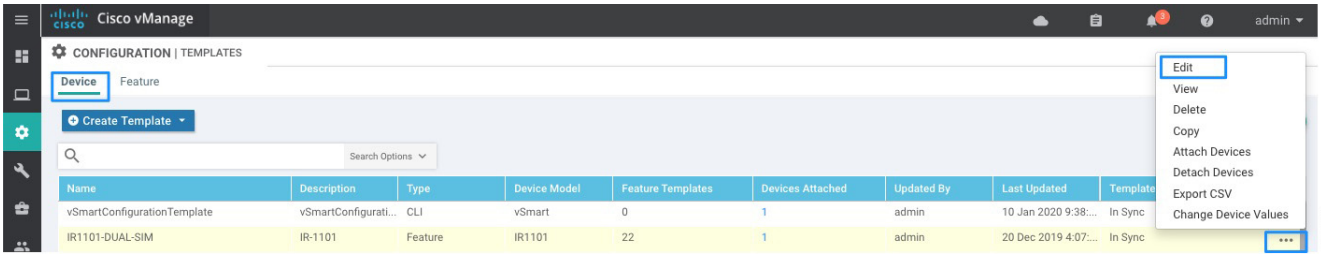
Section	Template sub-type	Template name	Note
Basic Information	System	System_Template	Blueprint on Appendix B
	Logging	Logging_Template	Blueprint on Appendix B
	NTP	NTP_Template	Blueprint on Appendix B
	AAA		Blueprint on Appendix B
	AAA-Cisco	AAA_Template	Blueprint on Appendix B
	BFD	BFD_Template	Blueprint on Appendix B
	OMP	OMP_Template	Blueprint on Appendix B
	Security	Security_Template	Blueprint on Appendix B
Transport & Management VPN (VPN0)	VPN0	RL_VPN0	
	VPN interface Cellular	RL_CELL_INT	
	VPN interface Cellular	RL_CELL_INT_EM	
Service VPN (VPN1)	VPN	RL_VPN1	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
	VPN Interface Ethernet	Loopback0	
Service VPN (VPN10)	VPN	RL_VPN10	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	
Service VPN (VPN11)	VPN	RL_VPN11	
	VPN Interface SVI	RL_ SVI-SERVICE-VPN-1	

	VPN Interface SVI	RL_ SVI-SERVICE-VPN-2	Optional if a second interface in same VPN is required
Cellular	Cellular Controller	RL_CELL_CONTROLLER_0_1_0	
	Cellular Controller	RL_CELL_CONTROLLER_0_3_0	
Additional Templates	Banner	Banner_Template	Blueprint on Appendix B
	Policy	Remote_Location_Policy	Local policy
	SNMP	SNMP_Template	Blueprint on Appendix B
Switch Portxxx	Switch Port	RL_SW_Ports_5_EM	

Modifying Templates

1. To modify device templates to add localized policy, go to **Configuration>Templates**.
2. Select the **Device** tab.
3. The page will show device templates that have already been configured. Click on the ellipses (**...**) at the end of the row for a specific device template. Choose **Edit** from the menu.

Figure 35 Edit a Template



4. Modify any settings, if desired.
5. Click **Update**. If the template is already attached to devices the wizard will continue to a configuration templates screen to show devices that will be updated. Click **Next** to preview changes and then click **Configure Devices** when you are ready to push configuration. Confirm that you want to proceed. Policy elements are now ready to be used on feature templates.