Engineering
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Virtual Chassis Fabric Best Practices Guide

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Table of Contents

About This Guide

This guide provides network architects and designers with best practice guidelines for designing, deploying, and configuring a Juniper Networks Virtual Chassis Fabric (VCF). It also provides a high-level overview of certain VCF concepts and behaviors, and prescriptive advice on how to configure and deploy your VCF.

VCF is a low-latency, high-performance fabric architecture that uses a spine and leaf topology to combine multiple devices in supported combinatoins into a resilient fabric architecture that is managed as a single device. VCF is optimized to support small and medium-sized data centers that contain a mix of 1-Gbps, 10-Gbps, and 40-Gbps Ethernet interfaces. Some VCF topologies also support 100-Gbps Ethernet connections.

This guide is available in PDF format only.

1

PART

Virtual Chassis Fabric Best Practices Guide

CHAPTER 1

Introduction to the Virtual Chassis Fabric Best Practices Guide

IN THIS CHAPTER

Scope of Virtual Chassis Fabric Best Practices Guide

The purpose of this guide is to provide network architects and designers with best practice guidelines for designing, deploying, and configuring a Juniper Networks Virtual Chassis Fabric (VCF). It also provides a high-level overview of certain VCF concepts and behaviors, and prescriptive advice on how to configure and deploy your VCF.

VCF is a low-latency, high-performance fabric architecture that uses a spine and leaf topology to combine multiple devices into a resilient fabric architecture that is managed as a single device. VCF is optimized to support small and medium-sized data centers that contain a mix of 1-Gbps, 10-Gbps, and 40-Gbps Ethernet interfaces, with some VCF topologies also supporting 100-Gbps Ethernet connections.

This guide is designed to accompany the Virtual Chassis Fabric Feature Guide, which provides detailed step-by-step instructions for a wide variety of VCF installation scenarios. Consult the Virtual Chassis Fabric Feature Guide as a resource if you want more detail about content in this guide.

Virtual Chassis Fabric Glossary

This glossary provides a list of common VCF terms.

- Autoprovisioned VCF—A VCF that is configured using autoprovisioning. In autoprovisioning, you must configure the member ID and serial number of each spine device before you can plug and play your leaf devices into the VCF.

- Homogeneous VCF—A VCF that is composed entirely of one type of switch. A homogenous VCF is considered to be a *non-mixed VCF*.

> **NOTE**: Different types of switches that can run the same software image when combined in a VCF can form what is also considered to be a non-mixed VCF that is not homegeneous. See Understanding Mixed Virtual Chassis Fabric for details.

- Leaf device—A switch fulfilling a role in the leaf layer of a VCF. The leaf layer in a VCF is the bottom layer. See Understanding Virtual Chassis Fabric Components for details the combinations of switches that can be in a VCF and in which roles.
- Mixed-mode VCF—A VCF that is composed of more than one type of switch that run different but compatible software images when combined in a VCF. You are required to configure a mixed-mode setting for the switches to interoperate in a VCF. See Understanding Mixed Virtual Chassis Fabric for details.
- Network ports—Network-facing ports on any member switch in a VCF that are used to connect to devices outside of the VCF.
- Nonprovisioned VCF—A VCF that is configured using nonprovisioning. In a nonprovisioned VCF, all roles for all switches are assigned using a primary-role election algorithm. We do not recommend using a nonprovisioned VCF configuration for most scenarios, and nonprovisioned VCF configuration should only be done by expert users.
- Nonprovisioned member switch—A member switch that was installed into a VCF without a network administrator explicitly defining the role and member ID of the switch.
- Non-mixed VCF—A VCF that is composed entirely of all the same type of switch, or a combination of switches that can run the same software image when combined in a VCF and do not require you to configure a mixed-mode setting for the switches to interoperate. See Understanding Mixed Virtual Chassis Fabric for details.
- Preprovisioned VCF—A VCF that is configured using preprovisioning. In a preprovisioned VCF, you configure the member ID and serial number of every device in the VCF.
- Provisioned member switch—A member switch in a VCF whose role and member ID were explicitly configured, or provisioned, by a network administer.
- Spine device—A switch fulfilling a role in the spine layer in a VCF. The spine layer in a VCF is the top layer. See Understanding Virtual Chassis Fabric Components for details on the switches that can form a VCF and which can be spine devices.
- Virtual Chassis port (VCP)—A port that is used as a fabric port to interconnect member switches in a Virtual Chassis or VCF. See Understanding Virtual Chassis Fabric Components for details on VCPs.

- Virtual Chassis Control Protocol (VCCP)—The protocol that creates and maintains a Virtual Chassis or VCF.

CHAPTER 2

Understanding Virtual Chassis Fabric

IN THIS CHAPTER

Virtual Chassis Fabric Introduction

VCF is a low-latency, high-performance fabric architecture that uses a spine and leaf topology to combine multiple devices into a resilient fabric architecture that is managed as a single device. VCF is optimized to support small and medium-sized data centers that contain a mix of 1-Gbps, 10-Gbps, and 40-Gbps Ethernet interfaces, with some VCF topologies also supporting 100-Gbps Ethernet connections.

VCF provides the following benefits:

- Latency—VCF provides predictable low latency by using a fabric architecture that ensures each device is only one or two hops away from every other device in the fabric. The weighted algorithm that makes traffic-forwarding decisions in a VCF avoids congestion and intelligently forwards traffic over all paths within the VCF to any destination device, ensuring predictable low latency for all traffic traversing the VCF.

- Resiliency—The VCF architecture provides a resilient framework because traffic has multiple paths across the fabric. Traffic is easily diverted to another path within the fabric when a device or link fails.

- Flexibility—You can easily expand the size of your VCF by adding devices to the fabric as your networking needs grow.

- Investment protection—In environments that need to expand because the capabilities of a QFX5110, QFX5100, QFX3600, QFX3500, or EX4300 Virtual Chassis are maximized, a VCF is often a logical upgrade option because it enables the system to evolve without having to remove the existing, previously purchased devices from the network.

- Manageability—VCF provides multiple features that simplify configuration and management. VCF, for instance, has an autoprovisioning feature that enables you to plug and play devices into the fabric after minimal initial configuration. VCF leverages many of the existing configuration procedures from a Virtual Chassis, so that you can configure and maintain a VCF easily if you are already familiar with the procedures for configuring and maintaining a Virtual Chassis.

VCF evolved from Juniper's Virtual Chassis technology, which allows you to interconnect multiple switches in a ring topology and manage the interconnected switches as a single device.

VCF inherited the following major architectural pillars from Virtual Chassis technology:

- All member devices in a VCF are managed and controlled by a pair of switches acting in the Routing Engine (RE) role, allowing the entire VCF to be controlled as a single device running Junos OS.

- A backplane is constructed over the Virtual Chassis port (VCP) links to allow the VCF to be managed as a single device running Junos OS.

- The ports connecting member devices are VCPs controlled using the Virtual Chassis Control Protocol (VCCP). The VCCP daemon (VCCPd) runs on every member device in the VCF to discover and manage the VCF topology.

- Many of the CLI commands used to create or maintain a Virtual Chassis are also used to create or maintain a VCF.

The following evolutions to the Virtual Chassis technology introduced by VCF include:

- Support for a multi-path fabric architecture that has the intelligence to forward traffic over the shortest paths within the fabric.

- Intelligent bandwidth allocation that detects and considers end-to-end bandwidth for all paths across the fabric when forwarding flows from one member switch in the fabric to another member switch in the VCF.

- Ability to calculate multiple bidirectional multicast distribution trees and perform load balancing based on these trees.

For more detailed overview information on VCF, see Virtual Chassis Fabric Overview and Understanding Virtual Chassis Fabric Components.

Virtual Chassis Technology in Virtual Chassis Fabric

VCF utilizes the software infrastructure of Juniper Network's flagship Virtual Chassis technology.

VCF, for instance, is managed as a single device running Junos OS and is configured and monitored using many of the CLI commands that are used to monitor and maintain a Virtual Chassis.

As with a Virtual Chassis, VCF uses a virtual management Ethernet (VME) interface, an optional but highly recommended user-configured interface that allows you to access and manage the VCF from a single IP address. A VME interface is a logical interface representing all of the out-of-band management ports on the member devices and it can be accessed from any member switch in the VCF that has a cabled management port. Therefore, even in the event of a Routing Engine switchover, you can log into the Virtual Chassis using the VME interface credentials.

VCF—also like a Virtual Chassis—has an inband virtual backplane that is constructed over the VCPs to enable resilient connectivity between all member switches in the fabric.

Virtual Chassis Fabric Member Switch Roles

Each member switch in a VCF is assigned one of the following three roles:

- Primary Routing Engine—The primary Routing Engine runs all Junos OS daemons and controller processes for the entire VCF. The primary Routing Engine is always a spine device.

- Backup Routing Engine—The backup Routing Engine runs Junos OS in standby mode and synchronizes kernel and protocol states with the primary Routing Engine to ensure it is ready to assume the primary Routing Engine role in the event of a primary Routing Engine failure. The backup Routing Engine is always a spine device.

- Linecard—All member switches in a VCF that are not in the primary or backup Routing Engine role—spine devices not in the primary or backup Routing Engine role and all leaf devices—assume the linecard role. The primary purpose of devices in the linecard role is to send and receive network traffic.

A member switch that cannot participate in any of the active roles is assigned the role of inactive.

- Inactive—Inactive member switches cannot forward packets, and an inactive member switch might not always be accessible for management purposes.

Routing Engine eligibility is user configurable. In an autoprovisioned or preprovisioned VCF, you can configure two member switches into the Routing Engine role as part of the configuration procedure, where one acts as the primary Routing Engine and the other as the backup Routing Engine. In a nonprovisioned VCF, you can set the primary-role priority values to ensure the switches with the highest primary role priorities assume the Routing Engine roles.

A VCF supports up to 20 member switches, as follows:

- 2 to 4 members are spine devices, where 2 spine devices act as primary and backup Routing Engines, and any other spine devices assume the linecard role.
- The remaining members are leaf devices that always assume the linecard role.

A VCF should consist of at least 4 devices—2 spine members configured in the primary and backup Routing Engine roles, and 2 leaf members in linecard role. If you have fewer than 4 devices, you should configure a Virtual Chassis (which uses a ring topology) instead of a VCF. (See Virtual Chassis Feature Guide for Switches.)

As a best practice, plan to use the highest-end supported devices as the spine members in the Routing Engine role in your VCF.

For details on member roles in a VCF and the switches that are supported in a VCF in which roles, see Understanding Virtual Chassis Fabric Components.

Spine and Leaf Recommendations

IN THIS SECTION

Spine and leaf device recommendations vary by type of VCF and the needs of your network.

A VCF can be set up with QFX5100 switches as the spine devices, referred to as a *QFX5100 VCF*, or using QFX5110-32Q switches as the spine devices, referred to as a *QFX5110 VCF*:

- A QFX5100 VCF has QFX5100 switches as spine members, and supports either all QFX5100 switches as leaf members (a non-mixed QFX5100 VCF), or any combination of EX4300, QFX3500, and QFX3600 switches, possibly with additional QFX5100 switches, as leaf members (a mixed-mode QFX5100 VCF).

NOTE: EX4300 multigigabit models (EX4300-48MP) are not supported in a VCF.

- A QFX5110 VCF supports QFX5110-32Q switches as spine members, and supports either all QFX5110 switches or any combination of supported QFX5100 switches and QFX5110 switches as leaf members. Both QFX5110 and QFX5100 switches run the same software image in a QFX5110 VCF, and do not require configuring mixed mode to interoperate.

QFX5100 VCF Spine and Leaf Recommendations

Table 1 on page 9 provides a list of recommended switches for a QFX5100 VCF based on the server attachment speeds of the servers in your data center.

Other combinations of spine and leaf switches are supported; consider the device combinations in this table as recommendations only.

Table 1: Spine and Leaf Switch Recommendations for a QFX5100 VCF

Device	1-Gbps Server Attachments	1-Gbps or 10-Gbps Server Attachments	Mix of 1-Gbps, 10-Gbps, and 40-Gbps Server Attachments
Spine	QFX5100-48S	QFX5100-24Q	QFX5100-24Q
Leaf	EX4300	QFX5100-24Q QFX5100-48S QFX5100-48T QFX5100-96S QFX3600	QFX5100-24Q QFX5100-48S QFX5100-48T QFX5100-96S QFX3600 EX4300

QFX5110 VCF Spine and Leaf Recommendations

In a QFX5110 VCF:

- Spine devices should be QFX5110-32Q switches, so as a result, the members acting as primary and backup in the Routing Engine role are QFX5110-32Q switches.

- Leaf devices can be QFX5110-32Q, QFX5110-48S switches, or any of the following QFX5100 switches:
  - QFX5100-24Q
  - QFX5100-48S
  - QFX5100-48T (starting in Junos OS Release 17.3R2)
  - QFX5100-96S

QFX5110 switches in a QFX5110 VCF have flexible port options for server attachments, uplink ports, and VCPs for VCF member interconnection.

QFX5110 switches support a small number of 100-Gbps ports that are usually used as uplink ports, but can be used as VCPs as well. QFX5110 switches also have 1-Gbps, 10-Gbps, and 40-Gbps port options. See the QFX5110 hardware documentation as follows for details on the ports supported on QFX5110 switches that can be used, as needed, as uplink ports or VCPs to take advantage of higher port speeds, and independent and channelized port options that can be used as server access ports on leaf or spine members:

- QFX5110-32Q Port Panel
- QFX5110-48S Port Panel

Guidelines for using ports on QFX5100 leaf members in a QFX5110 VCF for different speed server connections in your network are similar to those listed in Table 1 on page 9 for a QFX5100 VCF.

Multipath Forwarding in a Virtual Chassis Fabric

In a VCF, unicast packet forwarding is based on the Dijkstra Shortest Path First (SPF) algorithm. All shortest path routes from any switch to any other switch across the fabric are utilized.

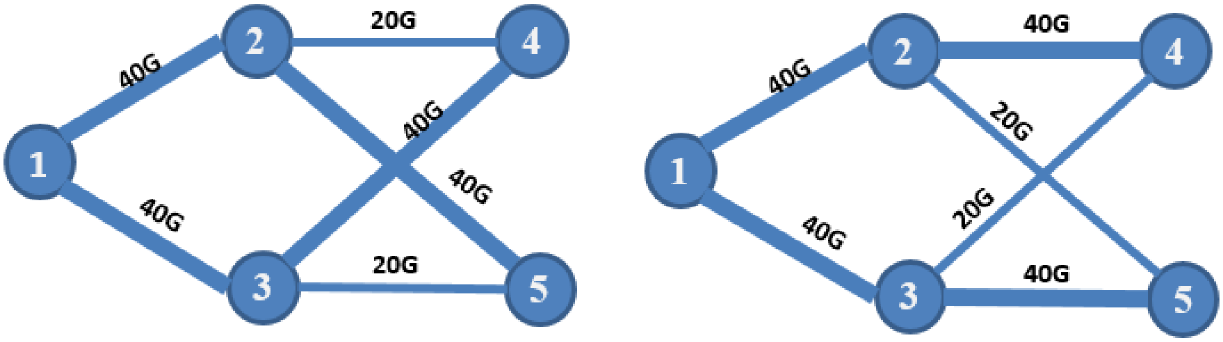
Multiple equal cost paths are used to carry unicast traffic from any switch in a VCF to any other switch in the same VCF. The transmitting switch in a VCF sprays packets across the VCF based on the bandwidth ratio of the end-to-end path bandwidths.

The VCF traffic management algorithm allocates weights across paths to avoid traffic congestions while transmitting traffic. The weights are based on the bandwidth available for each path across the VCF.

The SPF algorithm used in VCF is enhanced to record the minimum bandwidth—also known as the *bottleneck bandwidth*—of each path across the VCF. The path’s minimum bandwidth is then allocated to related next-hop links according to their link bandwidth. In this setup, each switch independently calculates its multipath weight to other switches and configures its own traffic spraying ratios. The overall traffic distribution is achieved on a hop-by-hop basis.

Figure 1 on page 11 illustrates this multipath forwarding scheme.

Figure 1: Multipath Bandwidth Allocation Example



In Figure 1 on page 11, switch 1 is a leaf device transmitting traffic, switches 2 and 3 are spine devices, and switches 4 and 5 are receiving traffic from switch 1.

For the first multipath topology in Figure 1 on page 11, the packets traveling from switch 1 to switch 5 have 2 shortest paths, with path bandwidths of 40-Gbps and 20-Gbps as listed in Table 2 on page 11. When transmitting packets destined to switch 5, switch 1 allocates weights to the two paths based on the end-to-end path bandwidth ratio of 2:1, so that traffic from switch 1 to switch 5 is transmitted twice as often through the 1 → 2 → 5 path as it is through the 1 → 3 → 5 path. For traffic destined to switch 4 from switch 1, switch 1 has the same two next-hop end-to-end path bandwidth ratios to forward the packets, but switch 1 transmits twice the number of flows through switch 3 as opposed to switch 2, as listed in Table 2 on page 11.

Table 2: Virtual Chassis Fabric Bandwidth Allocation Example

Node 1	Description	Path Bandwidth	Next Hop Link	Link Weight
1 → 5	1 → 2 → 5	40 Gbps	1 → 2	67%
	1 → 3 → 5	20 Gbps	1 → 3	33%
1 → 4	1 → 2 → 4	20 Gbps	1 → 2	33%
	1 → 3 → 4	40 Gbps	1 → 3	67%

This example illustrates that the link bandwidth used in downstream connections impacts bandwidth distribution on upstream links. For example, if the downstream links are connected as in the second illustration of Figure 1 on page 11, the end-to-end bandwidth ratio for the next hop links are inverted. This behavior of using the end-to-end bandwidth ratio is in contrast to traditional practices of allocating path weight based on the next-hop link bandwidth only. The link weight ratios for flows that are destined to switch 4 and switch 5 are different, which is in contrast to using a single ratio for traffic exiting at different nodes.

The capability of allocating link weights based on end-to-end path bandwidth and the capability of differentiating traffic according to its final egress nodes are referred to as *smart trunking*. VCF's smart trunking can, in most cases, allow better utilization of fabric bandwidth and reduce unnecessary congestions because of improper allocation of traffic flows inside the VCF.

Multicast Distribution Trees in a Virtual Chassis Fabric

VCF uses multicast distribution trees (MDTs) as the central mechanism for loop avoidance in forwarding of multicast, broadcast and flooding traffic inside the VCF. An MDT is calculated using the breadth-first search (BFS) algorithm rooted at any selected switch. The BFS algorithm is selected because it produces a tree that can cover the topology with the fewest number of hops, so it is conducive to shorter multicast latency. VCF uses the MDTs as bidirectional trees.

To load balance broadcast, unknown unicast, multicast, and flooding traffic evenly in any VCF topology, multiple MDTs are calculated. The number of MDTs calculated in a VCF matches the number of member devices in the VCF.

BUM and flooding traffic are assigned to a particular MDT based on VLAN ID, while known multicast traffic is load balanced to MDTs at the granularity of multicast next hops.

Control Path Resiliency and High Availability in a Virtual Chassis Fabric

IN THIS SECTION

This section discusses control path resiliency and high availability in a VCF, and includes the following sections:

Control Path Resiliency

VCF utilizes an in-band virtual backplane to carry fabric control traffic. The control plane software utilizes the built-in path resiliency to achieve control plane resiliency. VCF topologies can add multiple paths between any two nodes in the fabric by adding spine devices; for instance, a path from leaf node 1 to leaf node 2 has two paths when a VCF is using two spine devices, and four paths when a VCF is using four spines. VCF topologies should be created with the understanding that adding spine devices improves performance by providing multiple paths for traffic to travel and resiliency because additional paths remain available when a spine device fails.

NOTE: You should not configure more than 64 VCPs on a single spine device.

Graceful Routing Engine Switchover (GRES)

VCF is a dual Routing Engine architecture that supports graceful Routing Engine switchover (GRES). GRES allows the backup Routing Engine to assume the primary Routing Engine role without interruption to packet forwarding if the primary Routing Engine fails.

GRES preserves interface and kernel information so that traffic is not interrupted during a switchover. GRES alone, however, does not preserve the control plane in the event of a primary Routing Engine failure. Other events, such as protocol timers expiring or neighbor relationships dropping, can happen during a routing engine switchover. These behaviors are mitigated using nonstop active outing (NSR) and nonstop bridging (NSB), which are supported for VCF.

See Configuring Graceful Routing Engine Switchover for additional information on GRES in a VCF.

Nonstop Software Upgrade (NSSU)

Nonstop software upgrade (NSSU) provides a mechanism for upgrading Junos OS on Juniper Networks EX and QFX Series Ethernet Switches in a VCF using a single command-line interface (CLI) command with minimal traffic disruption. For VCFs that support NSSU, the feature requires active redundant Routing Engines to successfully upgrade the VCF, and the VCF must be preprovisioned.

NSSU leverages the underlying high availability features such as *GRES*, *NSR*, and NSB to enable upgrading the Junos OS version running on a switch or in a VCF configuration with no disruption to the control plane and minor, sub-second interruption to the data plane. NSSU upgrades member switches individually, permitting traffic to continue to flow through the line card switches that are not being upgraded. By configuring *link aggregation groups (LAGs)* such that the member links reside on different member switches, it is possible to achieve little to no sub-second traffic disruption on your VCF when performing an NSSU.

See Understanding Nonstop Software Upgrade on a Virtual Chassis Fabric for additional information on NSSU in a VCF.

CHAPTER 3

Virtual Chassis Fabric Design and Configuration

IN THIS CHAPTER

VCF Objective Metrics

IN THIS SECTION

This section provides information on the following objective metrics that you should consider when configuring a VCF:

Latency

VCF has a deterministic latency for both unicast and multicast traffic.

For unicast traffic forwarding, VCF utilizes the Djikstra shortest path first (SPF) algorithm. The overall latency is determined by the number of hops on the shortest paths from the ingress node to the egress node.

Multicast latency is determined by:

- The multicast distribution tree (MDT) that is selected to forward a multicast packet. MDT selection is based on the multicast group's next hop.
- The distance—the number of hops—from the ingress node on the MDT to the egress node on the MDT.

Fabric Link Resiliency

When designing a VCF topology, you should ensure fabric link resiliency between any pair of nodes within the VCF to avoid cases of link and node failures. Fabric link resiliency is improved in a VCF by adding spine devices that are interconnected to all satellite devices in the VCF. A leaf device in a VCF that has four spine devices, for instance, has four paths to every other leaf device in the VCF.

You must configure at least two spine devices in all VCF topologies. A two spine device topology ensures some fabric resiliency as well as support for *NSSU*. In most VCF topologies, however, you should configure four spine devices if possible to provide maximum fabric link resiliency.

You do not want a VCF to split in the event of a failed link or member switch. A good design principle for fabric link resiliency is to ensure that, under any single link or switch failure, the VCF topology remains fully connected.

Fabric Bandwidth

When designing a VCF, know the total bandwidth of a particular VCF path and determine whether the topology design satisfies your traffic needs.

- Unicast bandwidth—The maximum fabric bandwidth for unicast traffic between any pair of two nodes is the sum of the smallest segment bandwidth on all end-to-end paths. Therefore, unicast bandwidth between any node pair can be increased by adding intermediate devices in between. In a spine and leaf topology, bandwidth between leaf devices can be increased by adding spine devices.
- Multicast bandwidth—Multicast traffic travels along a multicast distribution tree on the VCF topology. An MDT is composed of hop-by-hop link segments. Therefore, a VCF's fabric multicast bandwidth is the minimum bandwidth of all aggregated fabric links between directly connected neighbors.

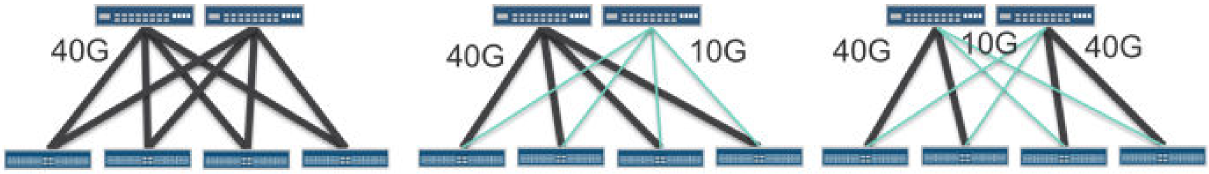
Reference Virtual Chassis Fabric Topologies

This section provides three VCF reference topologies, and a summary of the pros and cons of each topology.

NOTE: A VCF should include at least four members—two spine devices and at least two leaf devices. A three-member VCF is not a supported configuration. For topologies with three or fewer members, use a Virtual Chassis configuration instead.

Figure 2 on page 17 shows the reference topologies.

Figure 2: Good and Bad Spine and Leaf Examples



Example 1: If you want to build a VCF with two spine devices, we recommended that you use all 40-Gbps links, as shown in the first topology in Figure 2 on page 17. In this topology, the multicast bandwidth for the VCF is 40 Gbps.

Example 2: If you want to build a VCF with 40-Gbps and 10-Gbps links between spine and leaf devices, we recommend that all 40-Gbps links are terminated on the same set of spine devices, and all 10-Gbps fabric links are also terminated on the same set of spines, as shown in the second topology in Figure 2 on page 17. Note that in this scenario, bandwidth for leaf-to-leaf unicast traffic is 50 Gbps while the fabric bandwidth for multicast traffic is only 10 Gbps.

Example 3: We do not recommended mixing path bandwidth at a single spine, as show in the third topology in Figure 2 on page 17. VCF still functions in these topologies, but performance is not optimal. These topologies should only be used as transient topologies and are not recommended for production networks.

Mixed Virtual Chassis Fabric

A VCF with member switches from more than one product family is called a mixed VCF.

The following product families can be combined into a mixed QFX5100 VCF, which is a VCF where the spine devices are QFX5100 switches, and the leaf devices can be any of the following:

- QFX5100 switches
- QFX3500 and QFX3600 switches

- EX4300 switches

NOTE: A QFX5110 VCF, which is a VCF where the spine devices are QFX5110-32Q switches, can contain all QFX5110 switches or a mixture of QFX5110 and QFX5100 switches as leaf members. In either case, a QFX5110 VCF is considered to be a non-mixed VCF because both switch types run the same software image when interconnected into a QFX5110 VCF, and you are not required to set mixed mode. A QFX5110 VCF cannot include QFX3500, QFX3600, or QFX4300 switches.

The key benefits of allowing a mixed QFX5100 VCF include:

- Diversification of supported interfaces as the devices broaden the mix of 1-Gbps, 10-Gbps, and 40-Gbps network ports available in the VCF.

- Increased investment protection as previously purchased switches can be included in the VCF.

A QFX5100 VCF must use QFX5100 switches as spine devices, so a non-mixed QFX5100 VCF uses all QFX5100 switches as spine and leaf devices. A mixed QFX5100 VCF is any VCF that has at least one QFX3500, QFX3600, or EX4300 switch among the leaf devices.

The optimal QFX5100 VCF topology is to use a non-mixed VCF with QFX5100 switches only. A VCF composed entirely of QFX5100 switches supports the largest breadth of features available at the highest scalability and with the most high-speed interfaces as compared to QFX3500, QFX3600, and EX4300 switches. However, a mixed QFX5100 VCF gives you the flexibility to employ existing devices from your network as leaf devices.

NOTE:

The optimal VCF topology among all devices that support VCF technology is a QFX5110 VCF with all QFX5110 switches. A VCF composed entirely of QFX5110 switches supports the largest breadth of features available at maximum scalability with the highest speed interfaces. However, you also have the flexibility to employ existing QFX5100 switches from your network as leaf devices in a QFX5110 VCF.

All member switches in a mixed QFX5100 VCF must be configured into mixed mode using the **request virtual-chassis mode mixed** command. A device reboot is required for an update to the mixed mode setting to take effect. Mixed mode configuration is not required for a QFX5110 VCF that contains both QFX5110 and QFX5100 switches.

For more information on a mixed VCF, including the switches that can fulfill each role in a VCF, see Understanding Mixed Virtual Chassis Fabric.

Fabric Mode

A switch must be configured into fabric mode for it to properly join a VCF. You should configure a device into fabric mode before interconnecting it into a VCF.

NOTE: In autoprovisioned configurations, if a device is interconnected into a VCF before having fabric mode configured, the VCF will automatically set fabric mode and reboot the device. However, having a device reboot automatically during VCF configuration and operation can be unexpected. As a result, in this case you also usually want to configure fabric mode (and mixed mode at the same time, if applicable), and reboot the device *manually* before adding it to the VCF, rather than having the VCF do this automatically.

To change the fabric mode of a switch, enter the following command:

```
user@switch>request virtual-chassis mode fabric [local | member member-number | all-members] [reboot]
```

A reboot is required for a fabric mode change to take effect on the switch. If you are creating a mixed VCF, you have to configure all switches in the VCF into mixed Virtual Chassis mode. Because a reboot is also required to change the Virtual Chassis mode, we recommend changing the Virtual Chassis mode at the same time as you change the fabric mode so that you can update and apply both settings with a single reboot.

When fabric mode is disabled, switches can form a Virtual Chassis but cannot form a VCF because the enhanced fabric capabilities are not available.

See Understanding Virtual Chassis Fabric Components for additional information on fabric mode, and Understanding Mixed Virtual Chassis Fabric for details on which combinations of switches in a VCF require you to set mixed-mode.

Virtual Chassis Fabric License Requirement

A feature license is required to configure a VCF.

The VCF feature license is an independent feature license. The VCF feature license is not included in the enhanced feature licenses (EFLs) or the advanced feature licenses (AFLs) that are purchased to enable some features on some Juniper Networks switches.

For a VCF deployment, we recommend two license keys for redundancy—one for the device in the primary Routing Engine role and the other for the device in the backup Routing Engine role.

VCF Configuration Steps

IN THIS SECTION

This section provides a high-level overview of the VCF configuration steps and includes the following sections:

Virtual Chassis Fabric Preparation Review

Before starting to configure the VCF, the following design decisions should be made based on information in prior sections of this document:

1. Topology. Determine which spine and leaf architecture is the right topology for your network.

2. Type of devices in your VCF.

   - A QFX5110 VCF is a VCF with QFX5110 spine devices and any combination of supported QFX5100 and QFX5110 leaf devices. Both types of devices run the same Junos OS software image when interconnected together and configured into a QFX5110 VCF, so this is considered to be a *non-mixed* VCF. For best results when planning a QFX5100 VCF, use only QFX5110-32Q switches as the spine devices.

   - A QFX5100 VCF is a VCF with QFX5100 spine devices, and can have only QFX5100 leaf devices (a *non-mixed QFX5100 VCF*) or a combination of QFX5100, QFX3500, QFX3600, and EX4300 leaf devices running compatible Junos OS software (a *mixed QFX5100 VCF*).

   See Virtual Chassis Fabric Overview for details on the topology and devices that can be in a VCF.

3. Mixed or non-mixed VCF. Determine whether your VCF is a non-mixed VCF (see the previous step and Understanding Mixed Virtual Chassis Fabric).

   The optimal QFX5110 VCF topology is to use all QFX5110 devices, and specifically QFX5110-32Q switches as the spine devices. A QFX5110 VCF composed entirely of QFX5110 devices supports the largest breadth of features at the highest scalability while also supporting the highest number of high-speed interfaces.

The optimal QFX5100 VCF topology is to use a non-mixed VCF with QFX5100 devices only. A QFX5100 VCF composed entirely of QFX5100 devices supports the largest breadth of features at the highest scalability while also supporting the highest number of high-speed interfaces available on QFX5100 switches.

These decisions should be made before performing the VCF configuration steps for the following reasons:

- You need to know the topology to cable and configure the switches.

- A QFX5110 VCF can only be set up using QFX5110 and QFX5100 switches that are running the same Junos OS software, which must be a software image that includes “-qfx-5e-” in the software package filename when the Junos OS package is downloaded from the Software Center. QFX5100 switches running a Junos OS image that includes “-qfx-5-” in the software package filename *must* be upgraded to a package filename that includes “-qfx-5e-” before being included in a QFX5110 VCF. The upgrade requires rebooting the QFX5100 switch from USB install media and rebooting the switch. See Upgrading a QFX5100 Switch with a USB Device to Join a QFX5110 Virtual Chassis or Virtual Chassis Fabric for details.

- All member switches in a mixed VCF have to be rebooted to change the VCF mode. In a mixed-mode VCF, we recommend changing the fabric and mixed mode on each member switch—changing the fabric mode is a mandatory step that always requires a reboot—at the same time so that you can reboot the switch once for both configuration changes to take effect.

Most other design and configuration decisions, such as adding or removing VCPs, adding or removing member switches, or switching between preprovisioned and autoprovisioned configuration processes, can usually be changed without requiring system downtime.

Once a VCF topology has been decided, the VCF configuration generally involves the following steps:

1. Select either the preprovisioned or the autoprovisioned method of configuring the VCF.

2. Prepare each member switch for the VCF, including upgrading the member switches to the appropriate version of Junos OS that supports VCF, and setting the member switches into fabric mode and, if applicable, mixed mode.

3. Create the appropriate Virtual Chassis configuration.

4. Connect the VCPs.

Selecting a Provisioning Method

You can provision a VCF in one of the following ways:

- Autoprovision

- Preprovision
- Nonprovision (not recommended)

Consider the following factors when selecting a provisioning method:

- Autoprovisioning: Autoprovisioning simplifies the configuration process, because you can plug and play leaf devices into the VCF after completing a minimal initial configuration procedure that includes specifying the spine devices.
- Preprovisioning: Preprovisioning allows you to explicitly control the composition of the VCF, but it is more labor-intensive than autoprovisioning because you have to collect and configure the serial number of each member switch in the VCF.
- Nonprovisioning: We discourage the use of nonprovisioned VCF configuration. Only use a nonprovisioned VCF configuration if you are an expert user and you have a clear understanding of why you are using a nonprovisioned configuration over an autoprovisioned or a preprovisioned configuration.

Autoprovisioning a VCF

IN THIS SECTION

To autoprovision a VCF, you must first configure the roles and serial numbers of the spine switches before the leaf devices can plug and play into the VCF.

For detailed step-by-step instructions for configuring your VCF using autoprovisioning, see Autoprovisioning a Virtual Chassis Fabric.

This section discusses the following topics:

Preparing a Leaf Device

In an autoprovisioned VCF, you can plug-and-play leaf devices into the VCF. In an autoprovisioned VCF, VCPs are created automatically as leaf devices are cabled to spines devices.

Routing Engine Preparation

When building a mixed VCF, follow these rules:

- Select your Routing Engines from the list of eligible Routing Engine switch models. See Understanding Mixed Virtual Chassis Fabric.

- Configure and install your Routing Engine switches before your line card switches.

  While you are not required to install the Routing Engine switches first, primary and backup synchronizations occur as part of the Routing Engine switch process and multiple switchovers can lead to unpredictable results.

- (Recommended) Zeroize your spine device.

  All spine switches must be provisioned and are not required to be in factory-default state. However, an automatic reboot procedure is performed when the spine switch is not in the factory default state. If a switch was previously deployed in a Virtual Chassis or VCF, we recommend using the **request system zeroize** to erase all VCP configurations and to allow the automatic VCP conversions to happen without interference.

- Ensure that LLDP is enabled on all switches that will become VCPs.

  LLDP is enabled by default on all EX and QFX Series switch interfaces, so you only need to perform this check if the LLDP configuration was previously modified. See Configuring LLDP (CLI Procedure).

- Ensure the spine switches are set into the right mode before building the VCF. In the following example, a primary Routing Engine switch in a mixed VCF is set into mixed fabric mode before building the VCF:

  ```
  user@switch> request virtual-chassis mode fabric mixed local [reboot]
  Mode set to 'Fabric with mixed devices'.  (Reboot required)
  ```

  After the switch is rebooted, it will be set to operate in **mixed fabric** mode.

Leaf Device Preparation

Leaf devices must meet the following requirements before being interconnected into a VCF to be able to plug and play:

- The switch must be in factory default mode.

  A switch received from the factory that has not been configured can be immediately installed into an autoprovisioned VCF as a leaf device.

For switches that have previously been used in a network, set the switch into factory default mode by entering the **request system zeroize** command:

```
user@switch> request system zeroize
```

- (EX4300 switches using 40-Gbps interfaces only) Delete the existing VCP configurations.

  The 40-Gbps QSFP+ interfaces on EX4300 switches are configured as VCPs, by default. Automatic VCP conversion only works when the interfaces on both ends of the link are not configured into VCPs. You must, therefore, delete the default VCP configuration on 40-Gbps QSFP+ interfaces on the EX4300 switches for AVC to work. You can delete a VCP configuration using the **request virtual-chassis vc-port delete** command.

Sample VCF Autoprovisioned Configuration

This section shows a sample autoprovisioned VCF configuration.

You should configure the VCF from the primary Routing Engine:

```
Switch-1>show configurations virtual-chassis
auto-provisioned;
member 0 {
    role routing-engine;
    serial-number BBAK8864;
}
member 1 {
    role routing-engine;
    serial-number ED3702;
}
member 2 {
    role line-card;
    serial-number BBAK8714;
}
member 3 {
    role line-card;
    serial-number BBAK8759;
}
{master:0}
Switch-1>
```

This configuration only includes the serial numbers of the spine devices. You must configure two spine devices into the Routing Engine role and, if you are using three or four spine devices, configure the non-Routing Engine spine devices into the linecard role.

Connecting the VCPs

With any autoprovisioned configuration, including the sample configuration in the previous section, VCPs form automatically as leaf devices are cabled to the spine device.

The following actions might occur to newly-cabled leaf devices after the VCPs are formed:

- the leaf device might reboot.
- ports are automatically converted into VCPs.
- the leaf device joins the VCF.
- the spine device joins the VCF.

Each of these actions is discussed in more detail in the following sections.

Understanding the Leaf Device Reboot

Leaf devices automatically reboot when cabled to spine devices in an autoprovisioned configuration when the fabric mode or mixed mode needs to be changed to match the settings in the primary spine device.

Because your leaf switch is zeroized before it is cabled into a VCF, expect your leaf device to reboot immediately after you cable it into a VCF.

The leaf device is recognized by the VCF after the reboot.

Automatic VCP Conversion

Leaf devices automatically convert ports to VCPs in an autoprovisioned configuration.

For the automatic VCP conversion procedure to work, both ends of the link must be set as network ports initially.

NOTE: The 40-Gbps QSFP+ interfaces on EX4300 switches are configured as VCPs, by default. Automatic VCP conversion (AVC) only works when the interfaces on both ends of the link are not configured into VCPs. You must, therefore, delete the default VCP configuration on 40-Gbps

QSFP+ interfaces on the EX4300 switches for AVC to work. You can delete a VCP configuration using the **request virtual-chassis vc-port delete** command.

The process to create the VCP can take up to 60 seconds. If multiple same-speed links are interconnected between the same spine and aggregation devices, the VCPs automatically form a VCP LAG.

Leaf Devices Joining the VCF

After the network ports are converted into VCPs, the leaf switches are brought into the VCF and assigned member ID numbers.

Spine Devices Joining the VCF

If you add a spine device to an autoprovisioned VCF, you must first update the configuration to specify the new spine device's serial number and assign it a member ID.

A spine device joining an existing VCF goes through various procedures similar to a leaf switch joining a VCF, including:

- The spine switch reboots when the fabric mode or mixed mode is updated because it is not consistent with the primary Routing Engine.

  NOTE: We recommend changing the fabric and mixed mode settings before interconnecting your new spine device into the VCF by entering the **request virtual-chassis mode fabric mixed local reboot** command. This action avoids a potentially unexpected automatic device reboot upon cabling the device into the VCF.

- The joining spine switch reboots if it is in the factory-default state.
- Network ports are automatically converted into VCPs.

Understanding VCP Link Aggregation Group Creation

After the autoprovisioned VCF is formed, parallel links—same speed links connecting the same spine device to the same leaf device—between any pair of member switches are automatically converted into a VCP LAG and the combined bandwidth is added to fabric path calculations.

Stopping Automatic VCP Conversion

Once a VCF is formed, stopping the autoprovisioning process can avoid bringing in additional chassis into the VCF by mistake, especially in cases where you want to use the uplink interfaces on the spine devices as network ports.

To stop the autoprovisioning process, you can do one of the following two things:

- Disable LLDP on all the interfaces that are going to connect new member switches.
- Convert the autoprovisioned VCF into a preprovisioned VCF. This is a straightforward process because all of the member switches have serial numbers that are already discovered.

Preprovisioning a VCF

IN THIS SECTION

This topic describes the extra steps that are required to form a mixed VCF using preprovisioning instead of autoprovisioning. For detailed step-by-step instructions for configuring your VCF using autoprovisioning, see Preprovisioning a Virtual Chassis Fabric.

Member Switch Preparation

As in an autoprovisioned VCF, each member switch in a preprovisioned VCF must be set to the correct fabric and mixed mode for it to properly join the VCF. Setting these modes should be done on Routing Engine spine devices manually before cabling the VCF. When adding other spine or leaf devices, you can set these modes manually before interconnecting the new device into the VCF to avoid requiring the device to be rebooted at that time. Otherwise, for new devices that have been zeroized or are in the factory default configuration, upon interconnecting the new device into the VCF, the automatic VCP conversion process will also detect and set fabric and mixed modes if needed, and automatically reboot the device.

Fabric and mixed modes can be enabled or disabled at the same time by using the following operational commands on the member switch that is going to be a member of the VCF:

```
user@switch> request virtual-chassis mode fabric mixed local
Mode set to 'Fabric with mixed devices'.  (Reboot required)
```

BEST PRACTICE: To minimize disruption to an existing VCF, change the fabric and mixed mode settings and reboot a new member switch before cabling it into the VCF.

You can, however, change the fabric and mixed mode settings and reboot your switch after cabling it into a VCF.

The current and future mode settings of the member switches can be displayed by issuing the following command:

```
user@switch> show virtual-chassis mode

fpc0:
----------------------------------------------------------------------
Current mode : Fabric with similar devices

Future mode after reboot : Fabric with mixed devices

fpc1:
----------------------------------------------------------------------
Current mode : Fabric with mixed devices

Future mode after reboot : Fabric with mixed devices

OPS>
```

Verify that current and future modes of all member switches are correct. If any member switch's current and future modes are different, a reboot is required for that switch. For example, the previous display output shows that, in order for fpc0 and fpc1 to have the same fabric mode and mixed mode, fpc0 needs to be rebooted to set its mode to mixed mode.

Routing Engine Switch Preparation

The intended primary Routing Engine switch is prepared in the same way as it is for an autoprovisioned VCF.

Linecard Member Switch Preparation

Linecard member switches are prepared for a preprovisioned VCF in the same way as spine member switches are prepared for an autoprovisioned VCF.

Note that because every member switch needs to be provisioned, the member switches are not required to be in factory default state, as long as the intended linecards have LLDP enabled on any potential VCP links. However, we still recommend that you zeroize a linecard member switch before adding it to a VCF.

In addition to bringing a switch to its factory default configuration, the **request system zeroize** command also removes all VCPs configured on the switch. If a switch is previously used as member in a Virtual Chassis or VCF, the **request system zeroize** command can be used to clean up previously converted VCP ports. This is required for the automatic VCP port conversion procedure to be performed.

Preprovisioned VCF Configuration

In a preprovisioned VCF, all member switches are included in the Virtual Chassis configuration on the intended primary Routing Engine switch:

```
Switch-1> show configurations virtual-chassis
preprovisioned;
member 0 {
    role routing-engine;
    serial-number BBAK8864;
}
member 1 {
    role routing-engine;
    serial-number ED3702;
}
member 2 {
    role line-card;
    serial-number BBAK8714;
}
member 3 {
    role line-card;
    serial-number BBAK8759;
}
… // other members are omitted here …
{master:0}
Switch-1>
```

Connecting the VCPs

With the previously described preparations and configurations, the VCF will be formed as VCP links are connected.

The actions taken by the member switches automatically during VCF formation are similar to the actions in the autoprovisioned method until the VCF is fully formed.

These similar actions include:

- Provisioned member switches might reboot if they are in the factory-default state.
- Provisioned member switches reboot if the fabric or mixed mode needs to be changed.
- Automatic VCP port conversions occur.

Switches can only join the VCF if they are explicitly provisioned in the configuration. Hence, there is no need to disable LLDP on any ports to stop automatically converting VCPs. Instead, additional fabric links can be added between provisioned members and they will be automatically converted to VCP links.

Nonprovisioning a VCF

⚠ **CAUTION**: Configure your Virtual Chassis Fabric (VCF) using autoprovisioning or preprovisioning unless you have a compelling reason to use a nonprovisioned configuration. A nonprovisioned VCF configuration is highly discouraged.

Nonprovisioned VCF configuration should only be used by VCF experts in specialized scenarios. You can configure all aspects of a VCF using an autoprovisioned or a preprovisioned configuration.

See Configuring a Nonprovisioned Virtual Chassis Fabric for instructions on configuring a nonprovisioned VCF.

Adding a Leaf Device to an Operational VCF

When adding a leaf device to a VCF, be aware of the following factors:

- Make sure the new switch is running the same version of Junos OS that is running in the VCF.
- Set the appropriate mode—either fabric or mixed fabric—and reboot the switch before interconnecting it into the VCF.
- Zeroize the new device using the **request system zeroize** command.
- Update the VCF configuration to accommodate the new spine before cabling it into the VCF.

Interconnect the new device to the spine member that is in the primary Routing Engine role first, which is the most efficient way to synchronize the new member with the current VCF configuration and state. Interconnecting a new member only to the backup or another spine member can cause flooding of messages within the VCF as the primary tries to synchronize the new member through other leaf and spine member VCP links. After the new member is fully incorporated into the VCF, you can interconnect the remaining redundant VCP links to the backup and other spine devices without affecting traffic within the VCF.

See Adding a Device to a Virtual Chassis Fabric for detailed instructions on adding a leaf device to a VCF.