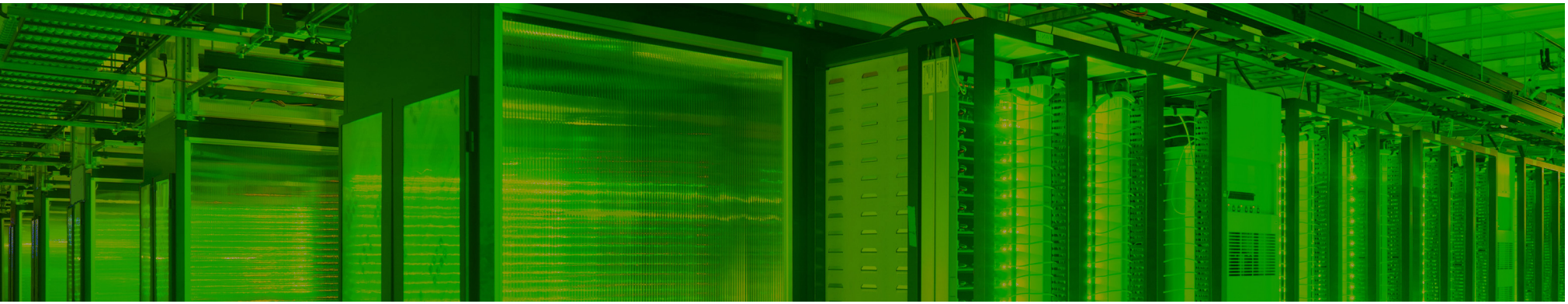
User Guide



NX500
VX1048
VX3048

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vello SYSTEMS

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Table of Contents

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AUTHORED BY ANTHONY HERNANDEZ - (415)786-2081 - anthony94122@outlook.com

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List of Figures

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List of Tables

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List of Cautions

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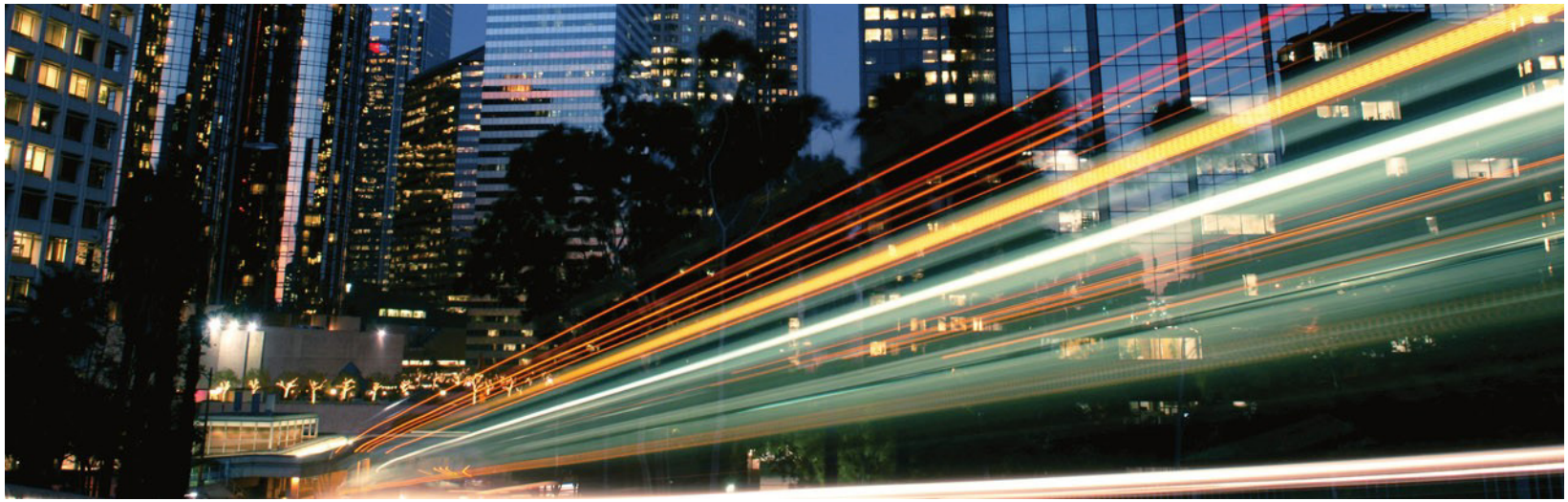
1 - Getting Started



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Welcome!

Vello Systems, Inc. offers an open, standards-based programmable network architecture that allows datacenter resources to dynamically respond to constantly changing application requirements within milliseconds. Eliminating the complexity of connecting storage and computing systems improves overall IT performance, reliability, and cost effectiveness. This provides an agile infrastructure that simplifies network operations and delivers reliably predictable network performance and continuous availability with minimal investment in design and capacity. Vello's networking solutions use the OpenFlow standard and REST APIs to integrate seamlessly into leading IT solutions. All of this comes with reduced administrative overhead that allows network operators to focus on value-added services.

Features and Benefits

Vello NX500 Controller and VX1048/VX3048 switches with the VelIOS Graphical User Interface (GUI) and Command Line Interface (CLI) offer compelling benefits for:

- IP provisioning and connectivity
- Bandwidth filling
- High-performance computing
- Continuous availability

IP Provisioning & Connectivity

Vello REST APIs simplify bandwidth allocation by automatically enabling rapid and accurate IP network connection provisioning across the network and multiple distributed sites. Applications request bandwidth provisioning through a Vello NX500 Controller, which enforces bandwidth utilization across a network of distributed Vello VX1048 and/or Vello VX3048 OpenFlow Ethernet switches. The NX500 Controller maintains an accurate, end-to-end inventory of all network resource allocation and usage by users (or clients) and applications. Real-time views provide insight into who is using the network, what resources are being used, and what is left to provision to make accurate network capacity planning simple.

Vello increases agility by using existing customer web portals and leveraging standard REST APIs to dynamically provision IP connections using the OpenFlow standard.

Vello's IP provisioning and connectivity management delivers:

- Faster connectivity
- Risk-free self-provisioning
- Web portal integration
- Instant global service inventory
- Centralized network bandwidth control
- Increased application visibility
- Maximized WAN utilization

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- Flow-based performance monitoring
- Higher availability with automated network failover

Bandwidth Filling

Vello maximizes network utilization and eliminates expensive over-provisioning by using policies to dynamically allocate bandwidth across the network. It can also deliver bandwidth to replication flows with more stringent Recovery Point Objective (RPO) requirements. Increased control of network resources reduces costs while ensuring more predictable performance.

Vello's on-demand application network bandwidth management delivers:

- Simplest bandwidth provisioning
- Increased application visibility
- Direct control of network bandwidth resources
- Easy interconnection of servers, storage systems, and applications
- Integration with application workflows by leveraging standard REST APIs
- Performance monitoring on a per-application basis

High-Performance Computing

The Vello NX500 Controller can be used to meter access to servers and applications in shared facility networks. Vello integrates with user databases and responds to requests from user portals to define bandwidth allocation on a per-user basis. This allows external users to efficiently utilize high-performance computing resources in a secure, isolated, and automated fashion. Scaling up is as easy as adding Vello VX1048 and/or VX3048 switches to meet increasing capacity requirements.

Vello's dynamic network access control to large computing and data resources delivers:

- Shared facility security application that leverages Vello REST APIs built on the Vello NX500 Controller with the Vello VX1048 and VX3048 switches
- Abstraction of the internal network extended to the outside world
- Easy-to-use, secure, multi-tenant solution

Continuous Availability

Enterprises are moving away from active/passive datacenters focused on disaster recovery to active/active datacenters that ensure continuous availability of mission-critical applications. Continuous availability requirements mean increased wide-area network (WAN) performance and availability demands between datacenters. Business continuity strategies are increasing the distances between redundant sites while the amount of enterprise data continues to grow exponentially. These conflicting demands are pushing networks to their limits.

Optical fiber networks provide the necessary bandwidth and performance to accommodate these trends; however, leasing sufficient capacity from a carrier or service provider can quickly become cost-prohibitive. The lack of control and associated risk of relying on a managed network services is another area of concern.

Enterprises are deploying their own optical WANs in order to have dedicated, protected, continuously available fiber networks to support mission-critical resources. This connectivity offers a strategic resource that offers both competitive advantages and risk mitigation. Buying can

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offer compelling advantages over leasing when accounting for the initial capital investment, zero staffing increase, and low operating costs.

The Vello NX500 Controller and VX1048/VX3048 switches with the Vello Network Operating System (VellOS) provide ultra-high bandwidth capacity and seamless integration with Vello CX systems.

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Vello Products

This section introduces you to the Vello hardware and software products described in this manual. See the *Hardware Specification* for additional information, including detailed specifications.

NX500 Controller

The NX500 Controller and resident VellOS delivers increased performance enabling multiple capabilities to enhance connectivity, responsiveness, and security. The NX500 is a low-power-consuming platform with the ability to operate as an enterprise-level appliance.

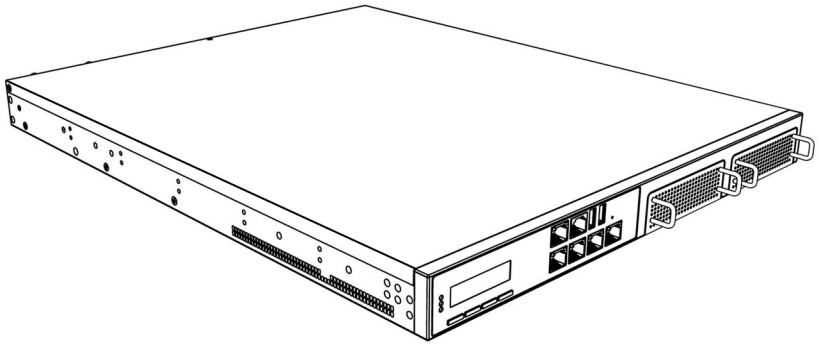

Figure 1.1: Vello NX500 Controller

Feature highlights include:

- Intel Xeon E3-1225 3.10GHz processor
- 4x1GbE (RJ45) OpenFlow control ports
- 1RU form factor
- Low power consumption

VX1048 Switch

Designed for high-availability datacenter environments, the Vello VX1048 Ethernet Forwarding Engine is a high-performance, OpenFlow-enabled 1RU 48-port 1GbE SFP switch with four 10GbE SFP+ uplinks that delivers non-blocking line-rate performance. The VX1048 meets the most demanding enterprise and cloud datacenter network scaling requirements while enabling network simplification by eliminating the need for various switches in different parts of the network.

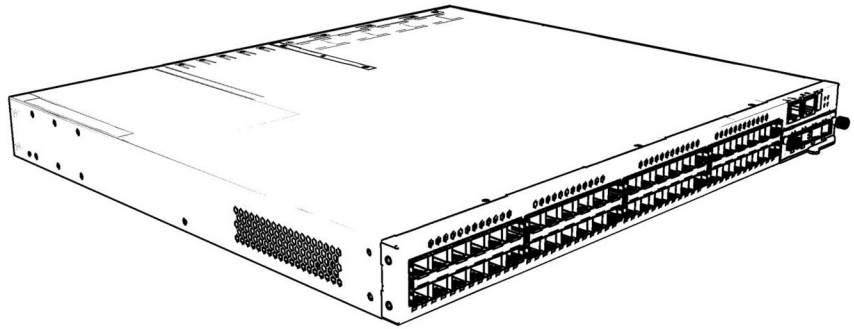

Figure 1.2: Vello VX1048 switch

Feature highlights include:

- VellOS-powered 1RU 1GbE Ethernet switch
- OpenFlow enabled

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- 176Gbps line rate throughput
- 132Mbps packet forwarding rate
- 1.7 to 2.6µs latency (RFC2544)

VX3048 Switch

Designed for high-availability datacenter environments, the Vello VX3048 Ethernet Forwarding Engine is a high-performance OpenFlow-enabled 1RU 48-port 10GbE SFP+ switch with four 40GbE QSFP+ uplinks that delivers non-blocking line-rate performance. The VX3048 meets the most demanding enterprise and cloud datacenter network scaling requirements while enabling network simplification by eliminating the need for various switches in different parts of the network.

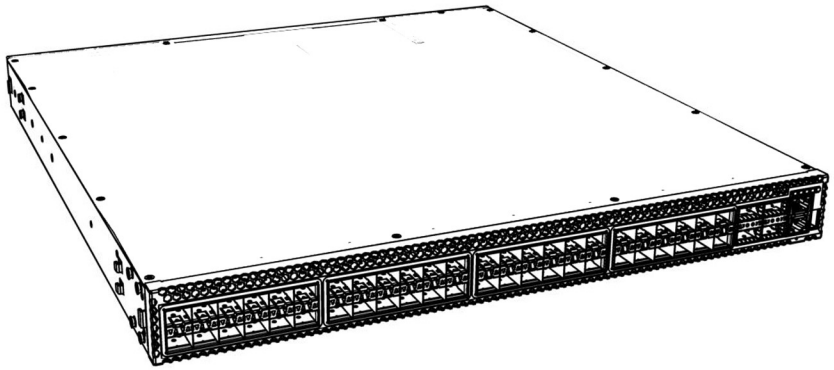


Figure 1.3: Vello VX3048 switch

Feature highlights include:

- VellOS-powered high-density 1RU 10GbE Ethernet switch
- OpenFlow enabled
- 1.28Tbps line rate throughput
- 960Mbps packet forwarding rate
- 860ns to 2.6µs latency (RFC2544)

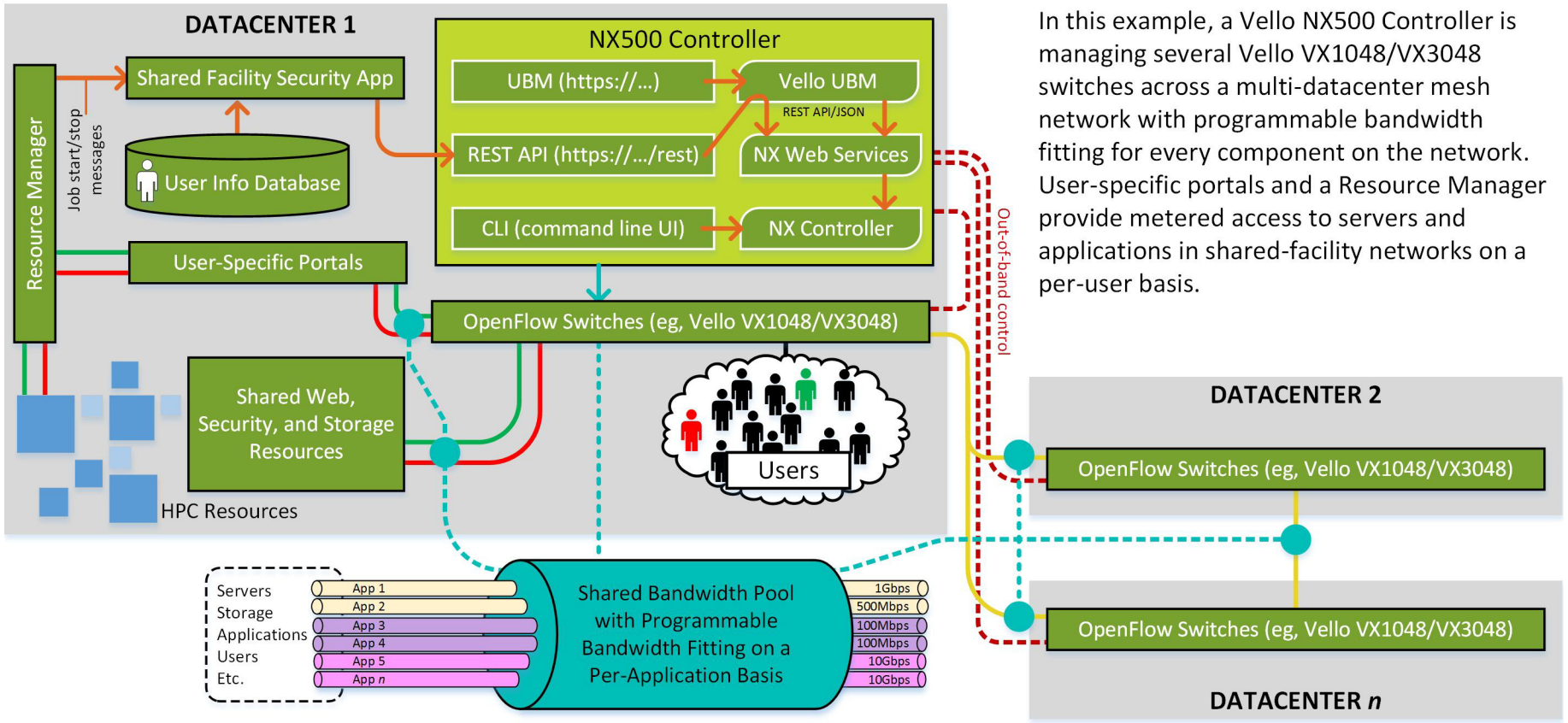
VellOS

VellOS simplifies network operations using a policy-driven architecture that allows applications and business imperatives to drive network resources in real time without the need for human intervention to reconfigure systems. The VellOS flow-computation engine creates the shortest flow between endpoints, based on user-defined policies, resulting in an agile infrastructure where applications can be effectively and efficiently deployed and maintained.

The Vello Solution

This diagram provides an example of a Vello NX Controller and VX1048/ VX3048 switches operating in a multi-datacenter mesh network.

Figure 1.4: Vello devices in a mesh network



In this example, a Vello NX500 Controller is managing several Vello VX1048/VX3048 switches across a multi-datacenter mesh network with programmable bandwidth fitting for every component on the network. User-specific portals and a Resource Manager provide metered access to servers and applications in shared-facility networks on a per-user basis.

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About This Manual

This section describes the formatting conventions and information contained in this manual.

Formatting Conventions

This manual uses several formatting conventions to present information of special importance.

Lists of items, points to consider, or procedures that do not need to be performed in a specific order appear in bullet format:

- Item 1
- Item 2

Procedures that must be followed in a specific order appear in numbered steps:

1. Perform this step first.
2. Perform this step second.

Specific keyboard keys are depicted in square brackets and are capitalized, for example: [ESC]. If more than one key should be pressed simultaneously, the notation will appear as [KEY1]+[KEY 2], for example [ALT]+[F4].

Interface elements such as document titles, fields, windows, tabs, buttons, commands, options, and icons appear in **bold** text.

Menus and submenus have the notation **Menu>Submenu**. For example, "Select **File>Save**" means that you should first open the **File** menu, and then select the **Save** option.

Specific commands appear in standard `Courier` font. Sequences of commands appear in the order in which you should execute them and include horizontal or vertical spaces between commands. The following additional formatting also applies when discussing Command Line Interface (CLI) commands:

- Actual commands appear in plain `Courier` font. Type these commands as shown.
- CLI responses from the system appear in bold **`Courier`** font.
- Optional values appear in square brackets, such as `[value]`. Do not include the brackets when adding an optional value to a command. If there is more than one optional value, you will see a vertical pipe between individual choices (such as `[yes|no]`). You may select either none or one of the optional values.
- Variable values appear inside carets, such as `<severity>`. In this case, replace the variable with a specific value from the list of available options for that variable. Do not include the carets when entering the value.
- Mandatory inputs where you must select one of two or more specific values appear in carets with a vertical pipe between individual options (such as `<tcp|ssl>`). In these cases, you must select one of the values when entering the command.

- Number ranges appear inside carets, such as <1-10>. In this example, you may input any number from 1-10. Do not include the carets when entering the value.

This manual also contains important safety information and instructions in specially formatted callouts with accompanying graphic symbols. These callouts and their symbols appear as follows throughout the manual:

CAUTION: CAUTIONS ALERT YOU TO THE POSSIBILITY OF EQUIPMENT DAMAGE AND/OR PERSONAL INJURY IF THESE INSTRUCTIONS ARE NOT FOLLOWED.

Note: Notes provide helpful information.

Organization

This manual contains the following chapters:

- **1 - Getting Started:** Introduces you to the Vello solution and value proposition and familiarizes you with the formatting and contents of this manual.
- **2 - Quick Start:** Provides a high-level overview of hardware installation, bring up, and configuration to get you up and running as fast as possible.
- **3 - Hardware Setup:** Describes the hardware setup process for the NX500 Controller and VX1048 and VX3048 switches in detail.
- **4 - Command Line Interface:** Lists all available commands along with detailed usage information for each command.
- **5 - Unified Bandwidth Manager:** Describes UBM functionality and usage.
- **6 - Usage & Maintenance:** Lists routine usage and maintenance tasks including monitoring and component replacement.
- **7 - Appendices:** Contains detailed regulatory, licensing, warranty, troubleshooting, and support information.

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Additional Information

This section lists related documentation and provides information on contacting Vello Systems, Inc.

Related Documentation

Please refer to the following documents for additional information:

- **Hardware Specification:** This manual contains detailed specifications for the Vello NX500 Controller and the VX1048 and VX3048 switches. It also lists the Field Replaceable Units (FRUs) for each device and provides ordering information.
- **REST API Manual:** This manual describes the Vello REST API in detail, including syntax, parameters, success and error responses, and usage examples.

Contact Information

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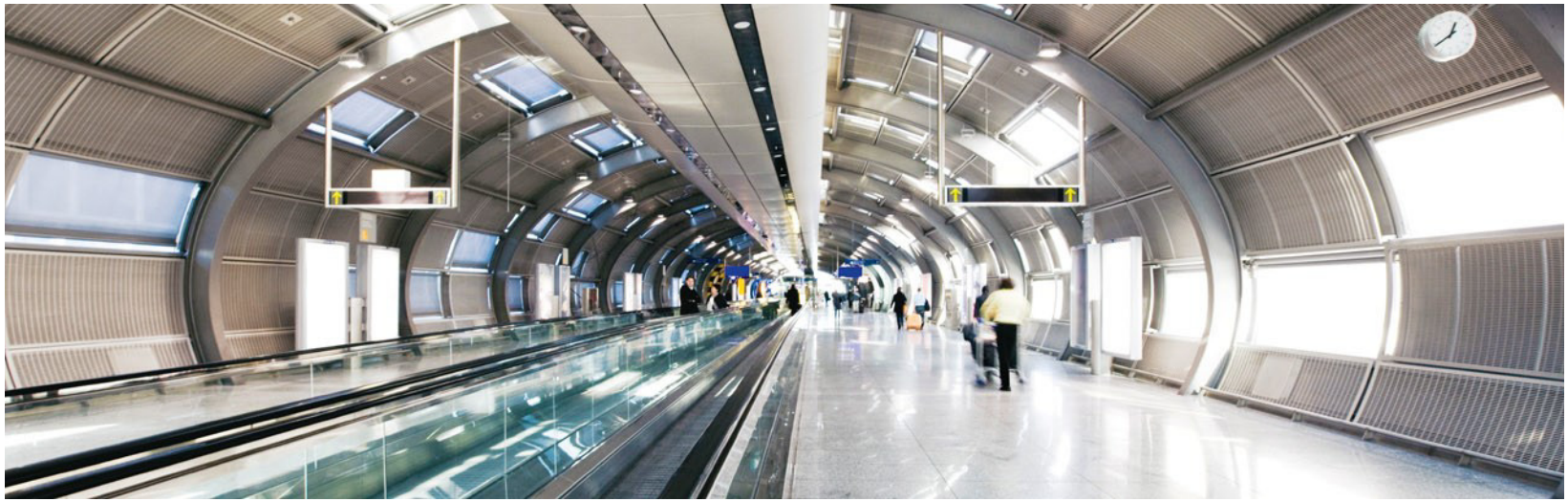
Germany
Forstring 96
63225 Langen
T. +49 6103 5095225

Please see *"Support" on page 140* for information about how to obtain support and warranty service.

2 - Quick Start



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Preparation

This section provides an overview of preparing to install the Vello NX500 Controller and VX1048/VX3048 switches.

CAUTION: FAILURE TO FOLLOW ALL OF THE SAFETY PRECAUTIONS LISTED IN *"Safety" on page 22* ***MAY RESULT IN EQUIPMENT DAMAGE AND/OR PERSONAL INJURY.***

The installation location must conform to the following general requirements:

- At least 2" (5cm) of air space on all sides of each Vello device
- Ambient temperature and humidity within limits
- Suitable access for installation, cabling, and maintenance, with easy visibility for all status LEDs
- Suitable grounded and surge-protected power outlets

When installing Vello devices:

- Mount all hardware so as to have all air flowing in the same direction, to avoid "heat loops" (see *"Airflow" on page 24*).
- Use a properly secured standard EIA 19"h equipment rack (see *"Rack Mounting" on page 24*).
- Install the heaviest equipment at the bottom of the rack.
- Fill rack and route cables so as to maximize air flow.
- Follow all applicable device and cable labeling, cable routing, and device mapping best practices.

Installation

This section summarizes the installation process for the NX500 Controller, VX1048 switch, and VX3048 switch. See *"3 - Hardware Setup" on page 21* for full install instructions.

Note: The sequence described in this section is a summarized version of the detailed instructions contained in "3 - Hardware Setup" on page 21. The numbering sequence in this section does not match the detailed instructions, but the overall process is identical.

Step 1: Unpack the Devices

Unpack each Vello device with caution, taking care to lift with your legs and to set the devices on sturdy, stable surfaces. The contents of each box are as follows:

- The NX500 Controller package includes:
  - NX500 Controller and documentation
  - AC or DC power cable, as appropriate
  - Console cable (RJ45 to DB9; same type as the VX3048 switch)
- The VX1048 switch package includes:
  - 1ea. - VX1048 switch and documentation
  - AC or DC power cable, as appropriate
  - Console cable (RJ45 to DB9; unique to the VX1048 switch)
- The VX3048 switch package includes:
  - 1ea. - VX3048 switch and documentation
  - AC or DC power cable, as appropriate
  - Console cable (RJ45 to DB9; same type as the NX500 Controller)

Step 2: Mount the Devices

To mount Vello devices:

1. Verify that you have all necessary tools and hardware on hand.
2. Wear an ESD-preventive wrist strap, and check the rack for proper grounding and structural stability.
3. Fasten brackets (Front and/or Rear) to the Vello device using screws and washers. Tighten the screws until hand tight plus a quarter turn. Do not overtighten.
4. Mark the holes in the rack where the Vello device will be installed.
5. If you are using a Rack Tray, install and secure the Rack Tray in the rack in accordance with manufacturer instructions.
6. With a helper, lift the Vello device into position in the rack or on the workbench.

CAUTION: INSTALLING A VELLO DEVICE REQUIRES TWO PEOPLE: ONE TO POSITION THE DEVICE IN THE RACK, AND THE OTHER TO SECURE THE DEVICE TO THE RACK.

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7. If you are using a rack tray or workbench/table, then slide the Vello device back into position on the tray. Workbench or table installations should allow at least 4" (10cm) all around the device for airflow and cooling.
8. If you are not using a rack tray, then position the Vello device in the correct position and hold it in place while you fasten the mounting brackets to the rack. Tighten all screws until they are hand tight plus a quarter turn.

Step 3: Connect Electrical Power

To connect a Vello device to electrical power:

1. Ground the device as described in *"Grounding" on page 29*.

CAUTION: FAILURE TO GROUND ALL DEVICES CAN CAUSE ABNORMAL OPERATION AND INCREASES THE RISK OF ELECTROCUTION AND INJURY OR DEATH.

2. Connect one end of the AC or DC power cord(s) to the power supply or supplies on the Vello device.
3. Connect the other end of the AC or DC power cord(s) to the power source. For DC devices:
   - The red cable is positive (+).
   - The black cable is negative (-).
4. On the NX500 Controller, power up the device by turning on the power switch on the rear of the unit. The VX1048 and XVX3048 switches will power on automatically.
5. Verify that Power LEDs are lit. See *"Power Supply LEDs" on page 39*.

Step 4: Connect Network Cables

To connect network wiring to the Vello devices:

1. Verify that all cables meet the requirements detailed in *"RJ45 Cable Specifications" on page 31* and *"SFP/SFP+/QSFP+ Specifications" on page 36*.
2. Familiarize yourself with the connection diagram in *"Step 4: Connect Network Cables" on page 14*.
3. Connect the Management port of each Vello VX1048/VX3048 switch to the Controlplane ports on the NX500 Controller.

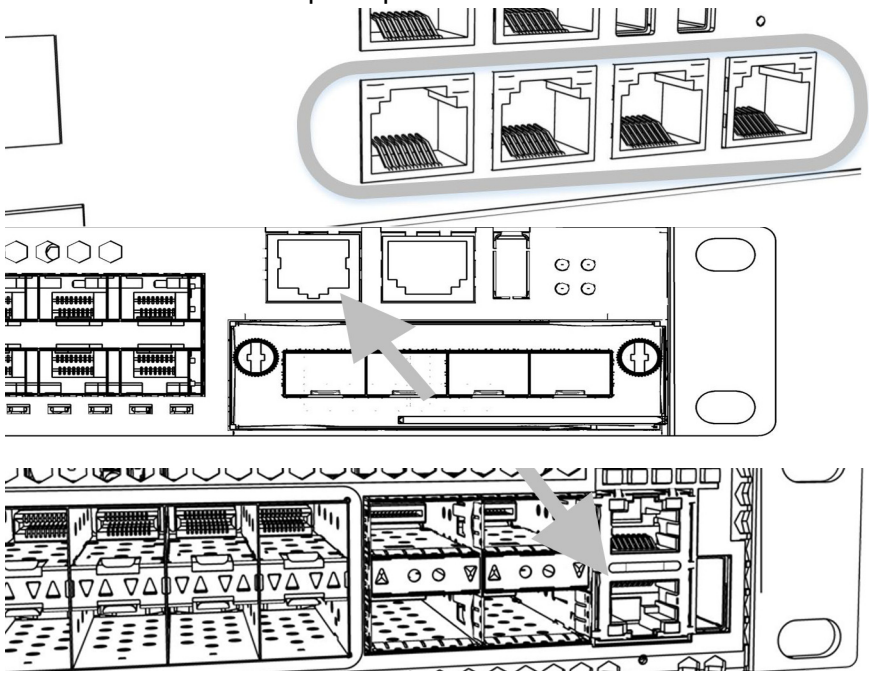


Figure 2.1: NX500 Controlplane ports (top), VX3048 Mgmt. ports (lower)

4. Connect the Management port of the NX500 Controller to your management network for UBM and REST API access (see *"Connecting to the Management Port" on page 33*).

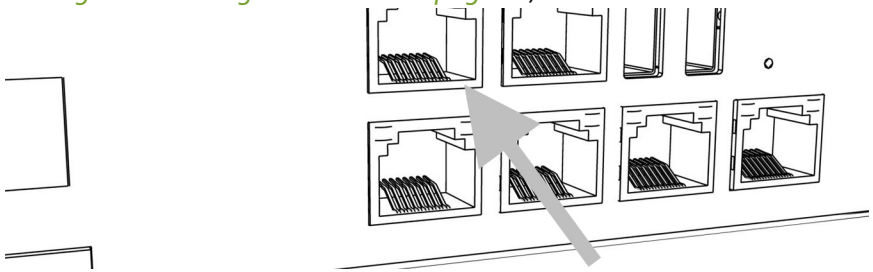


Figure 2.2: NX500 Controller Management port

5. Attach the included RJ45-to-DB9 serial cable to a DB9 COM port connector on a management PC or terminal.
6. Attach the RJ-45 end of the serial cable to the Console port on the Vello device.

Note: The Vello VX1048 switch uses a different type of RJ45-to-DB9 cable than the NX500 Controller and VX3048 switch (see "RJ45 Cable Specifications" on page 31).

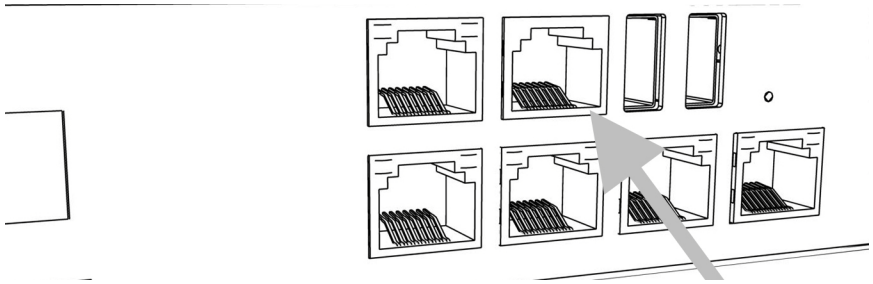


Figure 2.3: NX500 Controller Console port

- VX1048 switch

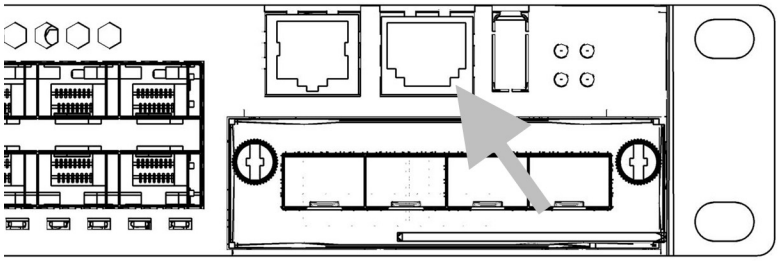


Figure 2.4: VX1048 switch Console port

- VX3048 switch

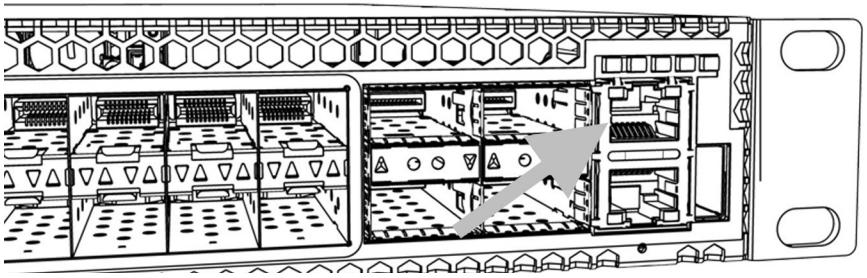


Figure 2.5: VX3048 Console port

7. Configure the required settings for the PCs COM port using VT-100 terminal emulator software (such as HyperTerminal) on the PC (see *"Console Connection Parameters" on page 34*).
8. Verify that the Console port LEDs on both the NX500 Controller and the VX1048/VX3048 switch illuminate (see *"RJ45 Cable Specifications" on page 31*).
9. Log in to the command-line interface (CLI) on the device as described in *"Connecting to a Device" on page 52*.

10. If you are making Ethernet connections to a Vello VX1048 switch, then connect one end of an Ethernet cable to an RJ45 Ethernet port on the VX1048 switch and route/connect it to the other device.

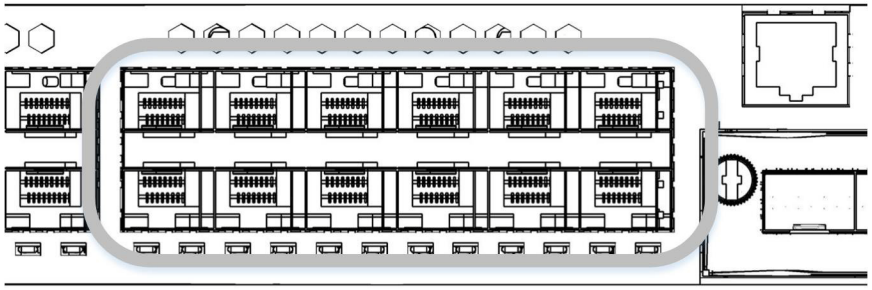


Figure 2.6: VX1048 switch Ethernet ports

11. Refer to *"Installing Optical Cables" on page 36* if you are connecting optical and/or DAC cables to a VX1048 or VX3048 switch.

12. Verify the following:

    - Power LEDs are lit on all devices (see *"Power Supply LEDs" on page 39*).
    - RJ45 Ethernet ports are lit as appropriate (see <*"RJ45 Ethernet Port Status LEDs" on page 39*).
    - 10GbE Port LEDs are lit as appropriate (see *"10GbE SFP+ Port LEDs" on page 40*).
    - 40GbE Port LEDs are lit as appropriate (see *"40GbE QSFP+ Port LEDs" on page 40*).
    - System Status LED (VX1048 and VX3048 only) is lit and indicating normal operation (see *"System Status LED" on page 40*).
    - Fan Status LEDs (VX1048 and VX3048 only) are lit and indicating normal operation (see *"Fan Status LED Indicators" on page 41*).

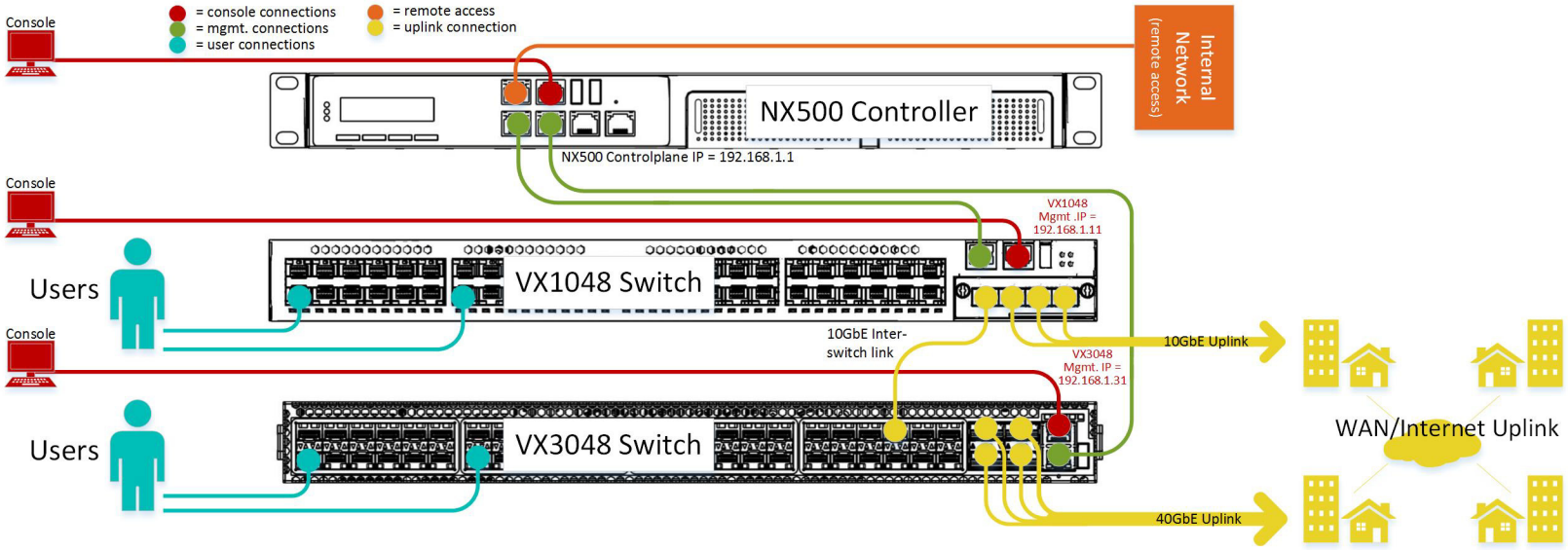
Sample Network Wiring Diagram

This diagram shows a sample network wiring diagram with the following features:

- One each NX500 Controller, VX1048 switch, and VX3048 switch
- Management Port connection to the NX500 Controller for remote UBM/REST API access (see *"Management Ports & Cables" on page 32*)
- Serial console connections to each device (see *"Console Ports & Cables" on page 34*)
- Controlplane connections between the NX500 Controller and the switches (see *"Connecting to the Management Port" on page 33*)
- WAN/Internet uplink (see *"Installing Optical Cables" on page 36*)
- 10GbE uplink from the VX1048 switch to the VX3048 switch (for storage array synch or other application requiring high intra-network data flow rates; see *"Inter-Switch Connections" on page 38*)

See *"Step 4: Connecting Network Wiring" on page 30* for a more detailed diagram.

Figure 2.7: Sample wiring diagram



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Configuration

This section summarizes how to configure the Vello NX500 Controller and VX1048/VX3048 switches using the Command Line Interface (CLI). See *"NX500 Bring-Up" on page 43*, *"VX1048 Bring-Up" on page 45*, and *"VX3048 Bring-Up" on page 47* for complete information.

NX500 Bring-Up

To bring up an NX500 Controller:

1. Disconnect all switches from the NX500 Controller.
2. Establish and configure a serial connection using the Console port, a DB9-to-RJ45 cable, and a host computer with a terminal program.
3. Set the following parameters:
   - System date and time (`set clock datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>`)
   - New password (`password`); must be 5-8 characters long and have a mix of uppercase letters, lowercase letters, and digits.
   - Controlplane Port IP address (IP address of the NX500 Controller Controlplane ports (`controlplane ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`)
   - Management network default gateway IP address (`management route add gateway <A.B.C.D>`)
   - NX500 Controller host name (`hostname <hostname>`)
4. Verify network connectivity (`ping <A.B.C.D>`).
5. Reconnect the switches to the NX500 Controller Controlplane ports.
6. Reboot the NX500 Controller (`reboot`).
7. Open a web browser from a computer connected to the internal network and navigate to `https://<A.B.C.D>` (where `<A.B.C.D>` is the Management port IP address configured in Step 5, above) to launch the UBM (see *"Launching and Logging In" on page 93*).

The NX500 Controller stores configuration settings in persistent memory to preserve them through system reboots.

VX1048 Bring-Up

To bring up a VX1048 switch:

1. Disconnect the switch from the NX500 Controller.
2. Establish and configure a serial connection using the Console port, a DB9-to-RJ45 cable, and a host computer running a terminal program. The VX1048 switch uses a different cable than the NX500 Controller or VX3048 switch.
3. Enter configuration mode (`configure terminal`).
4. Set the following parameters:
   - VX1048 switch host name (`hostname <hostname>`)

- Management IP address (IP address of the NX500 Controller; `management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`; this will typically be 192.168.1.1 and 255.255.255.0, respectively)

5. Reconnect the Management port on the VX1048 switch to a Controlplane port on the NX500 Controller.
6. Set the following parameters:
   - System date and time (`clock set datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>`)
   - NX500 Controller IP address and port (`openflow set controller tcp <A.B.C.D> <port>`; this will typically be 192.168.1.1:6633)
7. Disable auto-negotiation for ports used in a split optical flow (`disable autonego interface <port name>`).
8. Exit configuration mode (`exit`).
9. Configure at least one SSH user credential (`username <name> secret <name>`).
10. Write the configuration (`write memory`).
11. Verify connection to the NX500 Controller (`ping <A.B.C.D>`).
12. Access the **Switch Inventory** page of the Unified Bandwidth Manager application (see *"Switch Details Page" on page 97*) and verify that the newly configured VX1048 switch appears as **Active**.

VX3048 Bring-Up

To bring up a VX3048 switch:

1. Disconnect from the NX500 Controller.
2. Establish and configure a serial connection using the Console port, a DB9-to-RJ45 cable, and a host computer with a terminal program.
3. Set the following parameters:
   - Management IP address (IP address of the NX500 Controller; `management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`; this will typically be 192.168.1.1 and 255.255.255.0, respectively)
4. Reconnect the Management port on the VX3048 switch to a Controlplane port on the NX500 Controller.
5. Set the following parameters:
   - System date and time (`clock set datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>`)
   - NX500 Controller IP address and port (`openflow set controller tcp <A.B.C.D> <port>`; this will typically be 192.168.1.1:6633)
6. Verify connection to the NX500 Controller (`ping <A.B.C.D>`).
7. Access the **Switch Inventory** page of the Unified Bandwidth Manager application (see *"Switch Inventory Page" on page 95*) and verify that the newly configured VX3048 switch appears as **Active**.

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3 - Hardware Setup

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General Requirements

This section contains important safety information.

CAUTION: FAILURE TO FOLLOW ALL OF THE FOLLOWING SAFETY PRECAUTIONS MAY RESULT IN EQUIPMENT DAMAGE AND/OR PERSONAL INJURY.

Safety

Following these safety precautions will help avoid equipment damage and/or personal injury:

- Always store and mount the equipment in locations that meet all applicable environmental limits for the equipment. See the *Hardware Specification* for environmental requirements for the NX500 Controller and VX1048/VX3048 switches.
- Never place equipment on unstable surfaces.
- Never store or place any equipment on top of a rack-mounted unit.
- Install equipment away from strong radio and radar transmitters and high-frequency, high-current devices.
- Verify that the installation location provides electricity at the correct voltage for the equipment.
- Verify that the installation location is properly grounded and always follow directions for grounding all equipment.
- Always lift equipment properly with your knees to prevent personal injury. Have a helper assist you with heavy equipment.
- Always mount the equipment securely using properly rated brackets and fasteners.
- VX1048 and VX3048 switches are Class 1 laser devices. Never stare into the optical interfaces directly, because the high-energy light can cause permanent eye injury.
- Always keep the equipment's ventilation air holes free of obstructions.
- Use shielded cables and other electromagnetic shielding when necessary.
- Always power down the equipment and disconnect all power sources before cleaning.
- Never remove or uninstall equipment while it is still powered on or connected to power.
- Never clean the equipment with liquid or wet rags.
- Never expose the equipment to water or humidity in excess of stated specifications.
- Always run cables indoors or inside watertight conduit. Never expose cabling to the elements.
- Always wear anti-static gloves when replacing internal components, to prevent static electricity from damaging the components.

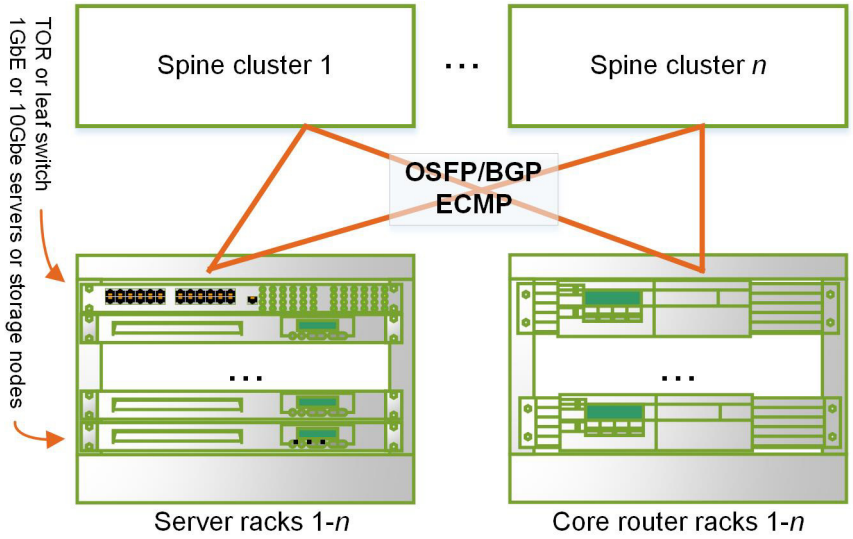
Step 1: Planning the Installation

This section outlines some of the key considerations when planning a network hardware installation.

Deployment Type

The Vello VX1048 and VX3048 switches can be deployed in a cloud datacenter or converged Ethernet datacenter.

- Cloud datacenters can use Vello switches as either top-of-rack switches or as part of a distributed spine network, to provide full line-rate switching at Layer 2 or Layer 3 across all ports.



- Converged Ethernet datacenters use Ethernet connections to link servers and data networks, with fiber channel connections linking servers to storage networks. The Vello VX3048 switch allows you to create a converged network that features lossless Ethernet connections between FC0E storage, servers, and other switches in the datacenter.

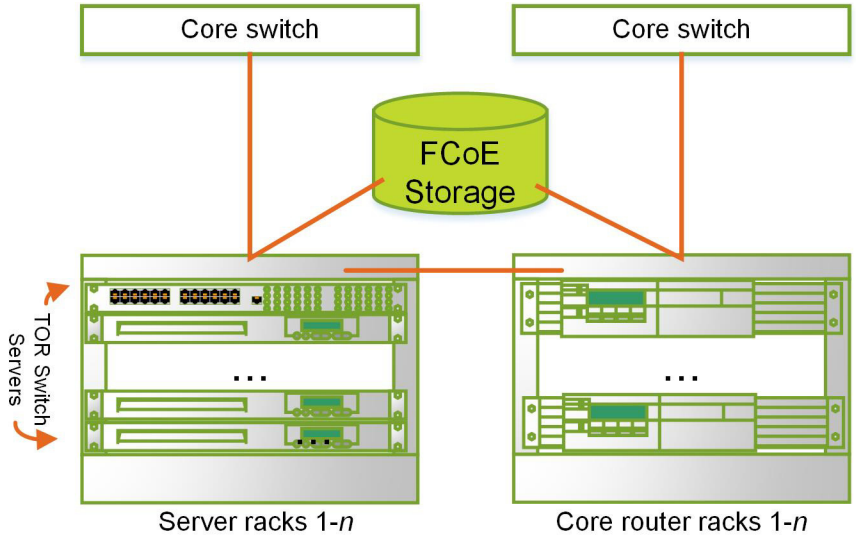


Figure 3.1: Cloud datacenter (left)

Figure 3.2: Converged Ethernet datacenter (above)

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Installation Location

The installation location must conform to the following general requirements:

- Provide at least 2" (5cm) of air space on all sides of each Vello device for proper airflow.
- Maintain ambient temperature between -40 and 70 °C (-40 to 158 °F), with relative humidity between 5% and 95% (non-condensing).
- Allow suitable access for installation, cabling, and maintenance.
- Allow administrators to easily see all status LEDs.
- Route twisted-pair cables away from power lines, fluorescent lighting fixtures, and other sources of electrical interference.
- Provide a separate grounded power outlet with surge suppression and a dedicated circuit breaker within 6' (2m) of each NX500 Controller or VX1048/VX3048 switch.

Airflow

The Vello NX500 and VX1048/VX3048 switches generate heat. It is important to mount all hardware so as to have all air flowing in the same direction. This avoids "heat loops" where heated air circulates between devices and could cause overheating. In general, all switches should be mounted such that their airflow aligns with that of the top-of-rack device. In general, most rack-mounted blade servers draw cool air from the front and expel heated air at the rear.

The Vello NX500 Controller and VX1048/VX3048 switches use front-to-back airflow. Mount these devices such that the air flow matches that of any other devices in the rack.

Note: In general, all devices should be installed or configured to as to have the airflow moving in the same direction as that of the NX500 Controller or other top-of-rack device.

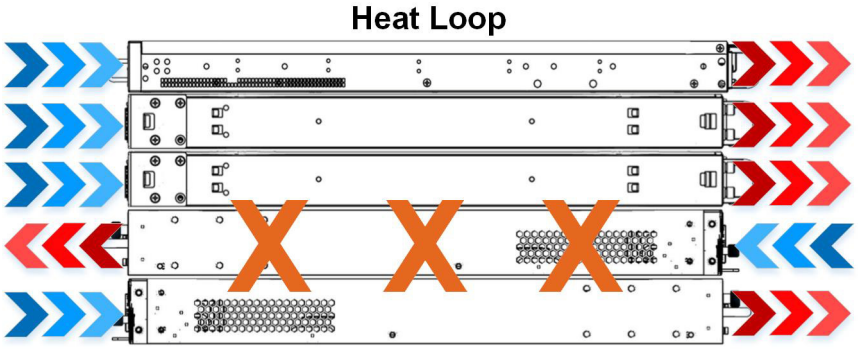

Figure 3.3: Heat loop

Rack Mounting

The following general guidelines apply when mounting a Vello device to a rack:

- You may use any standard EIA 19-inch equipment rack with either two or four posts with bracket holes spaced 1U (1.75" or 4.45 cm) apart.
- Racks must be secured to the building floor and/or ceiling and must conform to local seismic standards.

- Plan how best to arrange the NX500 Controller and VX1048/VX3048 switch(es). Install the heaviest equipment at the bottom of the rack for maximum stability.
- Route cables within the rack or cabinet to maximize the air flow.
- Open space improves airflow. Avoid completely filling the rack with equipment.

Network Cabling

Proper cable management is an essential part of all network implementations. The following guidelines will help you develop a cable management strategy to suit your needs:

- Always clearly label both ends of all network cables and record where each cable is connected. This helps you locate interconnected devices more rapidly, isolate faults more quickly, and efficiently upgrade network topology.

Note: Consider labeling cables at set points along their runs to help you trace routing in the future.

- Use your building floor plans to map the locations of all equipment that is connected to the network, being sure to specify how each device is connected, including cable labeling.
- Note the length of each cable and the maximum cable length supported by the switch ports.
- Use a location-based key when assigning prefixes to your cable labeling.
- Use sequential numbers for cables that originate from the same equipment.
- Implement a naming convention to differentiate between racks.
- Label each separate piece of equipment.
- Keep a readily accessible copy of your equipment map, including keys to all abbreviations, at each equipment rack.

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Step 2: Installing the Devices

This manual describes physical installation of Vello devices followed by bring-up and configuration. You may choose to bring-up and configure your devices prior to physical installation.

See the *Hardware Specification* for labeled diagrams of the NX500 Controller and VX1048/VX3048 switches to familiarize yourself with the devices before installation. The *Hardware Specification* contains detailed specifications for each device along with spare/replaceable parts lists, warranty, and regulatory information.

Unpacking

Always use proper lifting and carrying techniques to move the full boxes containing the Vello devices. Open all boxes on a sturdy level surface, being careful not to damage the internal contents when cutting or removing tape and other packing material. The contents of each box are as follows:

NX500 Controller

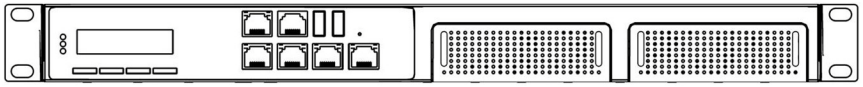

Figure 3.4: Vello NX500 Controller (front)

- NX500 Controller and documentation
- For AC devices: AC power cable (US or EU; one per power supply)
- For DC devices: Connector cables and source wires
- Console cable (RJ45 to DB9; same type as the VX3048 switch)

VX1048 Switch

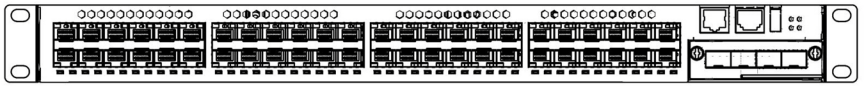

Figure 3.5: Vello VX1048 switch (front)

- 1ea. - VX1048 switch and documentation
- For AC devices: AC power cable (US or EU; one per power supply)
- For DC devices: Connector cables and source wires
- Console cable (RJ45 to DB9; unique to the VX1048 switch)

VX3048 Switch

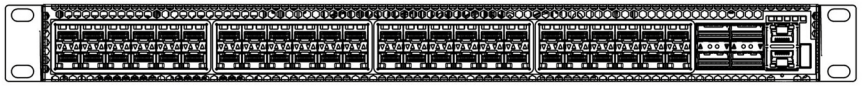

Figure 3.6: Vello VX3048 switch (front)

- 1ea. - VX3048 switch and documentation
- For AC devices: AC power cable (US or EU; one per power supply)
- For DC devices: Connector cables and source wires

- Console cable (RJ45 to DB9; same type as the NX500 Controller)

Mounting

You may mount Vello devices in standard 2-post or 4-post racks and cabinets. The top image displays a 2-post mounting (brackets and trays not shown), while the lower image displays a 4-post mounting.

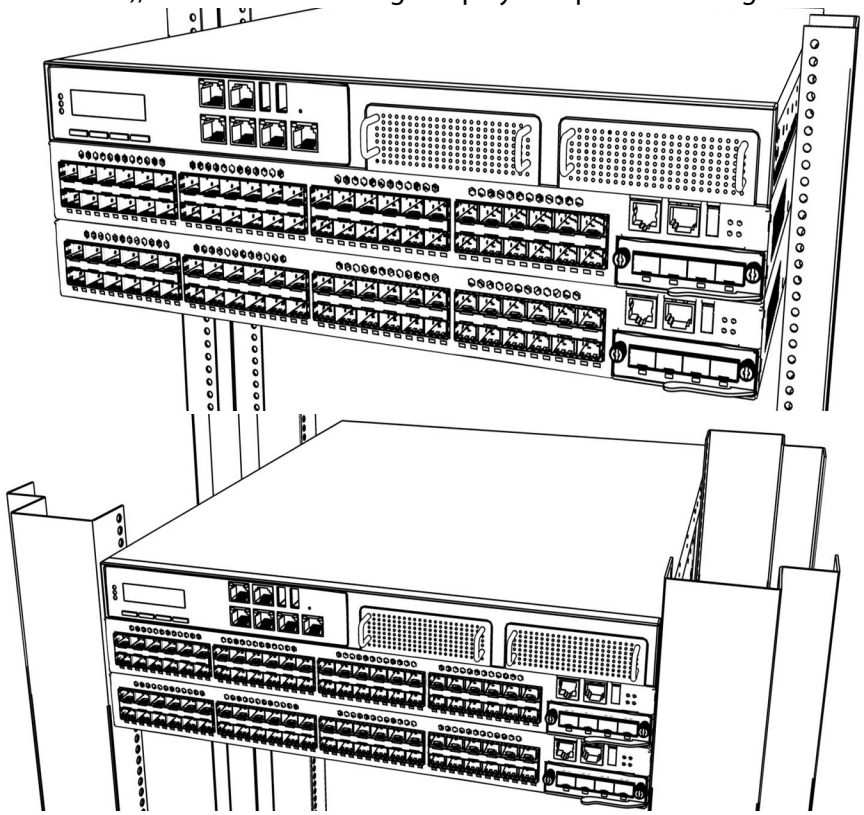

Figure 3.7: Rack mounting examples

Brackets

Vello devices include front and rear mounting brackets that are suitable for various types of racks. In general, you should use the brackets provided by your rack system manufacturer for best results.

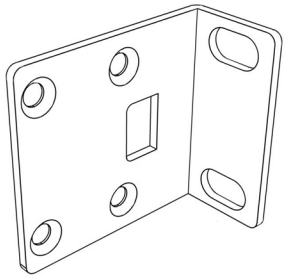

Figure 3.8: Front bracket

- **Front Mounting Brackets:** These brackets help orient and stabilize devices in the rack; however, they are not designed to be fully weight-bearing for the NX500 Controller or VX1048 switch.

CAUTION: USING ONLY FRONT MOUNTING BRACKETS TO SUPPORT THE FULL NX500 CONTROLLER OR VX1048 WEIGHT MAY CAUSE FAILURE AND DAMAGE/INJURY.

- **Rear Mounting Brackets:** These brackets may be used for the NX500 Controller and VX1048 switch. The VX3048 switch uses only front brackets..

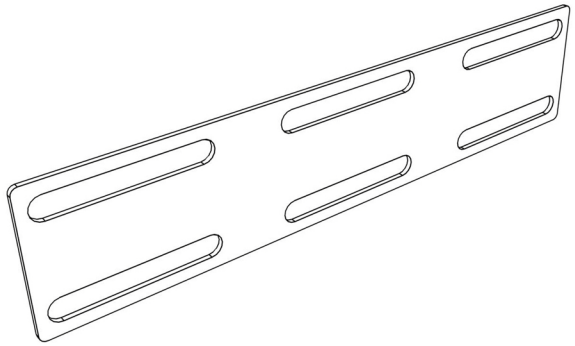

Figure 3.9: Rear bracket

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Mounting Methods

You may use any of the following mounting methods as appropriate to your specific rack system:

- Front mounting brackets and a rack tray
- Front and rear mounting brackets
- Workbench/table

Tools and Equipment

Before mounting the Vello device, make sure that you have all of the tools and fasteners you will need, such as:

- All mounting brackets/trays you will need for each device
- Screwdrivers (Phillips or flat head, depending on the screws being used)
- Mounting screws and any other hardware (nuts, washers, etc.) recommended by the rack manufacturer

Installation

The following instructions provide general information on mounting Vello devices. Always follow your rack manufacturer's instructions for information that is specific to the rack make/model you are using.

1. Determine the mounting method you are going to use to install the device.
2. Wear an ESD-preventive wrist strap, and check the rack for proper grounding and structural stability.
3. Fasten the brackets (Front and/or Rear) to the Vello device using screws and washers. Tighten the screws until hand tight plus a quarter turn. Do not overtighten.
4. Mark the holes in the rack where the Vello device will be installed.
5. If you are using a Rack Tray, install and secure the Rack Tray in the rack in accordance with manufacturer instructions.
6. With a helper, lift the Vello device into position in the rack or onto the workbench.

CAUTION: INSTALLING A VELLO DEVICE REQUIRES TWO PEOPLE: ONE TO POSITION THE DEVICE IN THE RACK, AND THE OTHER TO SECURE THE DEVICE TO THE RACK.

7. If you are using a rack tray or workbench/table, then slide the Vello device back into position on the tray. Workbench or table installations should allow at least 4" (10cm) all around the device for airflow and cooling.
8. If you are not using a rack tray, then position the Vello device in the correct position and hold it in place while you fasten the mounting brackets to the rack. Tighten all screws until they are hand tight plus a quarter turn.

Step 3: Connecting Electrical Power

This section guides you through connecting AC or DC power.

Grounding

Each Vello NX500 Controller and VX1048/VX3048 switch must be properly grounded in accordance with all applicable electrical codes and industry practices, to reduce interference and prevent electrocution.

CAUTION: FAILURE TO GROUND ALL DEVICES CAN CAUSE ABNORMAL OPERATION AND INCREASES THE RISK OF ELECTROCUTION AND INJURY OR DEATH.

To ground the device, connect the power cable of the device to a properly grounded power supply. You may also need additional grounding for the chassis, rack or cabinet mount. Always refer to your rack documentation for specific grounding requirements and instructions.

AC Wiring

These instructions are for Vello devices with AC power. See *"DC Wiring" on page 29* if your device uses DC power. To power your AC Vello device:

1. Ground the device as described in the previous section.
2. Verify that the available power matches the power supply voltage.
3. Plug the female end(s) of a power cable(s) into a power inlet on the back panel of the Vello device. Use one cord for each power supply.
4. Plug the male end(s) of the power cable(s) into an AC power outlet.
5. On the NX500 Controller, power up the device by turning on the power switch on the rear of the unit. The VX1048 and XVX3048 switches will power on automatically.
6. Verify that Power LEDs are lit. See *"Power Supply LEDs" on page 39*.

DC Wiring

These instructions are for Vello devices with DC power. See *"AC Wiring" on page 29* if your device uses AC power. To power your DC Vello device:

1. Ground the device as described in *"Grounding" on page 29*.
2. Loosen the connector screws on the DC power supply.
3. Insert the cables into the appropriate connectors, being sure not to reverse the polarity.
   - The red cable is positive (+).
   - The black cable is negative (-).
4. Repeat Steps 2-4 for the second power supply (if equipped).
5. On the NX500 Controller, power up the device by turning on the power switch on the rear of the unit. The VX1048 and XVX3048 switches will power on automatically.
6. Verify that the device Power LEDs are lit. See *"Power Supply LEDs" on page 39*.

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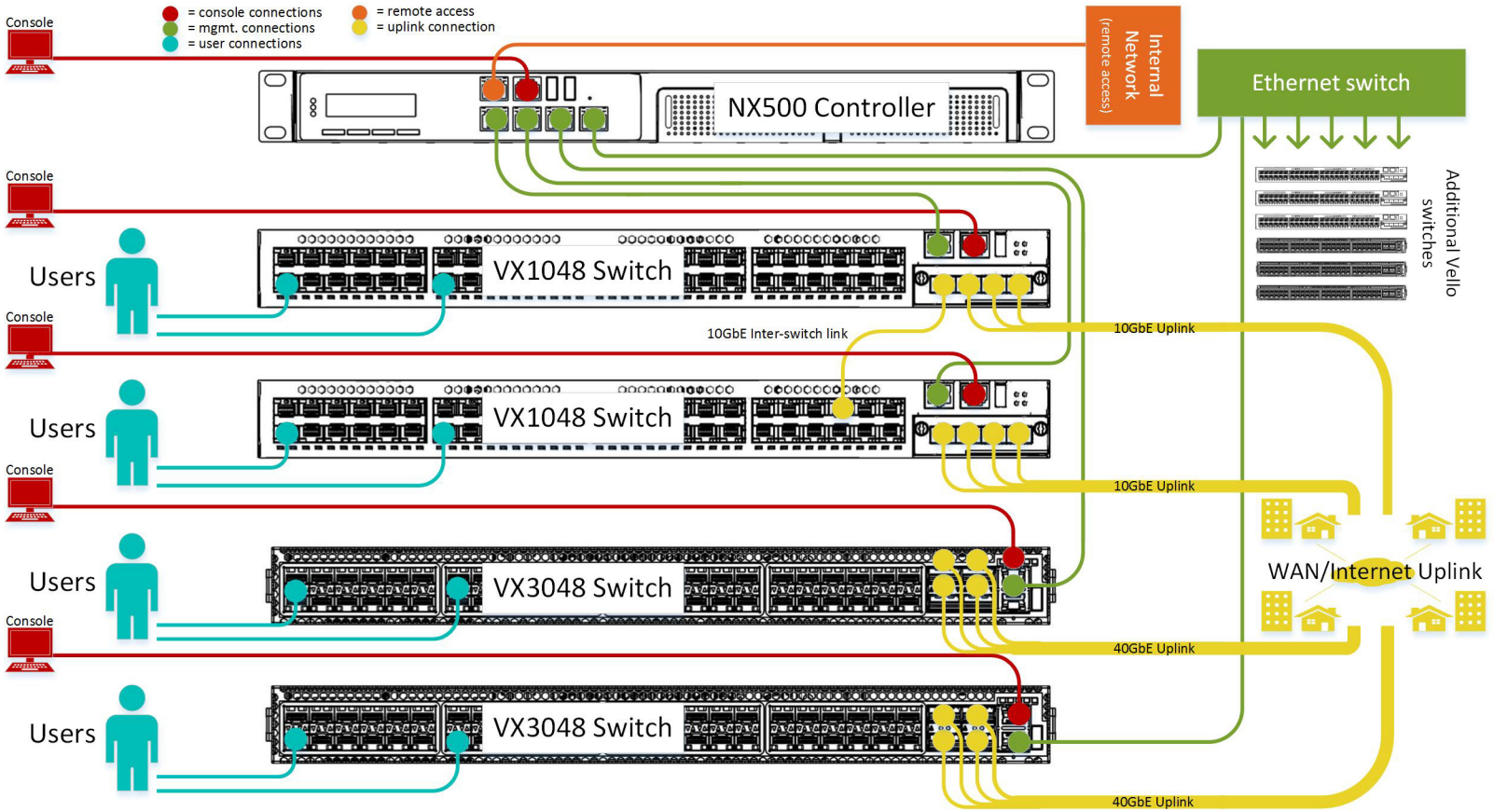
Step 4: Connecting Network Wiring

This section contains network cable specifications and describes connecting Vello devices to your network.

Figure 3.10: Network connection example



RJ45 Cable Specifications

The 10/100/1000 Base-T Ethernet interfaces included in Vello devices can use RJ-45 connectors that meet the following requirements:

Max transmission distance	100m
100Base-TX & 1000 Base-T cable requirements	• CAT 5 twisted pair • Enhanced CAT 5 twisted pair • CAT 6 shielded twisted pair
10 Base-T cable requirement	CAT 3 or CAT 4 twisted pair wires.

Table 3.1: RJ45 cable specifications

Note: Enhanced Category 5 or Category 6 cable is recommended for all critical RJ45 network connections because they require more rigorous testing than other categories.

The following tables provide pinouts for RJ45 network cables.

- **DB9 to RJ45 Control cable (NX500 Controller and VX3048 switch only)**: The Vello NX500 Controller and VX3048 switch share the same type of RJ45-to- DB9 cable to connect to a RS232 serial DB9 DTE (COM) PC/terminal port.

RJ-45	Null Modem	DB-9
3 TXD		2 RXD
5 SGND		5 SGND
6RXD		3 TXD

Table 3.2: NX500/VX3048 DB9 to RJ45 cable pinout

- **DB9 to RJ45 Control cable (VX1048 switch only)**: The Vello VX1048 switch requires a different RJ45-to- DB9 cable to connect to a RS232 serial DB9 DTE (COM) PC/terminal port.

RJ-45	Signal Direction	DB-9
1	CTS (Clear To Send)	8
2	DSR (Data Set Ready)	6
3	RXD (Receive Data)	2
4	GND	5
5	GND	5
6	TXD (Transmit Data)	3
7	DTR (Data Terminal Ready)	4
8	RTS (Request To Sen	

Table 3.3: VX1048 DB9 to RJ45 cable pinout

- **RJ45 straight-through:** Used for 10Base-T and 100Base-TX connections.

Pin No.	Description	Description	Pin No.
1	TX+	RX+	1
2	TX-	RX-	2
3	RX+	TX+	3
4	N/A	N/A	4
5	N/A	N/A	5
6	RX-	TX-	6
7	N/A	N/A	7
8	N/A	N/A	8

Table 3.4: RJ45 straight-through cable pinout

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- **RJ45 crossover:** Used for 10Base-T and 100Base-TX connections

Pin No.	Description	Description	Pin No.
1	TX+	RX+	3
2	TX-	RX-	6
3	RX+	TX+	1
4	N/A	N/A	4
5	N/A	N/A	5
6	RX-	TX-	2
7	N/A	N/A	7
8	N/A	N/A	8

Table 3.5: RJ45 crossover cable pinout

- **RJ45 1000Base-T:** All 1000Base-T ports support automatic MDI/MDI-X operation, allowing you to use straight-through cables for all network connections. 1000Base-T operation requires all four pairs of wires for both transmit and receive.

Pin	MDI Signal Name	MDI-X Signal Name
1	Bi-directional Pair A Plus (BI_DA+)	Bi-directional Pair B Plus (BI_DB+)
2	Bi-directional Pair A Minus (BI_DA-)	Bi-directional Pair B Minus (BI_DB-)
3	Bi-directional Pair B Plus (BI_DB+)	Bi-directional Pair A Plus (BI_DA+)
4	Bi-directional Pair C Plus (BI_DC+)	Bi-directional Pair D Plus (BI_DD+)
5	Bi-directional Pair C Minus (BI_DC-)	Bi-directional Pair D Minus (BI_DD-)
6	Bi-directional Pair B Minus (BI_DB-)	Bi-directional Pair A Minus (BI_DA-)
7	Bi-directional Pair D Plus (BI_DD+)	Bi-directional Pair C Plus (BI_DC+)
8	Bi-directional Pair D Minus (BI_DD-)	Bi-directional Pair C Minus (BI_DC-

Table 3.6: RJ1000Base-T cable pinout

Management Ports & Cables

Each Vello device has an RJ45 Management port that provides a dedicated management interface that is segregated from the data traffic crossing the other ports. Management ports on Vello devices support auto-negotiation and automatically select the optimum transmission mode (full or half duplex) and data rate (10, 100, or 1000 Mbps) if the attached device also supports this feature.

The Management ports on Vello VX1048 and/or VX3048 switches connect to the Controlplane ports on the NX500 Controller. This creates a management network that is separate from the data network. Management connections use SSL/TLS security with pre-installed certificates and keys. Devices authenticate each other when connecting, to ensure trust.

Note: The NX500 Controller can directly control up to four VX1048 or VX3048 switches. You may "daisy chain" management cables through a switch to control more switches from a single NX500 Controller.

The Management port on the NX500 Controller connects to the rest of your internal network, to allow remote UBM and REST API access.

Management Port Locations

The following diagrams illustrate the locations of the Management ports on Vello devices.

- NX500 Controller:

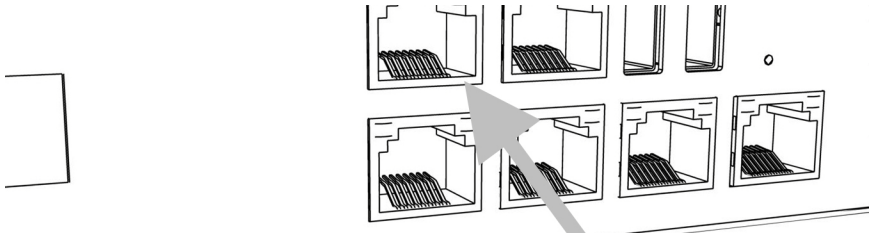

Figure 3.11: NX500 Controller Management port

- VX1048 switch

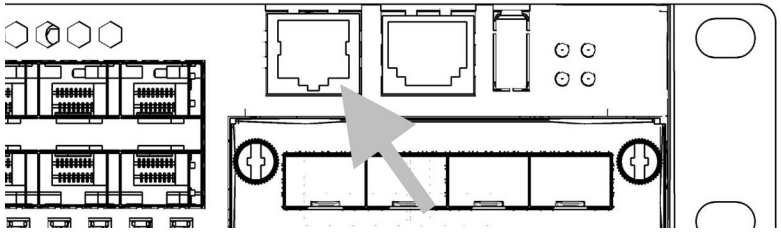

Figure 3.12: VX1048 switch Management port

- VX3048 switch

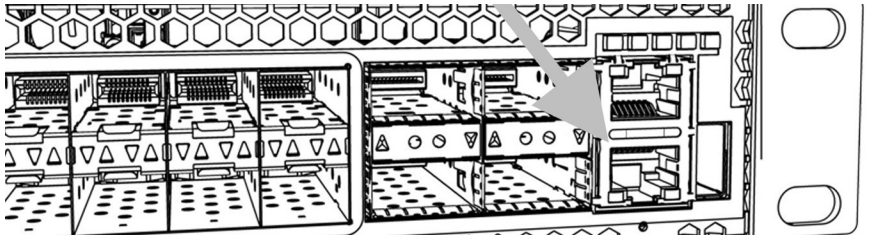

Figure 3.13: VX3048 switch Management port

Connecting to the Management Port

Use Category 5 or better unshielded twisted-pair (UTP) cable with RJ45 connectors at both ends to connect to the Management port on a Vello device, being sure not to exceed the 100m (328') limit specified in *"RJ45 Cable Specifications" on page 31*. To connect to the Management port:

1. Attach one end of a twisted-pair cable to one of the 1GbE RJ45 Controlplane ports on the Vello NX500 Controller (or to a switch that is connected to one of the Controlplane ports, if you are using more than four VX1048 and/or VX3048 switches.

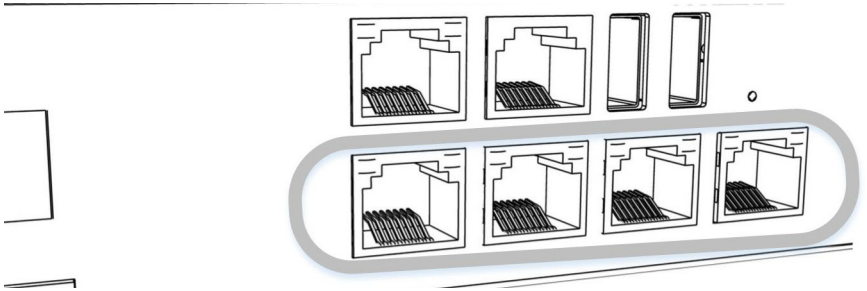

Figure 3.14: NX500 Controlplane ports

2. Attach the other end of the twisted-pair cable to the Management port on the Vello VX1048 or VX3048 switch.
3. Verify that the Management port LEDs on both the NX500 Controller and the VX1048/VX3048 switch illuminate. See *"RJ45 Ethernet Port Status LEDs" on page 39*.
4. Attach one end of a twisted-pair cable to the NX500 Controller's Management port.
5. Connect the other end of the twisted-pair cable to your internal network, to allow access to the UBM (see *"5 - Unified Bandwidth Manager" on page 89*) and REST API (See the *REST API Guide*).

6. Verify that the Link LED corresponding to the port on the NX500 Controller is lit and showing a valid connection. See *"RJ45 Ethernet Port Status LEDs" on page 39* for LED indications.

Console Ports & Cables

Each Vello device has an RJ45 Console port that allows you to connect the device to a VT-100 terminal or a PC running a VT-100 terminal emulator application in order to configure the device.

Console Port Locations

The following diagrams illustrate the locations of the Management ports on Vello devices.

- NX500 Controller:

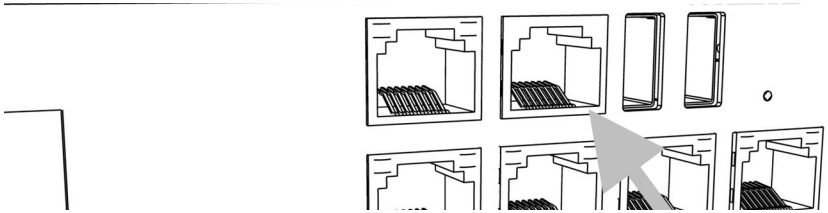

Figure 3.15: NX500 Controller Console port

- VX1048 switch

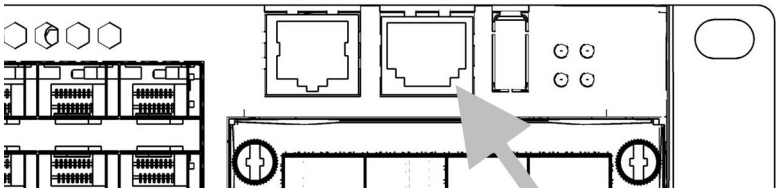

Figure 3.16: VX1048 switch Console port

- VX3048 switch

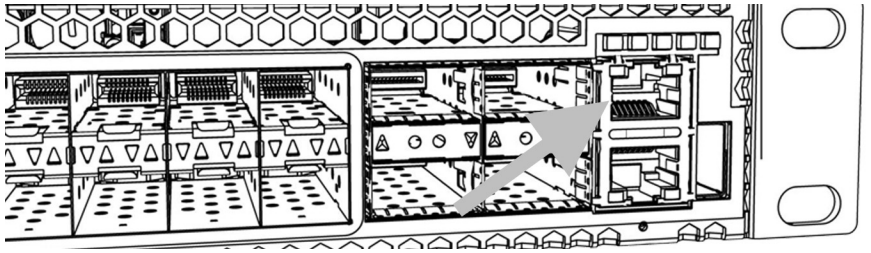

Figure 3.17: VX3048 Console port

Console Connection Parameters

Console connections between a Vello device and PC or terminal require the following parameters:

Parameter	Value
Default baud rate	• **NX500/BVX3048:** 115200bps • **VX1048:** 9600bps
Character size	8 characters
Parity	None
Stop bit	1
Data bits	8
Flow control	None

Table 3.7: Console connection parameters

Connecting to the Console Port

To connect to the Console port on a Vello device:

1. Attach the DB9 end of the included RJ45-to-DB9 serial cable to a DB9 COM port connector on a management PC or terminal.
2. Attach the RJ-45 end of the serial cable to the Console port on the Vello device.

Note: The Vello VX1048 switch uses a different type of RJ45-to-DB9 cable than the NX500 Controller and VX3048 switch (see "RJ45 Cable Specifications" on page 31).

3. Configure the required settings for the PCs COM port using VT-100 terminal emulator software (such as HyperTerminal) running on the management PC.
4. Verify that the Console port LEDs on both the NX500 Controller and the VX1048/VX3048 switch illuminate (see "RJ45 Ethernet Port Status LEDs" on page 39).
5. Log in to the command-line interface (CLI) on the device as described in "Connecting to a Device" on page 52.

VX1048 Ethernet Ports

Ethernet ports connect Vello devices to other devices on the network, such as PCs, printers, or servers using standard RJ45 cables (Categories 3-6, as appropriate; see "RJ45 Cable Specifications" on page 31).

Ethernet Port Locations

The following diagram illustrates the locations of the Ethernet ports on the Vello VX1048 switch:

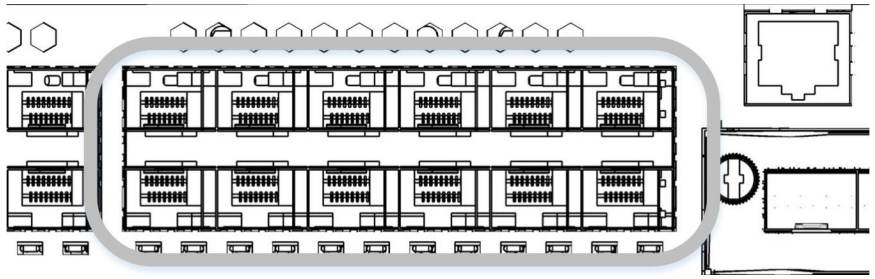

Figure 3.18: VX1048 switch Ethernet ports

Note: The Vello VX3048 switch is not equipped with standard Ethernet ports.

Connecting to the VX1048 Ethernet Ports

To connect to a VX1048 Ethernet port:

1. Route the Ethernet cable between the VX1048 switch and the other device, being sure to follow the guidelines in "Network Cabling" on page 25.
2. Connect one end of the Ethernet cable to the RJ45 Ethernet port on the VX1048 switch.
3. Connect the other end of the Ethernet to the Ethernet port on the other device.
4. Verify that the Link LED corresponding to the port on the VX1048 switch is lit and showing a valid connection. See "RJ45 Ethernet Port Status LEDs" on page 39 for LED indications.
5. Repeat this process for any additional device(s).

SFP/SFP+/QSFP+ Specifications

The Vello VX1048 and VX3048 switches include slots for optional SFP, SFP+, and QSFP+ fiber optic transceivers (not included) as follows:

VX1048	• 1000Base-SX (LC connector) • 1000Base-LX (LC connector)
VX3048	• 10GBase-CR (LC connector) • 10GBase-SR (LC connector) • 40GBase-CR4 (LC connector) • 40GBase-SR4 (LC connector)

Table 3.8: VX1048/VX3048 transceiver slots

Note: 40GbE QSFP+ fiber optic ports can provide either one 40Gbps full duplex link or four independent 10G fiber optic links. To do this, use a breakout cable to connect on 40GbE QSFP+ port to four 10GbE SFP+ ports.

Fiber Optic Cable Lengths

Be sure to factor in power constraints when planning the maximum cable lengths to use for your network. Fiber optic cables have the following maximum lengths::

Cable Type	Bandwidth/Length
1000Base-SX 62.5/125 micron multimode	• 160 MHz/km: 2-220m (7’-722’) • 200 MHz/km: 2-275m (7’-902’)
1000Base-SX 50/125 micron multimode	• 400 MHz/km: 2-500m (7’-1641’) • 500 MHz/km: 2-550m (7’-1805’)
1000Base-LX 9/125 micron single-mode	• N/A: 2m-10 km (7’ - 6.2mi)
10GBase-SR 62.5/125 micron multimode	• 160 MHz/km: 2-26m (7'-85') • 200 MHz/km: 2-33m (7'-108')
10GBase-SR 50/125 micron multimode	• 400 MHz/km: 2-66m (7'-216') • 500 MHz/km: 2-82m (7'-269') • 2000 MHz/km: 2-300m (7'-984')
40GBase-SR4 62.5/125 micron multimode	• 160 MHz/km: 2-26 m (7’-85’) • 200 MHz/km: 2-33 m (7’-108’)
40GBase-SR4 50/125 micron multimode	• 400 MHz/km: 2m-66m (7'-216') • 500 MHz/km: 2m-82m (7'-269') • 2000 MHz/km: 2m-300m (7'-984')

Table 3.9: Fiber-optic cable lengths

Direct Attach Cables

If you are using a Vello VX3048 switch, consider using Direct Attach Cable (DAC). DAC provides a low cost, low latency Ethernet connection over distances up to 10m (32’) by allowing you to connect two SFP+ or QSFP+ interfaces without fiber optics via SFP+/QSFP+ transceivers that don't include optical components. The Vello VX3048 switch supports the following types of DAC:

- 10GBase-CR
- 40GBase-CR4

Installing Optical Cables

Fiber optic connections require a compatible transceiver at either end. From device to device, the connection order is:

1. Device A
2. Transceiver

3. Fiber optic cable
4. Transceiver
5. Device B

The following sections describe fiber optic transceivers and cables in more detail.

SFP, SFP+, and QSFP+ Transceivers

To install an SFP, SFP+, or QSFP+ transceiver:

1. Select a transceiver that is suitable for the switch (VX1048 or VX3048) and your network requirements.
2. Remove the rubber cap protecting the port (if any) and retain it for future use.
3. Insert the transceiver with the optical connector facing outward and the slot connector facing down. Transceivers are shaped to only install in the correct orientation.
4. Slide the transceiver into the slot until it clicks into place.
5. Either connect a cable to the transceiver or use a protective rubber cap to keep the optics clean.

To uninstall a transceiver, disconnect the network cable and then release and pull the wire bail to remove the transceiver from the slot. Cover the exposed slot with a protective rubber cap.

Fiber Optic Cables

Use the following procedure to connect a fiber optic cable to a Vello VX1048 or VX3048 switch.

CAUTION: VX1048 AND VX3048 SWITCHES ARE CLASS 1 LASER DEVICES. NEVER STARE INTO THE OPTICAL INTERFACES DIRECTLY, BECAUSE THE HIGH-ENERGY LIGHT CAN CAUSE PERMANENT EYE INJURY.

1. Route the fiber optic cable between the VX1048 or VX3048 switch and the other device, being sure to follow the guidelines in *"Network Cabling" on page 25* and to not bend the cable beyond its minimum bending radius (typically a few inches; refer to the cable documentation for specifications).
2. Install an approved Laser Class 1 SFP/SFP+ transceiver, as described in the previous section.
3. Remove the rubber cap protecting the port (if any) and retain it for future use.
4. Verify that the fiber terminators are clean. If necessary, you may clean the cable plugs by gently wiping them with either a clean tissue or cotton ball moistened with ethanol. Dirty fiber connections impede light transmission and can degrade port performance.
5. Connect one end of the cable to the LC connector on the SFP, SFP+, or QSFP+ transceiver installed on the VX1048 or VX3048 switch.
6. Connect the other end of the cable to the LC port on the other device.
7. Verify that the Link LED corresponding to the port on the VX1048 or VX3048 switch is lit and showing a valid connection. See *"RJ45 Ethernet Port Status LEDs" on page 39* for LED indications.

DAC Cables

Use the following procedure to connect a DAC cable to a Vello VX1048 or VX3048 switch:

1. Route the twinax cable between the VX1048 or VX3048 switch and the other device, being sure to follow the guidelines in *"Network Cabling" on page 25*.
2. Install an approved DAC SFP+/QSFP+ transceiver, as described in *"SFP, SFP+, and QSFP+ Transceivers" on page 37*.
3. Remove the rubber cap protecting the port (if any) and retain it for future use.
4. Connect one end of the twinax cable to the DAC transceiver installed on the VX1048 or VX3048 switch.
5. Connect the other end of the twinax cable to the DAC port on the other device.
6. Verify that the Link LED corresponding to the port on the VX1048 or VX3048 switch is lit and showing a valid connection. See *"10GbE SFP+ Port LEDs" on page 40* and *"40GbE QSFP+ Port LEDs" on page 40* for LED indications.

Inter-Switch Connections

You may connect the Uplink ports on one Vello switch to the optical ports on another Vello switch. For example, you may connect a 10GbE Uplink port on a Vello VX1048 switch to one of the 10GbE ports on a Vello VX3048 switch. You would configure a flow between the two *nodes* (ports) using the UBM (see *"5 - Unified Bandwidth Manager" on page 89*) or the REST API (See the *REST API Guide*).

You may also create a "loop back" from the second switch back to the first for redundancy. This interconnection must be Layer-2 adjacent (where all L2 traffic passes without any filtering) for the NX500 Controller to monitor and manage the flow.

Step 5: Verify Proper Operation

The LEDs on Vello devices provide a wealth of information about power, connection, and general system status. This section describes the LEDs on the NX500 Controller and VX1048 and VX3048 switches.

Power Supply LEDs

Each Vello device has one Power LED per power supply that lights up green when the device is on and the power supply or supplies are functioning normally. The following diagrams illustrate the locations of the Power LEDs on Vello devices.

- NX500 Controller:

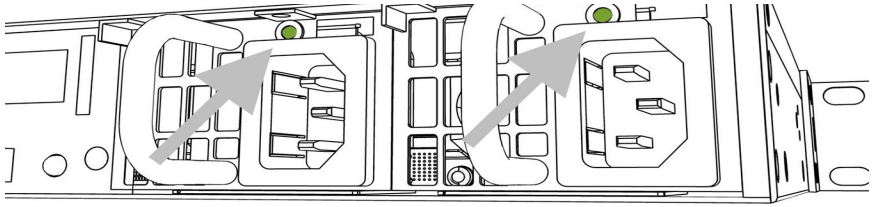

Figure 3.19: NX500 Controller power supply LEDs

- VX1048 switch

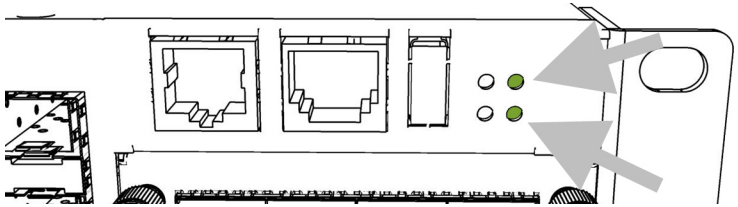

Figure 3.20: VX1048 switch power supply LEDs

- VX3048 switch

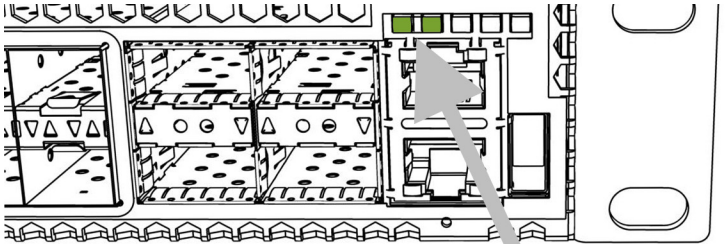

Figure 3.21: VX3048 switch power supply LEDs

Indicator	Status
PWR1 PWR2 (if equipped)	• **On - Green:** Normal operation. • **On - Amber:** Power supply malfunctioning. • **Off:** Power supply absent or malfunctioning.

Table 3.10: Power supply LEDs

RJ45 Ethernet Port Status LEDs

All Vello devices include two Port Status LEDs for each RJ45 port Ethernet port:

- Management port
- Console port
- 10/100/1000Base-T Ethernet ports

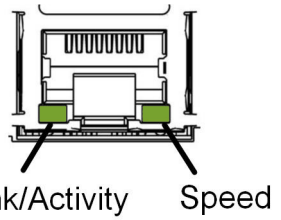

Figure 3.22: RJ45 Ethernet port status LEDs

These LEDs indicate both the status and speed of the connection at each port, as described in the following table:

LED	Condition
Link/Activity	• **On/Flashing Green:** Port has established a valid network connection. Flashing indicates activity. • **Off:** There is no valid link on the port.
Speed	• **On - Amber:** Valid 1000 Mbps link • **On - Green:** Valid 10/100 Mbps link

Table 3.11: Ethernet port LEDs

10GbE SFP+ Port LEDs

The Vello VX1048 and VX3048 switches include two Port Status LEDs for each 10GbE SFP+ port. These LEDs indicate both the status and speed of the connection at each port, as described in the following table:

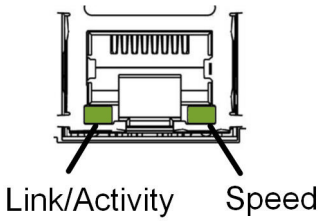

Figure 3.23: 10GbE SFP+ port status LEDs

LED	Condition
Link/Activity	• **On/Flashing Green:** Port has established a valid network connection. Flashing indicates activity. • **Off:** There is no valid link on the port.
Speed	• **On - Amber:** Valid 10GbE link • **On - Green:** Valid 1GbE link

Table 3.12: 10GbE SFP+ port LEDs

40GbE QSFP+ Port LEDs

The Vello VX3048 switch includes two Port Status LEDs for each 10GbE SFP+ port. These LEDs indicate both the status and speed of the connection at each port, as described in the following table:

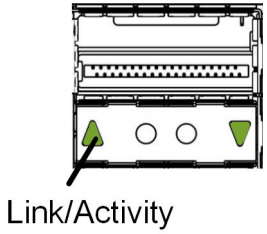

Figure 3.24: 40GbE QSFP+ port status LEDs

LED	Condition
Link/Activity	• **On/Flashing Green:** Port has established a valid 40GbE network connection. Flashing indicates activity. • **Off:** There is no valid link on the port.

Table 3.13: 40GbE QSFP+ port LEDs

System Status LED

The Vello VX1048 and VX3048 switches each include a System Status LED that indicates the overall switch status. The following diagrams illustrate the locations of the System Status LEDs on Vello devices.

- VX1048 switch:

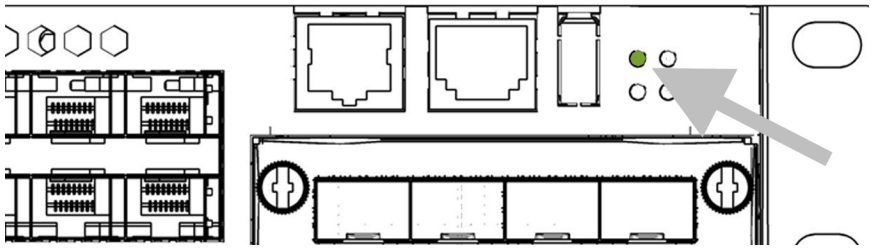

Figure 3.25: VX1048 switch system status LED

- VX3048 switch

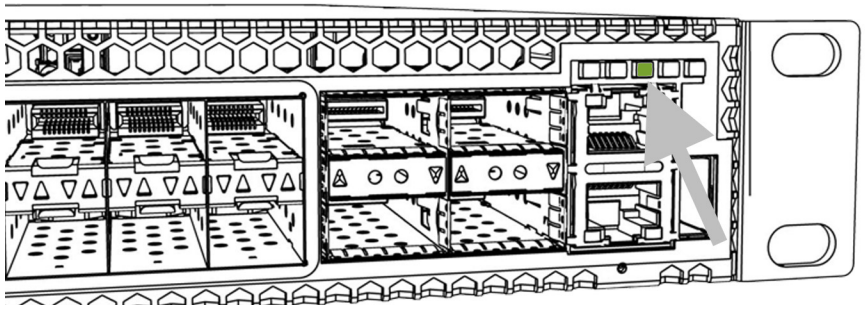

Figure 3.26: VX3048 switch system status LED

VX1048

The VX1048 System Status LED provides the following indications:

Color	Indication
Green	• **Slow flash (1x/2s):** Normal operation • **Rapid flash (2x/s):** CPU not running • **Steady:** Abnormal operation
Amber	• **Slow flash (1x/2s):** Switch is initializing • **Rapid flash (2x/s):** Switch is resetting • **Steady:** System alarm
Off	• No power, or fan tray removed

Table 3.14: VX1048 system status LED

VX3048

The VX3048 System Status LED provides the following indications:

Color	Indication
Green	Normal operation
Amber	Fault detected

Table 3.15: VX3048 system status LED

Fan Status LED Indicators

The Vello VX1048 and VX3048 switches each include a Fan Status LED that indicates the fan tray condition. The following diagrams illustrate the locations of the Fan Status LEDs on Vello devices:

- VX1048 switch

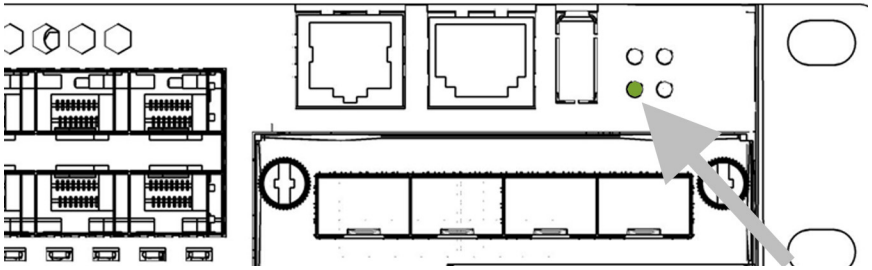

Figure 3.27: VX1048 switch fan status LED

- VX3048 switch

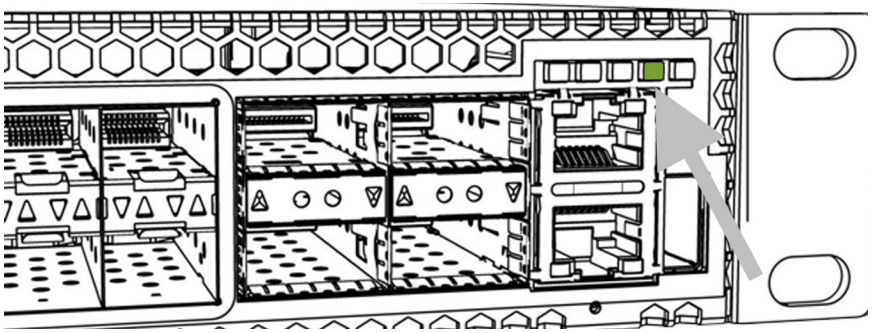

Figure 3.28: VX3048 switch fan status LED

The VX1048/VX3048 Fan Status LEDs provide the following indications:

Color	Indication
Green	Normal operation
Amber	Fan failure detected

Table 3.16: VX1048/VX3048 fan status LEDs

Step 6: Configuration

This section describes how to configure the Vello NX500 Controller and VX1048/VX3048 switches using the Command Line Interface (CLI) after the devices have been installed and connected as described in the previous sections. *"4 - Command Line Interface" on page 51* contains detailed CLI instructions, including serial console or SSH connections.

NX500 Bring-Up

This section describes how to configure a Vello NX500 Controller during initial bring-up so as to connect to Vello VX1048 and/or VX3048 switches. The default NX500 Controller settings are:

Configuration	Setting
Hostname	nvc
Date/Time	Unspecified
Logging	• Remote logging disabled • Log set to "Information" (see *"Log" on page 58*)
Management IP	DHCP
Controlplane IP	192.168.1.1
Communications	• **Baud rate:** 115200 • **Data bits:** 8 • **Parity:** none • **Stop bits:** 1 • **Flow control:** none

Table 3.17: NX500 Controller default settings

To bring up an NX500 Controller:

1. Disconnect all switches from the Controlplane ports on the NX500 Controller.
2. Connect a computer running a VT100-compliant terminal program (such as HyperTerminal) to the Console port on the NX500 Controller using the RJ45 to DB9 cable included with the Controller.

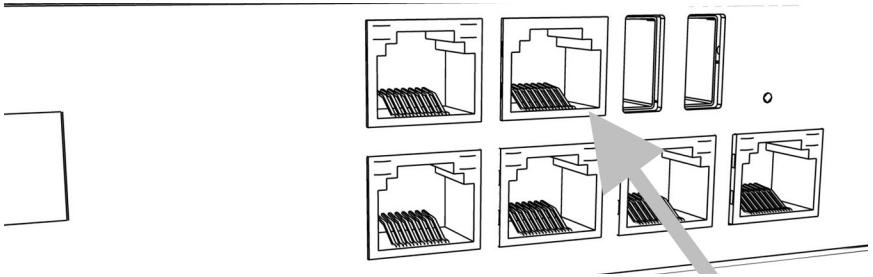

Figure 3.29: NX500 Controller Console port

3. Configure the serial connection as described in *"Console Connection Parameters" on page 34* and connect to the switch.

   The **`<controller>#`** command prompt appears (where **`<controller>`** is the hostname of the NX500 Controller).

4. Set the system date and time. The NX500 Controller uses local time by default. To set the system date and time, type the command `clock set datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>` and then press [ENTER]. For this command:

   - `<HH:MM:SS>` is hours, minutes and seconds, respectively.

- <1-12> indicates the month of the year (where 1=January, and so on).
- <1-31> is the current date.
- <2000-2037> is the current year (all 4 digits required).

The new date and time appears to confirm the change.

5. Change the default password by typing the command `password` and then pressing [ENTER].

   The **`New password:`** prompt appears along with guidelines for the new password.

   Enter a new password that is at least 5 characters and up to 8 characters long, using a mixture of uppercase letters, lowercase letters, and numbers.

   Confirmation text appears if the password change succeeds.

6. Set the Controlplane Port IP address (IP address of the NX500 Controller Controplane ports) by typing the command `controlplane ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>` (where `<A.B.C.D>` and `<yyy.yyy.yyy.yyy>`are valid IP addresses) and then press [ENTER].

   Confirmation text appears.

Note: This is the IP address you will use when configuring VX1048 and/or VX3048 Management connections to the NX500 Controller. All four Controlplane ports use the same IP address, to simplify configuration.

7. If desired, you may add an additional route to the Controlplane ports by typing the command `controlplane route add <A.B.C.D> netmask <yyy.yyy.yyy.yyy> where <A.B.C.D> and <yyy.yyy.yyy.yyy>` are valid IP addresses) and then press [ENTER].

   Confirmation text appears.

8. If you want to specify a static IP address for the Management port (optional), you may type the command `management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>` (where `<A.B.C.D>` and `<yyy.yyy.yyy.yyy>`are valid IP addresses) and then press [ENTER]. Skip to Step 10 if you are not specifying a static Management port IP address.

   Confirmation text appears.

Note: This is the IP address you will use to access NX500 Controller and VX1048/VX3048 switches from a remote network.

9. If you specified a static Management port IIP address in Step 8, then you will need to also specify the management network default gateway IP address by typing the command `management route add gateway <A.B.C.D>` (where `<A.B.C.D>` is a valid IP address) and then press [ENTER]. This address must be within the same subnet as the management address that you specified in Step 5, above. This is the IP address that switches will connect to.

   Confirmation text appears.

10. Set the name of the NX500 Controller by typing the command `hostname <hostname>` (where `<hostname>` is the name you want to assign to the NX500 Controller) and then press [ENTER]. The hostname may be from 5 to 63 character in length and may consist of virtually any combination of digits (0-9), letters (a-z), or hyphens (-). The exceptions are that all names must contain at least

one alphanumeric character and can neither begin nor end with a hyphen.

The command prompt changes from **<controller>(config)#** to **<hostname>(config)#**

11. Verify network connectivity using any of the following commands:
    - `ping <A.B.C.D>` (where `<A.B.C.D>` is a valid IP address) to ping the selected IP address with four packets of data.
    - `ping -c <A.B.C.D>` (where `<A.B.C.D>` is a valid IP address) to ping the selected IP address continually until you interrupt it by pressing [CTRL]+[C].
    - `traceroute <A.B.C.D>` (where `<A.B.C.D>` is a valid IP address) to trace the hops taken by the data to reach the specified IP address.
12. Reconnect the switches to the NX500 Controller Controlplane ports.
13. Reboot the NX500 Controller by typing the command `reboot` and then pressing [ENTER].
14. When the NX500 Controller reboots, open a web browser from a computer connected to the internal network and navigate to `https://<A.B.C.D>` (where `<A.B.C.D>` is the Management port IP address configured in Step 5, above).

    The Unified Bandwidth Manager **Login** page appears. See *"Launching and Logging In" on page 93*.

The NX500 Controller stores configuration settings in persistent memory to preserve them through system reboots.

VX1048 Bring-Up

This section describes how to configure a Vello VX1048 switch during initial bring-up so as to connect to a Vello NX500 Controller and be ready for deployment. The default VX1048 setting are:

Configuration	Setting
Hostname	nvs
Date/Time	unspecified
Logging	not enabled
IP Address	user-configured
Communications	• **Baud rate:** 9600 • **Data bits:** 8 • **Parity:** none • **Stop bits:** 1 • **Flow control:** none

Table 3.18: VX1048 switch default settings

To bring up a VX1048 switch:

1. Disconnect the switch from the Management port on the NX500 Controller.

2. Connect a computer running a VT100-compliant terminal program (such as HyperTerminal) to the Console port on the switch using the VX1048-specific RJ45 to DB9 cable included with the switch.

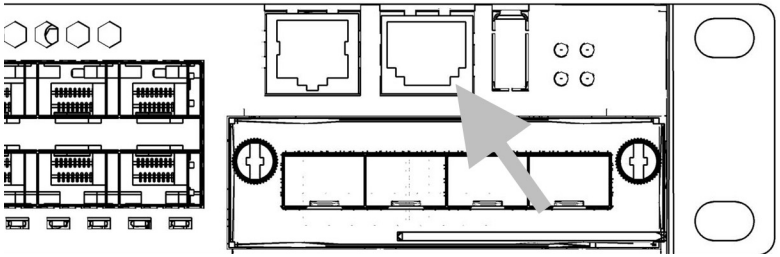

Figure 3.30: VX1048 switch Console port

3. Configure the serial connection as described in *"Console Connection Parameters" on page 34* and connect to the switch.

   The **<switch>#** command prompt appears (where **<switch>** is the hostname of the switch).

4. Enter configuration mode by typing the command `configure terminal` and then pressing [ENTER].

The command prompt changes to **<switch>(config)#** to indicate that the switch is in configuration mode.

5. Set the name of the switch by typing the command `hostname <hostname>` (where `<hostname>` is the name you want to assign to the switch) and then press [ENTER]. The hostname may be from 5 to 63 characters in length and may consist of virtually any combination of digits (0-9), letters (a-z), or hyphens (-). The exceptions are that all names must contain at least one alphanumeric character and can neither begin nor end with a hyphen.

   The command prompt changes from **<switch>(config)#** to **<hostname>(config)#**.

6. Set the management IP address (IP address of the NX500 Controller) by typing the command `management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>` (where `<A.B.C.D>` and `<yyy.yyy.yyy.yyy>` are valid IP addresses) and then press [ENTER].

   Confirmation text appears.

7. You must specify the management network default gateway IP address if the VX1048 switch is on a different subnet than the NX500 Controller. This step is optional if both devices are on the same subnet. Set the gateway IP address by typing the command `management route add gateway <A.B.C.D>` (where `<A.B.C.D>` is a valid IP address) and then press [ENTER].

   Confirmation text appears.

8. Reconnect the Management port on the VX1048 switch to a Controlplane port on the NX500 Controller.

9. Set the system date and time. The VX1048 uses local time by default. To set the system date and time, type the command `clock set datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>` and then press [ENTER]. For this command:

   - `HH:MM:SS` is hours, minutes and seconds, respectively.
   - `<1-12>` indicates the month of the year (where 1=January, and so on).
   - `<1-31>` is the current date
   - `<2000-2037>` is the current year (all 4 digits required).

   The new date and time appears to confirm the change.

10. Set the NX500 Controller IP address and port by typing the command `openflow set controller tcp <A.B.C.D> <port>` (where `<A.B.C.D>` is a valid IP address and `<port>` is a valid port number) and then press [ENTER].

Note: The default port is 6633.

The VX1048 switch will automatically connect to the NX500 Controller.

11. Exit configuration mode by typing the command `exit` and then pressing [ENTER].

The command prompt changes from **`<hostname>(config)#`** to **`<hostname>#`**.

12. Write the configuration to the onboard persistent memory by typing the command `write memory` and then pressing [ENTER].
13. Configure at least one SSH user credential by typing the command `username <name> secret <name>`, where `<name>` is the desired username (such as vello). You may configure more than one SSH user at once.
14. Verify that the VX1048 can connect to the NX500 Controller by typing the following commands and then pressing [ENTER] after each command:
    - `ping <A.B.C.D>` (where `<A.B.C.D>` is the management IP address of the NX500 Controller that you specified in Step 6, above. The system should indicate a successful ping attempt.
    - `show openflow controller status` displays the NX500 Controller status, which should be **`Online`**.

    If these commands fail, verify the following:
    - NX500 Controller is running.
    - NX500 Controller IP address and port are properly configured.
    - Management IP address and default gateway are set correctly.
    - Management network is setup correctly.

    See *"6 - Troubleshooting" on page 115* for additional troubleshooting information.
15. Access the **Switch Inventory** page of the Unified Bandwidth Manager application (see *"Switch Details Page" on page 97*) and verify that the newly configured VX1048 switch appears in the list with an **Active** status.

VX3048 Bring-Up

This section describes how to configure a Vello VX3048 switch during initial bring-up so as to connect to a Vello NX500 Controller and be ready for deployment. The default VX3048 setting are:

Configuration	Setting
Hostname	nvs
Date/Time	unspecified
Logging	not enabled
IP Address	user-configured
Communications	• **Baud rate:** 115200 • **Data bits:** 8 • **Parity:** none • **Stop bits:** 1 • **Flow control:** none

Table 3.19: VX3048 switch default settings

To bring up a VX3048 switch:

1. Disconnect from the NX500 Controller Management port.
2. Connect a computer running a VT100-compliant terminal program (such as HyperTerminal) to the Console port on the switch using the RJ45 to DB9 cable included with the switch.

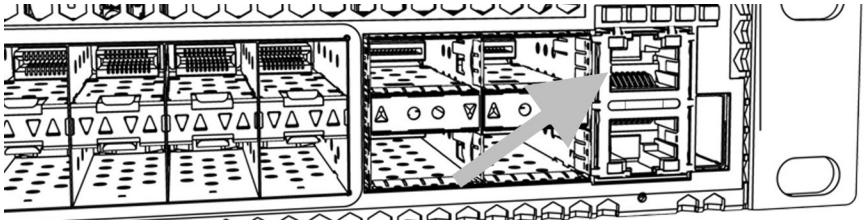

Figure 3.31: VX3048 Console port

3. Configure the serial connection as described in *"Console Connection Parameters" on page 34* and connect to the switch.

   The **<switch>#** command prompt appears (where <switch> is the hostname of the switch).

4. Set the management IP address (IP address of the NX500 Controller) by typing the command `management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>` (where <A.B.C.D> and <yyy.yyy.yyy.yyy> are valid IP addresses) and then press [ENTER].

   Confirmation text appears.

5. You must specify the management network default gateway IP address if the VX3048 switch is on a different subnet than the NX500 Controller. This step is optional if both devices are on the same subnet. Set the gateway IP address by typing the command `management route add gateway <A.B.C.D>` (where <A.B.C.D> is a valid IP address) and then press [ENTER].

   Confirmation text appears.

6. Reconnect the Management port on the VX3048 switch to a Controlplane port on the NX500 Controller.
7. Set the system date and time. The VX3048 uses local time by default. To set the system date and time, type the command `clock set datetime <HH:MM:SS> <1-12> <1-31> <2000-2037>` and then press [ENTER]. For this command:
   - <HH:MM:SS> is hours, minutes and seconds, respectively.
   - <1-12> indicates the month of the year (where 1=January, and so on).
   - <1-31> is the current date.
   - <2000-2037> is the current year (all 4 digits required).

   The new date and time appears to confirm the change.

8. Set the NX500 Controller IP address and port by typing the command `openflow set controller tcp <A.B.C.D> <port>` (where <A.B.C.D> is a valid IP address and <port> is a valid port number) and then pressing [ENTER]. The default port is 6633.

   The VX3048 switch automatically connects to the NX500 Controller.

9. Write the configuration (except auto-negotiation) to the onboard persistent memory by typing `write` and then pressing [ENTER].
10. Verify that the VX3048 can connect to the NX500 Controller by typing the following commands and then pressing [ENTER] after each command:

- `ping <A.B.C.D>` (where `<A.B.C.D>` is the management IP address of the NX500 Controller that you specified in Step 6, above. The system should indicate a successful ping attempt.
- `show openflow controller status` displays the NX500 Controller status, which should be **`Online`**.

If these commands fail, verify the following:

- NX500 Controller is running.
- NX500 Controller IP address and port are properly configured.
- Management IP address and default gateway are set correctly.
- Management network is setup correctly.

See *"6 - Troubleshooting" on page 115* for additional troubleshooting information.

11. Access the **Switch Inventory** page of the Unified Bandwidth Manager application (see *"Switch Inventory Page" on page 95*) and verify that the newly configured VX3048 switch appears in the list with an **Active** status.

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4 - Command Line Interface

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About the Command Line Interface

Vello devices ship with three methods for configuring the hardware and software:

- **REST API:** The REST API (see the *REST API Guide*) offers the greatest functionality and is the interface you will use for most configuration and maintenance operations.
- **UBM:** This web-based application is a subset of the REST API that provides a clean graphical interface for performing the most common API operations. See *"5 - Unified Bandwidth Manager" on page 89*.
- **CLI:** The Command Line Interface is available through either a direct serial or SSH connection. This interface is primarily used for initial device bring-up and configuration, and for low-level troubleshooting. This chapter describes the CLI in detail.

Connecting to a Device

There are two ways to connect to a Vello device:

- Directly via a serial console connection
- SSH connection

Direct Serial Connections

To connect via a direct serial connection, you may either:

- Connect directly to the Console port on the selected device using an RJ45 to DB9 cable and a terminal application (such as HyperTerminal). This requires you to be in the same physical location as the device.
- Connect the device to a terminal server and then access the device via the server. This allows you to be located anywhere that has access to the server. Refer to your terminal server documentation for connection and configuration instructions.

The direct serial connection method guarantees access to the Vello device but does not provide any built-in security. You are responsible for providing adequate physical security for the Vello devices to prevent unauthorized access to the Console ports. If you are using a terminal server, then you are responsible for providing adequate physical and access rights security, to prevent unauthorized access to the Vello devices.

Vello devices use the following serial communications settings:

Table 4.1: Default serial communication settings

Device	Baud Rate	Data Bits	Parity	Stop Bits	Flow Control
NX500 Controller	115200	8	none	1	none
VX1048 switch	9600	8	none	1	none
VX3048 switch	115200	8	none	1	none

SSH Connections

SSH connections provide a layer of security for accessing the CLI on Vello devices. To connect to a Vello device using SSH:

1. Log into a Linux machine on the network, that has access to the Console port on the Vello device you are trying to access.
2. Run the command `ssh vello@<A.B.C.D>`, where `<A.B.C.D>` is the Console IP address of the Vello device you are accessing.
3. Enter your Vello device password at the prompt.

   The device command prompt appears.

CLI User Management

The following table displays the default login settings for the NX500 Controller and VX1048/VX3048 switches:

Device	Username	Password
NX500 Controller	vello	vello
VX1048 switch	User-configured (see *"Username" on page 69*)	User-configured (see *"Username" on page 69*)
VX3048 switch	vello	vello

Table 4.2: Default user and password settings

Device	Username	Password
NX500 Controller	root	NQ731bc$p
VX1048 switch	no root shell access available	
VX3048 switch	root	vello

Table 4.3: Root user and password settings

CAUTION: YOU MUST CHANGE ALL DEFAULT PASSWORDS TO STRONG PASSWORDS TO ENSURE PROPER SECURITY FOR EACH VELLO DEVICE. SEE THE PASSWORD INSTRUCTIONS FOR THE NX500 CONTROLLER, VX1048 SWITCH, AND VX3048 SWITCH IN THIS CHAPTER FOR DETAILED INSTRUCTIONS.

CAUTION: MISUSE OF ANY CLI COMMAND WHILE LOGGED IN AT ROOT LEVEL CAN CAUSE CONFIGURATION ERRORS AND/OR LOSS OF DATA.

Vello devices support multiple concurrent logins, as follows:

- One person may log in to a single device more than once.
- Multiple persons may be logged in to a single device at once.

In all cases, the Vello device treats these logins as multiple logins from the same user (`vello`) and the most recent action "wins." For example, if two persons each configure a different Management port IP address, the person who configures that port last will have their settings retained by the Vello device.

When changing the user password:

- You must enter the old password when connecting via SSH.
- You are not prompted for the old password when connecting via a direct serial connection. This ensures password recovery ability if the old password is lost.

Executing CLI Commands

To execute a CLI command:

1. At the device command prompt, type the command.
2. Press [ENTER].

The device will:

- Execute the command (if the command is properly entered)
- Display an error message followed by the command prompt (if the command is not properly entered)

NX500 Controller CLI

This section describes accessing and using the CLI on the NX500 Controller. Commands appear in the same order in which they display when you run the ? command. This alphabetical list will help you find the command you are looking for more quickly:

Accessing the NX500 CLI

You may access the NX500 Controller CLI via SSH or directly via serial console connection via the Console port (see *"Console Ports & Cables" on page 34*).

Initial Messages

The NX500 Controller displays the following upon successful SSH or serial connection:

```
Network Virtualization Controller Console
Copyright 2013, Vello Systems, Inc.
NX version <version> compiled <month> <day>
<year> <hh:mm:ss>

Enter 'help' to display a command list
<hostname>#
```

In the above example, "**<hostname>#**" is the command prompt. For example, if the host name of the NX500 Controller is "NX500-01," then the command prompt will read **NX500-01#**.

Commands

This section lists and describes the NX500 Controller CLI commands.

Help

The **Help** command displays a list of all of the available NX500 Controller CLI commands with a short description of each command. To use this command:

```
help
```

?

You may obtain detailed help for a particular command by typing `<command> ?` at the command prompt. For example, typing `show ?` displays a list of all of the options available for the **Show** command. To use this command:

```
<command> ?
```

Where:

`<command>` is a valid NX500 Controller command.

Show

The **Show** command displays various NX500 Controller settings. To use this command:

- **`show clock:`** Displays the current system date and time in HH:MM:SS MM:DD:YYYY format. Use the `clock set datetime` command described below to change the system date and time.
- **`show controlplane ip address:`** Displays the IP address of the Controlplane (Ethernet) ports on the NX500 Controller. See *"Connecting to the Management Port" on page 33*.
- **`show cores:`** Lists all core (crash dump) files on the current device, if any. Core files contain information that Vello Technical Support can use to diagnose problems.
- **`show images:`** Lists any available image(s) with upgrade files currently residing on the NX500 Controller in the format total <kb> <filename> (where <kb> is the image size in kilobytes and <filename> is the name of the image file, such as **vello-nx500-v7.0.101.2.tar.bz2**).
- **`show management ip address:`** Displays the IP address of the Management port on the NX500 Controller.
- **`show system log [tail <1-1000>]:`** Displays the system log. Adding `tail` followed by a number between 1 and 1000 displays the specified number of lines from the log file. If no tail is added, the entire log displays.
- **`show version:`** shows the current software image version running on the NX500 Controller.

Clock

The **Clock** command sets the system date and time on the NX500 Controller. Specify the time based on your current time zone:

```
clock set datetime <HH:MM:SS> <1-12> <1-31>
<2000-2037>
```

Where:

- `<HH:MM:SS>` represents the time, and HH = hours, MM = minutes, SS = seconds.
- The `1-12` range indicates the month, where 1 = January, 2 = February, and so on.

- `1-31` indicates the day of the month.
- `2000-2037` indicates the year. All 4 digits must be specified.

Successful execution of this command displays the new system date and time to confirm the change.

Hostname

The **Hostname** command either displays or changes the host name of the NX500 Controller. A host name is a descriptive name given to a device to distinguish it on the network. To use this command:

- **`hostname`:** When used without an argument, this command displays the current host name of the NX500 Controller.
- **`hostname [new host name]`:** When used with an argument, this command changes the host name of the NX500 Controller to the new user-specified name.

A host name must conform to the following requirements:

- The total length must be 63 characters or less.
- You may use almost any combination of letters (A-Z), numbers, (0-9), and hyphens.
- A host name cannot begin and/or end with a hyphen (-).
- No other punctuation or special characters are allowed.
- Spaces are not allowed.

Management

The **Management** command configures the IP address of the Management port on the NX500 Controller. To use this command:

- **`management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`:** Sets the Management port IP address and net mask to a specified value.
- **`management ip address dhcp`:** Sets the Management port IP address and subnet mask to use DHCP (dynamic addressing).
- **`management route add gateway <A.B.C.D>`:** Adds a Management port gateway IP address. This IP address must be reachable by the configured IP address and net mask specified by the **management ip address** command.
- **`management route del gateway <A.B.C.D>`:** Deletes the specified Management port gateway IP address.

In the above examples:

- `<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).
- `<yyy.yyy.yyy.yyy>` signifies a valid, properly formatted net mask. This value must be contiguous, with a prefix of ones followed by zeros.

Controlplane

The **Controlplane** command configures the IP address of the Controlplane ports on the NX500 Controller to which the switches connect. To use this command:

- **`controlplane ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`:** Configures the IP address and netmask.
- **`controlplane route <add|del> <A.B.C.D> netmask <yyy.yyy.yyy.yyy> gateway <zzz.zzz.zzz.zzz>`:** Adds the specified route (if you enter `add`) or removes the specified route (if you enter `del`).

- **`controlplane mode <tcp|ssl>`:** Configures the NX500 Controller to connect via TCP (if you enter `tcp`) or to require an SSL connection (if you enter `ssl`).

In the above examples:

- `<A.B.C.D>` signifies a valid, properly formatted port IP address (such as `192.168.1.1`). The NX500 Controller uses the same IP address for all four ports to simplify configuration.
- `<yyy.yyy.yyy.yyy>` signifies a valid, properly formatted net mask. This value must be contiguous, with a prefix of ones followed by zeros.
- `<zzz.zzz.zzz.zzz>` signifies a valid, properly formatted gateway IP address (such as `192.168.1.1`).

Note: DHCP cannot be used for these ports. You must specify an IP address.

Log

The **Log** command sets the log type and location. To use this command:

- **`log <level>`:** Defines the severity of events that will appear in the log, as described below.
- **`log remote <A.B.C.D|off>`:** Remote logging forwards the NX500 Controller log to a different device on the network.
  - Supplying a properly formatted IP address turns on remote logging at the specified IP address.
  - The `off` argument disables remote logging. If you disable remote logging, you will need to re-enter the desired IP address if you want to turn this function back on in the future.

Note: The specified remote device must have a syslog daemon installed and running in order to receive and store remote logs from the NX500 Controller.

- **`log local <on/off>`:** Local logging stores the system log on the NX500 Controller. The `on` argument enables local logging, and the `off` argument disables local logging. Local logging is independent of remote logging, meaning that you can have one with or without the other. Local logs are saved when the NX500 Controller reboots. You may retrieve local logs using the **send log** command (see *"Send" on page 59*). Log files are rotated based on file size and are therefore not stored indefinitely.

By default, the VX1048 and/or VX3048 switches connected to the NX500 Controller forward their logs to the NX500 Controller. Enabling remote logging on the NX500 Controller forwards logs from both the NX500 Controller and connected switches to the remote location. Logs forward instantly when a new event occurs.

Each loggable event has a severity level associated with that event. In descending (most to least) order of criticality, the available severity levels are:

- emergency
- alert
- critical
- error
- warning

- notice
- information (info)
- debug

Enabling a logging severity level also enables the more critical levels above the selected level. For example, setting `log level warning` also captures error, critical, alert, and emergency-level events to the system log.

Copy

The **Copy** command retrieves NX500 Controller system update images from a remote machine. To use this command:

```
copy image scp <filename> <A.B.C.D> <port> <user>
```

Where:

- `<filename>` is the complete path and filename of the image you want to retrieve from the remote machine.
- `<A.B.C.D>` is the IP address of the remote machine.
- `<port>` is the port number to use for this connection.
- `<user>` is the username that will make the connection. You will be prompted to enter a password if one is configured for the selected user. You may also be asked to confirm the connection.

Delete

The **Delete** command deletes NX500 Controller system update images or core (crash dump) files. To use this command:

```
delete <core|image> <filename>
```

Where:

- `core` or `image` is the type of file to delete.
  - Selecting `core` deletes the specified core file from the NX500 Controller.
  - Selecting `image` deletes the specified image file.
- `<filename>` is the name of the file to delete, such as `core.nwi_https.991.1365616317.11`.

Send

The **Send** command sends NX500 Controller system log files or core files to a remote system. To use this command:

```
send <cores|logs> scp <A.B.C.D> <port> <user>
```

Where:

- `cores` or `logs` is the type of file to send.
  - Selecting `cores` sends all core files currently on the NX500 Controller.
  - Selecting `logs` sends the current system log file.
- `<A.B.C.D>` is the IP address of the remote device that will receive the files.
- `<port>` is the port number to use for this operation.
- `<user>` is the username that will make the connection. You will be prompted to enter a password if one is configured for the selected user. You may also be asked to confirm the connection.

Ping

The **Ping** command verifies that the NX500 Controller can communicate with the selected device by sending a small amount of data to that device and noting if and when that device acknowledges that data. To use this command:

- **`ping <A.B.C.D>`:** Pings the specified IP address four times.
- **`ping -c <A.B.C.D>`:** Pings the specified IP address continuously until you press [CTRL]+[C] to stop it.

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

Traceroute

The **Traceroute** command traces the routes that data packets are taking to reach the specified remote device. To use this command:

```
traceroute <A.B.C.D>
```

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

Upgrade

The **Upgrade** command upgrades the software image or UBM on the NX500 Controller. To use this command:

```
upgrade <nx|vmgr> <image>
```

Where:

- `nx` or `vmgr` is the type of upgrade to perform.
  - Selecting `nx` upgrades the NX500 Controller software image.
  - Selecting `vmgr` upgrades the UBM version on the NX500 Controller.
- `<image>` is the name of a valid software image that is stored on the NX500 Controller, such as **vello-nx500-v7.0.101.2.tar.bz2**. In this example, the command would be `upgrade vello-nx500-v7.0.101.2.tar.bz2`.

The NX500 Controller asks you to confirm the upgrade with the prompt **`Do you want to proceed with the upgrade? [y/N]`**.

- Press [y] to update the NX500 Controller (must be lowercase).
- Press [N] to cancel the update.

During the upgrade process, the NX500 Controller will display status messages while unpacking, validating, and installing the update. When the upgrade is complete, the screen will read **`Done. Upgrade complete`**.

You must reboot the NX500 Controller using the **Reboot** command as described below to begin using the upgraded image.

Reboot

The **Reboot** command reboots the NX500 Controller. To use this command:

```
reboot
```

The NX500 Controller sends the following message and then reboots immediately:

```
Broadcast message from <user>@<hostname> <date>
<time>
The system is going down for reboot NOW!
```

In the above message:

- **<user>** is the currently logged-in user.
- **<hostname>** is the host name of the NX500 Controller.
- **<date>** is the current system date in MM:DD:YYYY format.
- **<time>** is the current system time in HH:MM:DD format.

Password

The **Password** command changes the password for the default users. Please see *"NX500 Passwords" on page 61* for detailed instructions on using this command.

Tlsconfig-key

The **Tlsconfig-key** command sets the TLS private key. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-cert

he **Tlsconfig-cert** command set the TLS public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-ca

The **Tlsconfig-ca** uploads a public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsshow

The **Tlsshow** command displays the public CA and public certificates that are currently installed on the NX500 Controller. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Exit

The **Exit** command logs you out of the NX500 Controller. To use this command:

```
exit
```

- If you are connected via an SSH client, you will see a client prompt.
- If you are connected via a terminal program, you will see the connection go inactive.
- If you exit when directly connected to the Console port on the NX500 Controller, the current session ends and a new one begins automatically with a command prompt displayed on screen.

NX500 Passwords

This **Password** command functions differently when you are connected to the NX500 Controller via SSH versus via direct serial connection via the Console port. In general:

- **SSH connection:** You may change the password for the `vello` user, provided that you have the old password (see *"NX500 Vello User (SSH Connection)" on page 62*).
- **Serial connection via the Console port:** You may change the password for the `vello` and `root` users without needing the old password (*"NX500 Vello User (Serial Console Connection)" on page 62* and the section thereafter). You may also reset the UBM `admin` user password to the default `vello123` (see *"UBM Admin User Reset (Serial Console Connection)" on page 64*).

NX500 Vello User (SSH Connection)

To set or change the password for the `vello` user when connected via SSH:

1. At the command prompt, type `password` and then press [ENTER].

   The prompt **`Old password:`** appears. This is a security measure.

2. Enter the current password for the `vello` user and then press [ENTER]. This password is case-sensitive.

   - If you mistype the password, the NX500 Controller displays the error message **`Incorrect password for <user>. The password for <user> is unchanged.`** (where <user> is the user name of the currently logged-in user).
   - If you enter the password correctly, the NX500 Controller displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

3. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the NX500 Controller displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

4. Reenter the new password exactly as originally typed, and then press [ENTER].

   - If the password and confirmation match, the message **`Changing password for <user>`** appears, where **`<user>`** is the currently logged-in user.
   - If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

NX500 Vello User (Serial Console Connection)

To set or change the password for the `vello` user when connected directly to the NX500 Controller via the Console port:

1. At the command prompt, type `password` and then press [ENTER].

   The NX500 Controller displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

2. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the NX500 Controller displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

3. Reenter the new password exactly as originally typed, and then press [ENTER].
   - If the password and confirmation match, the message **`Password changed`** appears.
   - If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

NX500 Root User (Serial Console Connection)

To set or change the password for the `root` user when connected directly to the NX500 Controller via the Console port:

1. At the command prompt, type `password root` and then press [ENTER].

   The NX500 Controller displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

2. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the NX500 Controller displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

3. Reenter the new password exactly as originally typed, and then press [ENTER].
   - If the password and confirmation match, the message **`Password changed`** appears.
   - If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

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UBM Admin User Reset (Serial Console Connection)

To reset the password of the UBM admin user to the default vello123 when connected directly to the NX500 Controller via the Console port:

1. At the command prompt, type `password vmgr reset` and then press [ENTER].

   The NX500 Controller displays the message **`This will reset the admin user password for the GUI.`** followed by the **`Do you wish to proceed? [y/N]`** prompt.

2. Press `y` (lowercase) to confirm the reset, or any other character to abort.

   If you confirm the reset, the message **`The admin user password was reset to the factory default value`** appears. You may now log into the UBM (see *"Launching and Logging In" on page 93*).

VX1048 Switch CLI

This section describes accessing and using the CLI on a VX1048 switch.

Accessing the VX1048 CLI

You may access the VX1048 switch CLI via SSH or directly via serial console connection via the Console port (see *"Console Ports & Cables" on page 34*). Commands appear in the same order in which they display when you run the ? command. The following alphabetical lists will help you find the command you are looking for more quickly.

Note: The VX1048 switch uses a different RJ45-to-DB9 cable than the NX500 Controller and VX3048 switch (see "RJ45 Cable Specifications" on page 31).

- The Exec mode commands are:
  - **Boot:** *"Boot" on page 67*
  - **Copy:** *"Copy" on page 67*
  - **Exit:** *"Exit" on page 68*
  - **Help:** *"Help" on page 66*
  - **Ping:** *"Ping" on page 68*
  - **Reboot:** *"Reboot" on page 68*
  - **Show:** *"Show" on page 66*
  - **Traceroute:** *"Traceroute" on page 68*
  - **Write:** *"Write" on page 68*
  - **?:** *"?" on page 66*
- The Config mode commands are:
  - **Clock:** *"Clock" on page 69*
  - **Disable:** *"Disable" on page 71*
  - **Enable:** *"Enable" on page 71*
  - **End:** *"End" on page 71*
  - **Hostname:** *"Hostname" on page 69*
  - **Log:** *"Logging" on page 71*
  - **Management:** *"Management" on page 70*
  - **Openflow:** *"Openflow" on page 70*
  - **Tlsconfig-ca:** *"Tlsconfig-ca" on page 71*
  - **Tlsconfig-cert:** *"Tlsconfig-cert" on page 71*
  - **Tlsconfig-key:** *"Tlsconfig-key" on page 71*
  - **Tlsshow:** *"Tlsshow" on page 71*
  - **Username:** *"Username" on page 69*

Initial Messages

The VX1048 switch displays a command prompt upon successful SSH or serial connection:

```
<hostname>#
```

In the above example, "**<hostname>#**" is the command prompt. For example, if the host name of the VX1048 switch is "VX1048-01," then the command prompt will read **VX1048-01#**.

Modes

The VX1048 switch can run in the following modes:

- **Exec:** Normal operation mode
- **Config:** Configuration mode

  To enter Configuration mode, use the command `configure terminal`.

  The command prompt changes to `<hostname>(config)#`, where `<host name>` is the name of the switch.

  To exit Configuration mode and return to Exec mode, use either of the following commands:

  - end
  - `exit`

Exec Mode Commands

This section describes the CLI commands that are available when the VX1048 switch is in Exec mode. See *"Config Mode Commands" on page 69* for the Config mode commands.

Help

The **Help** command displays a list of all of the available VX1048 switch CLI commands with a short description of each command to use this command:

```
help
```

?

You may obtain detailed help for a particular command by typing `<command> ?` at the command prompt. For example, typing `show ?` displays a list of all of the options available for the **Show** command. To use this command:

```
<command> ?
```

Where:

`<command>` is a valid VX1048 switch command.

Show

The **Show** command displays various VX1048 switch settings. To use this command:

- **`show clock`:** Displays the current system date and time in HH:MM:SS MM:DD:YYYY format. Use the `clock set datetime` command described below to change the system date and time.
- **`show interface status`:** Displays port information and status for all ports.
- **`show interface <port name>`:** Displays port information and status for the selected port, where `<port name>` is the selected port.

- **`show management ip address:`** Displays the IP address of the Management port on the VX1048 switch.
- **`show openflow controller status:`** Displays the current status of the OpenFlow connection between the NX500 Controller switch and the VX1048 switch.
- **`show logging buffer <1-1000>]:`** Displays the most recent 20 lines of the log file by default. Adding a number between 1 and 1000 displays the specified number of lines from the log file.
- **`show transceiver detail:`** Displays details for the transceivers installed on the VX1048 switch (see *"SFP, SFP+, and QSFP+ Transceivers" on page 37*).
- **`show version:`** shows the current software image version running on the VX1048 switch.

Copy

The **Copy** command retrieves VX1048 switch system update images from a remote machine. To use this command:

```
copy mgmt-if <tftp:|ftp:> <A.B.C.D>/<remote path/
filename> flash: <local path/filename>
```

Where:

- `tftp:` and `ftp:` are trivial or standard file transfer protocols, respectively.
- `<A.B.C.D>` is the IP address of the server that contains the upgrade image.
- `<remote path/filename>` is the complete path and name of the upgrade image.
- `<local path/filename>` is the local path and filename where the upgrade image will be saved on the VX1048 switch.

Upon receiving confirmation, the VX1048 switch displays the following messages:

```
Download from URL to temporary file.
...  (a series of dots as a progress indicator)
Received <bytes> bytes in <x.y> seconds
Copy the temporary file to its destination.
...  (another series of dots as a progress indicator)
<bytes> bytes in <x.y> seconds, <kbps> kbytes/
second
<hostname>#
```

Where:

- `<bytes>` is the image file size.
- `<x.y>` is the time in seconds and tenths of a second/ The two times may not match; this is normal.
- `<kbps>` is the transfer rate in kilobytes per second.

After copying the image to the VX1048 switch, use the **Boot** command (see below) to specify this image as the new default system image.

Boot

The **Boot** command specifies the default system image to utilize. To use this command, enter:

```
boot system flash: <path>
```

Where:

`<path>` is the full path to the desired image.

You must reboot the VX1048 switch using the **Reboot** command (see below) to begin using the newly specified image.

Reboot

The **Reboot** command reboots the VX1048 switch. To use this command:

```
reboot
```

The VX1048 switch requests confirmation.

- To confirm, press [Y].
- To abort, press [n].

Upon receiving confirmation, the VX1048 switch reboots and displays the following messages:

```
% Rebooting ...
Connection to <A.B.C.D> closed by remote host.

Connection to <A.B.C.D> closed.
```

In the above message, **<A.B.C.D>** is the IP address of the VX1048 switch.

Ping

The **Ping** command verifies that the VX1048 switch can communicate with the selected device by sending a small amount of data to that device and noting if and when that device acknowledges that data. To use this command:

```
ping <A.B.C.D>
```

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

You may abort the ping by pressing [CTRL]+[C] at any time.

Traceroute

The **Traceroute** command traces the routes that data packets are taking to reach the specified remote device. To use this command:

```
traceroute <A.B.C.D>
```

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

Write

The **Write** command writes the current VX1048 configuration to the persistent memory on the switch. To use this command:

```
write memory
```

This command does not store auto-negotiation configuration (see *"Enable" on page 71*) to persistent memory.

Exit

The **Exit** command logs you out of the VX1048 switch. To use this command:

```
exit
```

- If you are connected via an SSH client, you will see a client prompt.
- If you are connected via a terminal program, you will see the connection go inactive.

If you exit when directly connected to the Console port on the VX1048 switch, the current session ends and a new one begins automatically with a command prompt displayed on screen.

Config Mode Commands

This section describes the CLI commands that are available when the VX1048 switch is in Config mode. See *"Exec Mode Commands" on page 66* for the Exec mode commands.

Clock

The **Clock** command sets the system date and time on the VX1048 switch Controller. Specify the time based on your current time zone:

```
clock set datetime <HH:MM:SS> <1-12> <1-31>
<2000-2037>
```

Where:

- `<HH:MM:SS>` represents the time, and HH = hours, MM = minutes, SS = seconds.
- The `1-12` range indicates the month, where 1 = January, 2 = February, and so on.
- `1-31` indicates the day of the month.
- `2000-2037` indicates the year. All 4 digits must be specified.

Successful execution of this command displays the new system date and time to confirm the change.

Hostname

The **Hostname** command either displays or changes the host name of the VX1048 switch. A host name is a descriptive name given to a device to distinguish it on the network. To use this command:

- **`hostname:`** When used without an argument, this command displays the current host name of the VX1048 switch.
- **`hostname [new host name]:`** When used with an argument, this command changes the host name of the VX1048 switch to the new user-specified name.

A host name must conform to the following requirements:

- The total length must be 63 characters or less.
- You may use almost any combination of letters (A-Z), numbers, (0-9), and hyphens.
- A host name cannot begin and/or end with a hyphen (-).
- No other punctuation or special characters are allowed.
- Spaces are not allowed.

Username

The **Username** command allows you to set up a set of user credentials that enable remote SSH logins to the VX1048 switch. To use this command:

```
username <username> secret <password>
```

Where:

- `<username>` is the name of the user being created.

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- `<password>` is the desired password for the specified user.

CAUTION: THE VX1048 DOES NOT CONTAIN BUILT-IN PASSWORD LIMITS; HOWEVER, FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

You must connect directly to the Console port on the VX1048 switch when creating the first user credential. You may create all subsequent credentials remotely.

The VX1048 switch does not require confirmation when creating a new password. Thus, whatever word you enter in the command line as the `<password>` immediately becomes the password for that user when you press [ENTER].

When using this command:

- You may repeat this process as many times as required to create however many individual user credentials you need.
- To change a password for a user, simply enter that user's username and a new password as if you are creating a new credential. The only difference in this case is that you are entering an existing username instead of a new one.
- To delete a user, use the command `no username <username>`, where `<username>` is the name of the user you are deleting.

Management

The **Management** command configures the IP address of the Management port on the VX1048 switch. To use this command:

- **`management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`:** Sets the Management port IP address and net mask to a specified value.
- **`management ip address dhcp`:** Sets the Management port IP address and subnet mask to use DHCP (dynamic addressing).
- **`management route add gateway <A.B.C.D>`:** Adds a Management port gateway IP address. This IP address must be reachable by the configured IP address and net mask specified by the **management ip address** command.
- **`management route del gateway <A.B.C.D>`:** Deletes the specified Management port gateway IP address.

In the above examples:

- `<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).
- `<yyy.yyy.yyy.yyy>` signifies a valid, properly formatted net mask. This value must be contiguous, with a prefix of ones followed by zeros.

Openflow

The **Openflow** command specifies the address, port, and connection type being used by the VX1048 switch to access the NX500 Controller. To use this command:

```
openflow set controller <tcp|ssl> <A.B.C.D>
<port>
```

Where:

- `tcp` or `ssl` is the connection type (Transmission Control Protocol or Secure Socket Layer).

- `<A.B.C.D>` is the valid IP address of the NX500 Controller. This is the IP address specified using the **Controlplane** command on the NX500 Controller, as described in *"Controlplane" on page 57*.
- `<port>` is the port number to connect to. The default port is 6633.

Reboot the VX1048 switch using the **Reboot** command (see *"Reboot" on page 68*) after setting the OpenFlow IP address to establish the connection to the NX500 Controller.

Logging

The **Logging** command specifies various VX1048 system logging options. Please see Please see *"VX1048 Logging Options" on page 72* for detailed instructions on using this command.

Enable

The **Enable** command enables port auto-negotiation for the specified port. You may enable auto-negotiation when not using VX1048 ports in a split optical flow configuration. To use this command:

```
enable autonego interface <port name>
```

Where:

`<port name>` is the specific port to disable.

Disable

The **Disable** command disables port auto-negotiation for the specified port. You must disable auto-negotiation when using VX1048 ports in a split optical flow configuration. To use this command:

```
disable autonego interface <port name>
```

Where `<port name>` is the specific port to disable.

Tlsconfig-key

The **Tlsconfig-key** command sets the TLS private key. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-cert

he **Tlsconfig-cert** command set the TLS public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-ca

The **Tlsconfig-ca** uploads a public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsshow

The **Tlsshow** command displays the public CA and public certificates that are currently installed on the VX1048 switch. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

End

The **End** command exits Config mode and returns to Exec mode. To use the command:

```
end
```

The command prompt changes from `<hostname>(config)#` to `<hostname)#`, where `<hostname>` is the host name of the VX3048 switch.

VX1048 Logging Options

The VX1048 switch includes extensive logging options, which are described in this section.

Buffer

The **Logging Buffer** command specifies the number of log lines to accumulate in memory before writing to disk. To use this command:

```
logging buffer <10-1000>
```

Where:

`<10-1000>` is the number of log lines that must accumulate in memory before being written to disk.

File

The **Logging File** command enables or disables logging to a file on the local disk. To use this command:

```
logging file [enable|disable]
```

Where:

- `enable` enables writing logs to disk.
- `disable` disables writing logs to disk.

Logging Level

The **Logging Level c**ommand specifies the severity of events that get passed to the specified VX1048 port (module) or written to disk. To use this command:

```
logging level [module|file] <severity>
```

Where:

- `module` specifies the VX1048 port to which to send the logs.
- `file` specifies that logs will be written to a file on disk.
- `<severity>` is the severity of events that will be logged (see *"Severity Levels" on page 73*).

Merging Logs

The **Logging Merge** command combines (merges) multiple log files into a single file for convenience and ease of use. To use this command:

```
logging merge [enable|disable] fifo-size <100-
10240> timeout <1-300>
```

Where:

- `enable` enables log merging
- `disable` disables log merging
- `<100-10240>` is the number of lines that must accumulate before logs are merges (optional)
- `<1-300>` is the timeout interval, in seconds (optional)

Logging Server

The **Logging Server** command specifies a remote server and facility to which the VX1048 will forward logs. To use this command:

```
logging server [enable|disable] <A.B.C.D> <facil-
ity> <severity>
```

Where:

- `enable` enables logging to a remote server.
- `disable` disables logging to a remote server.

- `<A.B.C.D>` is the IP address of the remote server.
- `facility` is the identifier of the application or process on the remote server that will receive log messages from the VX1048 switch. The available options are:
  - `kern`
  - `user`
  - `mail`
  - `daemon`
  - `auth`
  - `syslog`
  - `lpr`
  - `news`
  - `uucp`
  - `cron`
  - `authpriv`
  - `local0` through `local7`, inclusive
  - `<0-11>` facility value
  - `<16-23>` facility value
- `<severity>` is the severity of events that will be logged (see next section).

Logging Timestamp

The **Logging Timestamp** command specifies whether log entries have timestamps and, if so, the format to use for timestamps. To use this command:

```
logging timestamp [option]
```

Where:

`[option]` is one of the following:

- **`rfc3164`:** RFC 3164 style
- **`rfc3339`:** RFC 3339 style
- **`bsd`:** BSD style (same as RFC 3164)
- **`iso`:** ISO style (same as RFC 3339)
- **`date`:** Date command style
- **`none`:** No timestamp

Severity Levels

Each loggable event has a severity level associated with that event. In descending (most to least) order of criticality, the available severity levels are:

- emergency
- alert
- critical
- error
- warning
- notice

- information (info)
- debug

Enabling a logging severity level also enables the more critical levels above the selected level. For example, setting `logging level file warning` also captures error, critical, alert, and emergency-level events to the VX1048 system log.

Other VX1048 Commands

The Vello VX1048 switch includes additional commands that run in Config mode. These commands appear in this section for reference purposes only; you should only execute these commands when working under the direct guidance of Vello Technical Support.

CAUTION: MISUSE OF THESE COMMANDS CAN CAUSE CONFIGURATION ERRORS AND LOST DATA. ONLY USE THESE COMMANDS UNDER THE DIRECT GUIDANCE OF VELLO TECHNICAL SUPPORT.

The additional Config mode commands are:

- **`console`:** Configure the Console port.
- **`duplex`:** Set the duplex mode of the Console interface.
- **`ip`:** Internet Protocol (IP).
- **`ipg`:** Inter-Packet Gap.
- **`media-type`:** Specifies the port media type.
- **`no`:** Negate a command or set its defaults.
- **`ntp`:** NTP.
- **`qinq`:** Configure QinQ.
- **`shutdown`:** Shut down the selected interface.
- **`speed`:** Set the speed of the selected interface.
- **`temperature`:** Temperature threshold configuration

VX3048 Switch CLI

This section describes accessing and using the CLI on a VX3048 switch.

Accessing the VX3048 CLI

You may access the VX3048 switch CLI via SSH or directly via serial console connection via the Console port (see *"Console Ports & Cables" on page 34*). Commands appear in the same order in which they display when you run the ? command. This alphabetical list will help you find the command you are looking for more quickly:

Initial Messages

The VX3048 switch displays the following upon successful SSH or serial connection:

```
Network Virtualization Switch Console
Copyright 2013, Vello Systems, Inc.
VX version <version> compiled <month> <day>
<year> <hh:mm:ss>

Enter 'help' to display a command list
<hostname>#
```

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In the above example, "**<hostname>#**" is the command prompt. For example, if the host name of the VX3048 switch is "VX3048-01," then the command prompt will read **VX3048-01#**.

Commands

This section lists and describes the VX3048 switch CLI commands.

Help

The **Help** command displays a list of all of the available VX3048 switch CLI commands with a short description of each command. To use this command:

```
help
```

?

You may obtain detailed help for a particular command by typing `<command> ?` at the command prompt. For example, typing `show ?` displays a list of all of the options available for the **Show** command. To use this command:

```
<command> ?
```

Where:

`<command>` is a valid VX3048 switch command.

Show

The **Show** command displays various VX3048 switch settings. To use this command:

- **`show clock:`** Displays the current system date and time in HH:MM:SS MM:DD:YYYY format. Use the `clock set datetime` command described below to change the system date and time.
- **`show cores:`** Lists all core (crash dump) files on the current device, if any. Core files contain information that Vello Technical Support can use to diagnose problems.
- **`show images:`** Lists any available image(s) with upgrade files currently residing on the VX3048 switch in the format total <kb> <filename> (where <kb> is the image size in kilobytes and <filename> is the name of the image file, such as **vello-vx3048-v7.0.101.2.tar.bz2**).
- **`show management ip address:`** Displays the IP address of the Management port on the VX3048 switch.
- **`show openflow controller status:`** Displays the current status of the OpenFlow connection between the VX3048 switch and the NX500 Controller.
- **`show system log [tail <1-1000>]:`** Displays the system log. Adding `tail` followed by a number between 1 and 1000 displays the specified number of lines from the log file. If no tail is added, the entire log displays.
- **`show version:`** shows the current software image version running on the VX3048 switch.

Clock

The **Clock** command sets the system date and time on the VX3048 switch. Specify the time based on your current time zone:

```
clock set datetime <HH:MM:SS> <1-12> <1-31>
<2000-2037>
```

Where:

- `<HH:MM:SS>` represents the time, and HH = hours, MM = minutes, SS = seconds.
- The `1-12` range indicates the month, where 1 = January, 2 = February, and so on.
- `1-31` indicates the day of the month.
- `2000-2037` indicates the year. All 4 digits must be specified.

Successful execution of this command displays the new system date and time to confirm the change.

Hostname

The **Hostname** command either displays or changes the host name of the VX3048 switch. A host name is a descriptive name given to a device to distinguish it on the network. To use this command:

- **`hostname`:** When used without an argument, this command displays the current host name of the VX3048 switch.
- **`hostname [new host name]`:** When used with an argument, this command changes the host name of the VX3048 switch to the new user-specified name.

A host name must conform to the following requirements:

- The total length must be 63 characters or less.
- You may use almost any combination of letters (A-Z), numbers, (0-9), and hyphens.
- A host name cannot begin and/or end with a hyphen (-).
- No other punctuation or special characters are allowed.
- Spaces are not allowed.

Management

The **Management** command configures the IP address of the Management port on the VX3048 switch. To use this command:

- **`management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>`:** Sets the Management port IP address and net mask to a specified value.
- **`management ip address dhcp`:** Sets the Management port IP address and subnet mask to use DHCP (dynamic addressing).
- **`management route add gateway <A.B.C.D>`:** Adds a Management port gateway IP address. This IP address must be reachable by the configured IP address and net mask specified by the **management ip address** command.
- **`management route del gateway <A.B.C.D>`:** Deletes the specified Management port gateway IP address.

In the above examples:

- `<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).
- `<yyy.yyy.yyy.yyy>` signifies a valid, properly formatted net mask. This value must be contiguous, with a prefix of ones followed by zeros.

Openflow

The **Openflow** command specifies the address, port, and connection type being used by the VX3048 switch to access the NX500 Controller. To use this command:

```
openflow set controller <tcp|ssl> <A.B.C.D>
<port>
```

Where:

- `tcp` or `ssl` is the connection type (Transmission Control Protocol or Secure Socket Layer).
- `<A.B.C.D>` is the valid IP address of the NX500 Controller. This is the IP address specified using the **Controlplane** command on the NX500 Controller, as described in *"Controlplane" on page 57*.
- `<port>` is the port number to connect to. The default port is 6633.

Reboot the VX3048 switch using the **Reboot** command (see *"Reboot" on page 81*) after setting the OpenFlow IP address to establish the connection to the NX500 Controller.

Ovs-ofctl

The **Ovs-ofctl** command is a CLI-based OpenFlow switch management utility that is intended solely for troubleshooting under the guidance of Vello Technical Support. In general, each of these functions can be performed using UBM (see*"5 - Unified Bandwidth Manager" on page 89*) and/or the REST API (see the *REST API Guide*). This list appears in this manual for general information only. If needed, Vello Technical Support will ask you to execute some of these commands and will provide precise guidance at that time.

CAUTION: MISUSE OF THESE COMMANDS CAN CAUSE CONFIGURATION ERRORS AND LOST DATA. ONLY USE THESE COMMANDS UNDER THE DIRECT GUIDANCE OF VELLO TECHNICAL SUPPORT OR EXACTLY AS DIRECTED BY A TROUBLESHOOTING PROCEDURE.

- **`ovs-ofctl show`:** Shows the current state of all ports on the VX3048 switch.
- **`ovs-ofctl dump-desc`:** Displays basic information about the VX3048 switch, such as manufacturer information, hardware type, firmware date, and the switch serial number.
- **`ovs-ofctl dump-tables`:** Displays current table statistics.
- **`ovs-ofctl dump-ports`:** Displays current port statistics.
- **`ovs-ofctl dump-flows`:** Displays flow(s) that match(es) the user-supplied search string.
- **`ovs-ofctl dump-aggregate`:** Displays aggregate flow statistics.
- **`ovs-ofctl mod-port`:** Modifies a port.
- **`ovs-ofctl get-frags`:** Displays current fragment handling behavior.
- **`ovs-ofctl set-frags`:** Specifies fragment handling behavior.
- **`ovs-ofctl add-flow`:** Adds a new flow.
- **`ovs-ofctl mod-flows`:** Modifies flow(s) that match(es) the user-supplied search string.

- **`ovs-ofctl del-flows`:** Deletes flow(s) that match(es) the user-supplied search string.
- **`ovs-ofctl monitor`:** Prints data packets traveling through the switch on screen.
- **`ovs-ofctl ping`:** Measures latency (delay) of ping requests.

Log

The **Log** command sets the log type and location. To use this command:

- **`log <level>`:** Defines the severity of events that will appear in the log, as described below.
- **`log remote <A.B.C.D|off>`:** Remote logging forwards the VX3048 switch log to a different device on the network. Supplying a properly formatted IP address turns on remote logging at the specified IP address; the `off` argument disables remote logging. If you disable remote logging, you will need to reenter the desired IP address if you want to turn this function back on in the future.

Note: The specified remote device must have a syslog daemon installed and running in order to receive and store remote logs from the VX3048 switch.

- **`log local <on/off>`:** Local logging stores the system log on the VX3048 switch. The `on` argument enables local logging, and the `off` argument disables local logging. Local logging is independent of remote logging, meaning that you can have one with or without the other. Local logs are saved when the VX3048 switch reboots. You may retrieve local logs using the **send log** command (see *"Send" on page 80*). Log files are rotated based on file size and are therefore not stored indefinitely.

By default, the VX3048 switch forwards its logs to the NX500 Controller. Enabling remote logging on the VX3048 switch forwards logs directly to the remote location. Logs forward instantly when a new event occurs.

Each loggable event has a severity level associated with that event. In descending (most to least) order of criticality, the available severity levels are:

- emergency
- alert
- critical
- error
- warning
- notice
- information (info)
- debug

Enabling a logging severity level also enables the more critical levels above the selected level. For example, setting `log level warning` also captures error, critical, alert, and emergency-level events to the system log.

Copy

The **Copy** command retrieves VX3048 switch system update images from a remote machine. To use this command:

```
copy image scp <filename> <A.B.C.D> <port> <user>
```

Where:

- `<filename>` is the complete path and filename of the image you want to retrieve from the remote machine.
- `<A.B.C.D>` is the IP address of the remote machine.
- `<port>` is the port number to use for this connection.
- `<user>` is the username that will make the connection. You will be prompted to enter a password if one is configured for the selected user. You may also be asked to confirm the connection.

Delete

The **Delete** command deletes VX3048 switch system update images or core (crash dump) files. To use this command:

```
delete <core|image> <filename>
```

Where:

- `core` or `image` is the type of file to delete.
  - Selecting `core` deletes the specified core file from the VX3048 switch.
  - Selecting `image` deletes the specified image file.
- `<filename>` is the name of the file to delete, such as `core.nwi_https.991.1365616317.11`.

Send

The **Send** command sends VX3048 switch system log files or core files to a remote system. To use this command:

```
send <cores|logs> scp <A.B.C.D> <port> <user>
```

Where:

- `cores` or `logs` is the type of file to send.
  - Selecting `cores` sends all core files currently on the VX3048 switch.
  - Selecting `logs` sends the current system log file.
- `<A.B.C.D>` is the IP address of the remote device that will receive the files.
- `<port>` is the port number to use for this operation.
- `<user>` is the username that will make the connection. You will be prompted to enter a password if one is configured for the selected user. You may also be asked to confirm the connection.

Ping

The **Ping** command verifies that the VX3048 switch can communicate with the selected device by sending a small amount of data to that device and noting if and when that device acknowledges that data. To use this command:

- **`ping <A.B.C.D>`:** Pings the specified IP address four times.
- **`ping -c <A.B.C.D>`:** Pings the specified IP address continuously until you press [CTRL]+[C] to stop it.

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

Traceroute

The **Traceroute** command traces the routes that data packets are taking to reach the specified remote device. To use this command:

```
traceroute <A.B.C.D>
```

Where:

`<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).

Upgrade

The **Upgrade** command upgrades the software image on the VX3048 switch. To use this command:

```
upgrade <image>
```

Where:

`<image>` is the name of a valid software image that is stored on the VX3048 switch, such as **vello-vx3048-v7.0.101.2.tar.bz2**. In this example, the command would be `upgrade vello-vx3048-v7.0.101.2.tar.bz2`.

The VX3048 switch asks you to confirm the upgrade with the prompt **`Do you want to proceed with the upgrade? [y/n]`**.

- Press [y] to update the VX3048 switch (must be lowercase).
- Press [N] to cancel the update.

During the upgrade process, the VX3048 switch will display status messages while unpacking, validating, and installing the update. When the upgrade is complete, the screen will read **`Done. Upgrade complete`**.

Reboot

The **Reboot** command reboots the VX3048 switch. To use this command:

```
reboot
```

The VX3048 switch sends the following message and then reboots immediately:

`Broadcast message from <user>@<hostname> <date> <time>`
`The system is going down for reboot NOW!`

In the above message:

- **`<user>`** is the currently logged-in user.
- **`<hostname>`** is the host name of the VX3048 switch.
- **`<date>`** is the current system date in MM:DD:YYYY format.
- **`<time>`** is the current system time in HH:MM:DD format.

Password

The **Password** command changes the password for the currently logged-in user. This command functions differently when you are connected to the VX3048 switch via SSH versus via direct serial connection via the Console port.

To use this command when connected via SSH:

1. At the command prompt, type `password` and then press [ENTER].

   The prompt **`Old password:`** appears. This is a security measure.

2. Enter the current password for the currently logged-in user and then press [ENTER]. This password is case-sensitive.

   - If you mistype the password, the VX3048 switch displays the error message **`Incorrect password for <user>. The password for <user> is unchanged.`** (where <user> is the user name of the currently logged-in user).
   - If you enter the password correctly, the VX3048 switch displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

3. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the VX3048 switch displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

4. Reenter the new password exactly as originally typed, and then press [ENTER].

- If the password and confirmation match, the message **`Changing password for <user>`** appears, where **`<user>`** is the currently logged-in user.
- If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

This command works the same way when you connect to the VX3048 switch via a serial console, except that you are not prompted to enter the old password.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

Tlsconfig-key

The **Tlsconfig-key** command sets the TLS private key. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-cert

he **Tlsconfig-cert** command set the TLS public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Tlsconfig-ca

The **Tlsconfig-ca** uploads a public certificate. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

TIsshow

The **TIsshow** command displays the public CA and public certificates that are currently installed on the VX3048 switch. See *"Using Keys and Certificates" on page 86* for information about certificates and keys and using this command.

Exit

The Exit command logs you out of the VX3048 switch. To use this command:

`exit`

- If you are connected via an SSH client, you will see a client prompt.
- If you are connected via a terminal program, you will see the connection go inactive.

If you exit when directly connected to the Console port on the VX3048 switch, the current session ends and a new one begins automatically with a command prompt displayed on screen.

VX3048 Passwords

This **Password** command functions differently when you are connected to the VX3048 switch via SSH versus via direct serial connection via the Console port. In general:

- **SSH connection:** You may change the password for the `vello` user, provided that you have the old password (see next section).
- **Serial connection via the Console port:** You may change the password for the `vello` and `root` users without needing the old password (see *"VX3048 Vello User (Serial Console Connection)" on page 84* and *"VX3048 Root User (Serial Console Connection)" on page 84*).

VX3048 Vello User (SSH Connection)

To set or change the password for the `vello` user when connected via SSH:

1. At the command prompt, type `password` and then press [ENTER].

   The prompt **`Old password:`** appears. This is a security measure.

2. Enter the current password for the `vello` user and then press [ENTER]. This password is case-sensitive.

   - If you mistype the password, the VX3048 switch displays the error message **`Incorrect password for <user>. The password for <user> is unchanged.`** (where <user> is the user name of the currently logged-in user).
   - If you enter the password correctly, the VX3048 switch displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

3. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the NVX3048 switch displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

4. Reenter the new password exactly as originally typed, and then press [ENTER].

- If the password and confirmation match, the message **`Changing password for <user>`** appears, where **`<user>`** is the currently logged-in user.
- If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

VX3048 Vello User (Serial Console Connection)

To set or change the password for the `vello` user when connected directly to the VX3048 switch via the Console port:

1. At the command prompt, type `password` and then press [ENTER].

   The VX3048 switch displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

2. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the VX3048 switch displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

3. Reenter the new password exactly as originally typed, and then press [ENTER].

   - If the password and confirmation match, the message **`Password changed`** appears.
   - If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

VX3048 Root User (Serial Console Connection)

To set or change the password for the `root` user when connected directly to the VX3048 switch via the Console port:

1. At the command prompt, type `password root` and then press [ENTER].

The VX3048 switch displays the message **`Enter the new password (minimum of 5, maximum of 8 characters). Please use a combination of upper and lowercase letter and numbers.`** followed by the **`New password:`** prompt.

2. Enter the new password and then press [ENTER].

   If the new password meets all requirements (see below), the VX3048 switch displays the **`Re-enter new password:`** prompt.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

3. Reenter the new password exactly as originally typed, and then press [ENTER].
   - If the password and confirmation match, the message **`Password changed`** appears.
   - If the password and confirmation do not match, the error message **`They don't match; try again.`** appears. Reenter the password confirmation.

Passwords must meet the following criteria:

- Minimum length of 5 characters
- Maximum length of 8 characters
- Combination of uppercase letters, lowercase letters, and numbers
- Punctuation and special characters not allowed
- New password not similar to the old password

Using Keys and Certificates

The Vello NX500 Controller and VX1048/VX3048 switches support SSL/TLS security for OpenFlow connections, to protect against snooping and various attacks, such as "man in the middle," where an interloper connects between the target devices and communicates as if they were the devices themselves. These measures also ensure that Vello devices can authenticate each other as trusted devices on an OpenFlow connection.

Establishing an SSL connection requires each device to have all of the following installed:

- **Private device key:** This is commonly used in typical public-key cryptography.
- **Public device certificate:** This is commonly used in typical public-key cryptography.
- **Public peer Certificate Authority (CA) certificate:** Devices use this to determine that *peers* (other devices they are connected to) are trusted. Here, the CA vouches for the identity of each device. This works because all devices trust the CA. Think of this like the government-issued identification carried by most people. Presenting this card to other people when needed (such as when writing a check) works because people trust both the government and the identification cards it issues as proof of a person's identity. The same idea applies to public CA certificates.

Generating Keys and Certificates

Vello devices ship with all necessary keys and certificates installed. You can reinstall these keys if needed using the commands described in *"NX500 Controller CLI" on page 55*, *"VX1048 Switch CLI" on page 65*, and *"VX3048 Switch CLI" on page 75*. However, you may need to create your own keys and certificates in some cases.

CAUTION: IMPROPER CERTIFICATE/KEY CREATION AND/OR INSTALLATION CAN CAUSE CONNECTION ERRORS AND LOSS OF NETWORK RESOURCES, WITH ALL OF THE CONSEQUENCES OF THAT LOSS.

Creating your own keys and certificates requires you to have a preexisting Public-Key Infrastructure (PKI).

- If you have a PKI, refer to that documentation for instructions on creating certificates and keys for the NX500 Controller and all Vello VX1048/VX3048 switches that are connected to that NX500 Controller.
- If you do not have a PKI, you may use a tool such as the **ovs-pki** utility provided by OpenVSwitch (www.openvswitch.org).

To use the ovs-pki utility:

1. Install ovs-pki on a Linux system.
2. Execute the following commands on the Linux system:
   - `mkdir new_pki`

- `cd new_pki`
- `ovs-pki init -d pki -l /dev/null`
- `ls pki/`

This creates two directories:

- **controllerca:** Generates keys and certificates for use on the Vello NX500 Controller.
- **switchca:** Generates keys and certificates for use on a Vello VX1048 or VX3048 switch that will connect to the NX500 Controller.

3. Generate the key and certificates for the switch by running the command `ovs-pki -d pki/req+sign <sw_hostname> switch`, where `<sw_hostname>` is the host name of the switch.

   This command generates three files:

   - **<sw_hostname>-privkey.pem:** Private key for the switch.
   - **<sw_hostname>-cert.pem:** Public certificate for the switch.
   - **<sw_hostname>-req.pm:** Switch certificate request. You can delete this file.

4. Repeat Step 3 for each switch, being sure to use the correct host name for each switch.

5. Generate the key and certificates for the NX500 Controller by running the command `ovs-pki -d pki/req+sign <cl_hostname> controller`, where `<cl_hostname>` is the host name of the NX500 Controller.

   This command generates three files:

   - **<cl_hostname>-privkey.pem:** Private key for the NX500 Controller.
   - **<cl_hostname>-cert.pem:** Public certificate for the NX500 Controller.
   - **<cl_hostname>-req.pm:** Controller certificate request. You can delete this file.

6. Upload the following to each device:

   - Private device key, using the **Tlsconfig-key** command.
   - Public device certificate, using the **Tlsconfig-cert** command.
   - Public peer certificate, using the **Tlsconfig-ca** command.

CAUTION: BE SURE TO UPLOAD THE CORRECT FILES FOR EACH AFFECTED DEVICE. UPLOADING FILES TO A DEVICE THAT ARE INTENDED FOR ANOTHER DEVICE AND/OR SKIPPING ONE OR MORE DEVICES CAN CAUSE CONNECTION ERRORS AND LOSS OF NETWORK RESOURCES, WITH ALL OF THE CONSEQUENCES OF THAT LOSS.

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Using the Tlsconfig Commands

This section describes how to use the Tlsconfig commands included in the Vello CLI.

Tlsconfig-key

The **Tlsconfig-key** command uploads a private device key to the Vello NX500 Controller or BVX1048/VX3048 switch. To use this command:

1. On the selected device, run the command `Tlsconfig-key`.
2. The prompt **`Paste the contents of the key or certificate. When finished, type "done:" on a line by itself`** appears.
3. Paste the contents of the private device key for this device. When finished, start a new line, then type `done`.

Tlsconfig-cert

The **Tlsconfig-cert** command uploads a public device certificate to the Vello NX500 Controller or BVX1048/VX3048 switch. To use this command:

1. On the selected device, run the command Tlsconfig-cert
2. The prompt **`Paste the contents of the key or certificate. When finished, type "done:" on a line by itself`** appears.
3. Paste the contents of the private device key for this device. When finished, start a new line, then type `done`.

Tlsconfig-ca

The **Tlsconfig-ca** command uploads a public peer certificate to the Vello NX500 Controller or BVX1048/VX3048 switch. To use this command:

1. On the selected device, run the command Tlsconfig-ca
2. The prompt **`Paste the contents of the key or certificate. When finished, type "done:" on a line by itself`** appears.
3. Paste the contents of the private device key for this device. When finished, start a new line, and then type `done`.

Tlsshow

The **Tlsshow** command displays the public CA and public certificates that are currently installed on the VX3048 switch. To use this command:

```
tlsshow
```

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5 - Unified Bandwidth Manager

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Vello Unified Bandwidth Manager (UBM) is a secure web-based application (HTTPS) for managing software-defined networking (SDSN) as part of the Vello OpenFlow Network Solution. UBM resides on the NX500 Network Controller (see *"NX500 Controller" on page 5* and leverages both the REST API (see the *REST API Guide*) and the NX500 flow agent to configure and monitor the networked Vello VX1048/VX3048 switches.

UBM features an easy-to-use interface that simplifies common network administrator operations, such as:

- Flow, node, and bandwidth management
- Real-time flow performance monitoring
- Real-time port statistics
- Switch inventory
- Basic administrative security

The following diagram illustrates how clients interface with the NX500.:

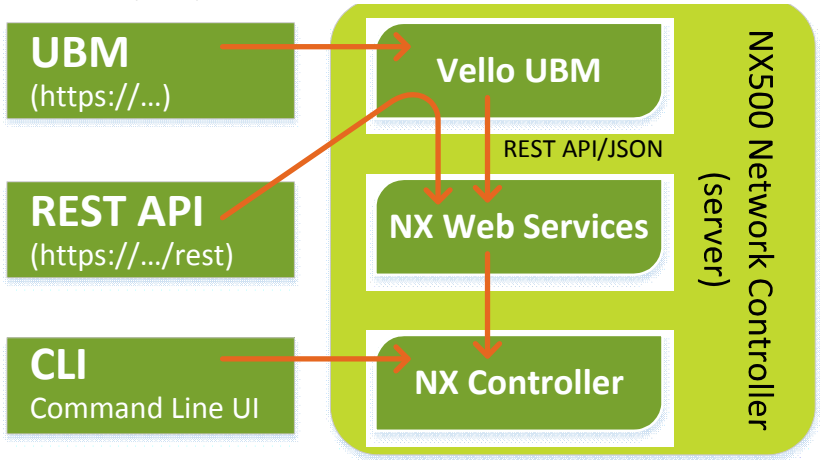

Figure 5.1: NX500 Controller interfaces

Note: This chapter discusses UBM only. See "4 - Command Line Interface" on page 51 for CLI information and the REST API Guide for REST API information.

Definitions

This section uses the following terms:

Software Defined Network (SDN)

A *software-defined network* (SDN) uses software to decouple network control from hardware in favor of a software application called a controller. This provides much greater flexibility and control at a much lower cost than traditional hardware-based methods.

Node

A *node* is a port on a VX1048 or VX3048 switch. It may also specify either a single IP address (such as a PC) or a range of IP addresses that represent a subnet that is allowed into and/or out of that port. Thus, a node can be defined by either:

- A combination of IP address/netmask of a host/network and a physical VX port through which the host/network can be reached.
- A VX switch port only. This represents any network entities that can be reached through the VX port regardless of Layer 2 or Layer 3 addressing.

Flow

A *flow* is a logical network route through the SDN, between nodes. The act of defining a flow means that traffic is both permitted and expected to flow between the nodes. The NX500 Controller automatically computes the individual physical ports and switch links through the SDN that are required to create the flow, and programs the VX1048 and/or VX3048 switch(es) appropriately. A flow may have the following properties:

- **Direction:** A flow may be *unidirectional* (one way) or *bidirectional* (both ways) between a pair of nodes.
- **Bandwidth:** All flows require reserved (guaranteed) bandwidth. If the user does not supply a value, the bandwidth reservation will default to the node port speed. This bandwidth is reserved throughout all of the physical links that comprise the flow. The flow cannot be created if the specified bandwidth is unavailable.

  When creating a flow, the NX500 Controller updates the network topology with new bandwidth reservations to ensure that future flows will not impinge on the bandwidth reserved for that flow. Removing a flow frees up the reserved bandwidth for use by other flows.
- **Unicast or Multicast:** A *unicast* flow is a connection between two nodes. Packets received on a source VX1048/VX3048 port transfer to a destination port on that switch. A *multicast* flow exists when a packet received on a single source VX1048/VX3048 port transfers to multiple destination ports on that switch. Multicast flows require a multicast destination address and must be unidirectional.

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System Requirements

UBM comes pre-installed on the NX500 Controller. The following sections define the minimum client and hardware configuration requirements for accessing and launching the application.

Client Requirements

The computer used to access UBM must meet the following minimum requirements in order to function as an effective NX500 Controller client:

- **Operating System:** Windows 7 or 8
- **Browser:** Firefox 18.0 to 20.0; Chrome 24.0 to 26.0; or Internet Explorer 9 or 10
- **Minimum resolution:** 1024x768

Note: UBM does not block or warn users who attempt to log in using unsupported systems and/or browsers. Users assume all risks of data loss and other abnormal functions if they attempt to run UBM on a system that does not meet the stated requirements.

Hardware Configuration Requirements

The NX500 Controller must be set up as follows before you may access and log in to UBM:

- Physical installation must be complete.
- Management IP must be configured through the CLI (see *"4 - Command Line Interface" on page 51*).
- Ethernet cable connection must be established between the NX500 Controller and the client computer.

Each Vello VX1048 and/or VX3048 switch that will be part of the network being managed by the NX500 Controller must be set up as follows before you may access and log in to UBM:

- Physical installation must be complete.
- Management IP must be configured through the CLI (see *"4 - Command Line Interface" on page 51*).
- Ethernet cable connection must be established between the switch(es) and the NX500 Controller Controlplane port(s) to enable detection and UBM management.

Please refer to the following:

- *"3 - Hardware Setup" on page 21* for installation instructions that cover the NX500 Controller and the VX1048/VX3048 switches.
- *"4 - Command Line Interface" on page 51* for instructions on using the CLI to configure the management IP on the NX500, VX1048, and VX3048.

Launching and Logging In

To launch and log in to UBM:

1. Open a supported web browser (see *"System Requirements" on page 92*).
2. Navigate to the NX500 Controller's management IP address, which will be `https://<A.B.C.D>`, where `<A.B.C.D>` is the Management IP address of the NX500 Controller.

Note: Be sure to use the https:// prefix; the normal http:// prefix will return a 404 (page not found) error.

3. The NX500 Controller uses a self-signed certificate, which will trigger a security warning in your browser. Ignore and dismiss this warning to proceed to the UBM **Login** page.

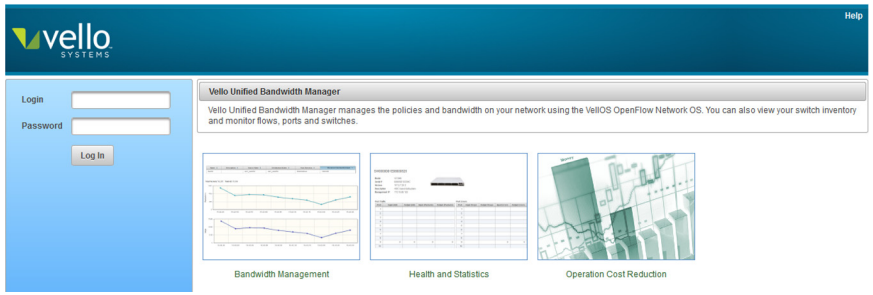


Figure 5.2: UBM Login page

4. Enter your user name in the **Login** field (case sensitive). The default user name is `admin`.
5. Enter your password in the **Password** field (case sensitive). The default password is `vello123`.
6. UBM will prompt you to change your password.

CAUTION: FAILURE TO SELECT A STRONG PASSWORD MAY EXPOSE THE NETWORK TO UNAUTHORIZED ACCESS AND TO ALL OF THE CONSEQUENCES THEREOF.

7. Click the **Log In** button to display the **Inventory** page.

Note: UBM allows multiple simultaneous logins by the same user (sessions). In these situations, only the most recent change made by any session will be stored.

Forgotten Password

If a user forgets their password, another UBM user may log in to change the password. If all users lose their passwords, you may regain access using the CLI. See *"Changing a User's Password" on page 113* for instructions on changing a user's password and *"UBM Admin User Reset (Serial Console Connection)" on page 64* for information on using the CLI to restore the default (admin) user password.

Common UBM Elements

UBM includes the following universal elements throughout the application:

- The UBM version number appears in the lower right corner of the **Login** page.
- The username of the currently logged in user appears in the upper right corner of all pages whenever a user is logged in.
- Clicking the Vello icon in the upper left corner of any application page returns you to the **Login** page.
- Clicking the **Log Out** link in the upper right corner of any page logs you out of UBM.
- An asterisk next to a data-entry field indicates that the field is required.
- All add/edit/delete operations take effect immediately when the user clicks an **OK** button to confirm the operation. There is no "undo" operation.
- Clicking a column header in most tables (except the **Port Traffic** table described in *"Port Traffic Table" on page 98* and the **Port Errors** table described in *"Port Errors Table" on page 98*) sorts the entire table in ascending (A-Z) order of the selected column's contents. Clicking the column header again sorts in descending (Z-A) order.
- Clicking the **Help** link in any page displays help content for that page.
- User sessions time out after 60 minutes of inactivity and redirect the user to the **Login** page.

Global Navigation

The top of the UBM interface contains a menu bar.

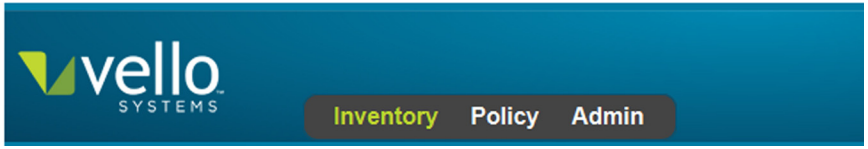


Figure 5.3: Menu bar

This menu bar has the following options:

- **Inventory:** Clicking the **Inventory** option accesses the **Switch Inventory** page, which lists the Vello VX1048 and/or VX3048 switches managed by the NX500 Controller and allows you to navigate to more detailed information, as well as remove a switch from the NX500 Controller. See *"Removing a Switch" on page 99*.
- **Policy:** Clicking the **Policy** option accesses the **Flow** and **Nodes** policy pages. See *"Flows Policy Page" on page 100* and *"Nodes Policy Page" on page 107*.
- **Admin:** Clicking the **Admin** option accesses the **Admin** page. See *"Admin Page" on page 110*.

Switch Inventory Page

The **Switch Inventory** page lists all of the Vello VX1048 and/or VX3048 switches configured for management by the NX500 Controller and their status (**Active** or **Inactive**). This page refreshes every 30 seconds.

*Note: All Vello VX1048/VX3048 switches need to be configured to refer to the NX500 Controller as the OpenFlow controller in order for them to appear in the **Switch Inventory** page. See "VX1048 Bring-Up" on page 45 and "VX3048 Bring-Up" on page 47 for instructions on configuring switches.*

The page is divided into two areas:

- **All Switches** list (left side)
- **Switch Inventory** table (right side)

All Switches List

The **All Switches** list shows all VX1048 and/or VX3048 switches managed by the NX500 Controller in alphanumeric order by switch ID. Each switch in the list appears with a colored dot that indicates either **Active** (green) or **Inactive** (red) status. Clicking a switch ID or double-clicking a row in the **Switch Inventory** table opens the **Switch Details** page for the selected switch (see "Switch Details Page" on page 97). The switch IDs listed in the **All Switches** list match the IDs listed in the **Switch ID** column of the **Switch Inventory** table. In the **All Switches** list:

- **Active** (green dot) means that the listed switch is connected to the network and operating normally.

Figure 5.4: Switch Inventory page

- **Inactive** (red dot) means that the NX500 Controller is not receiving the "keep alive" signal from that switch. This can occur for a number of reasons, such as:
  - The switch may have been physically disconnected from the network. Always remove a switch from the Inventory of the NX500 Controller when intentionally removing that switch from the network (see *"Removing a Switch" on page 99*).
  - The switch may have been configured to point to another controller. Remove this switch from the Inventory of the NX500 Controller (see *"Removing a Switch" on page 99*).
  - The switch may be malfunctioning and no longer passing traffic.
  - The switch may be functioning normally, but the NX500 Controller is not receiving the "keep alive" signal from that switch for some reason.

Viewing Individual Switch Status

Clicking a switch ID opens the **Switch Details** page for the selected switch, which displays detailed information for the selected switch (IP address, software version, and more). See *"Switch Details Page" on page 97* for more information about the **Switch Details** page.

Switch Inventory Table

The **Switch Inventory** table lists all of the Vello VX1048 and/or VX3048 switches being managed by the NX500 Controller. This table refreshes itself every 30 seconds and is read-only. The switches listed in this table match the list in the **All Switche**s list on the left side of the S**witch Inventory** page.

The table contains the following columns:

- **Switch ID:** Unique identifier for each switch (cannot be changed)
- **IP:** Network management address for each switch, which was specified during installation
- **Manufacturer:** Lists **Vello** as the switch manufacturer for Vello switches
- **Hardware:** Model number of the switch (such as VX1048 or VX3048)
- **Software:** VellOS version running on each switch
- **Serial #:** Unique serial number for each switch
- **Status:** Lists the status (**Active** or **Inactive**) for each switch

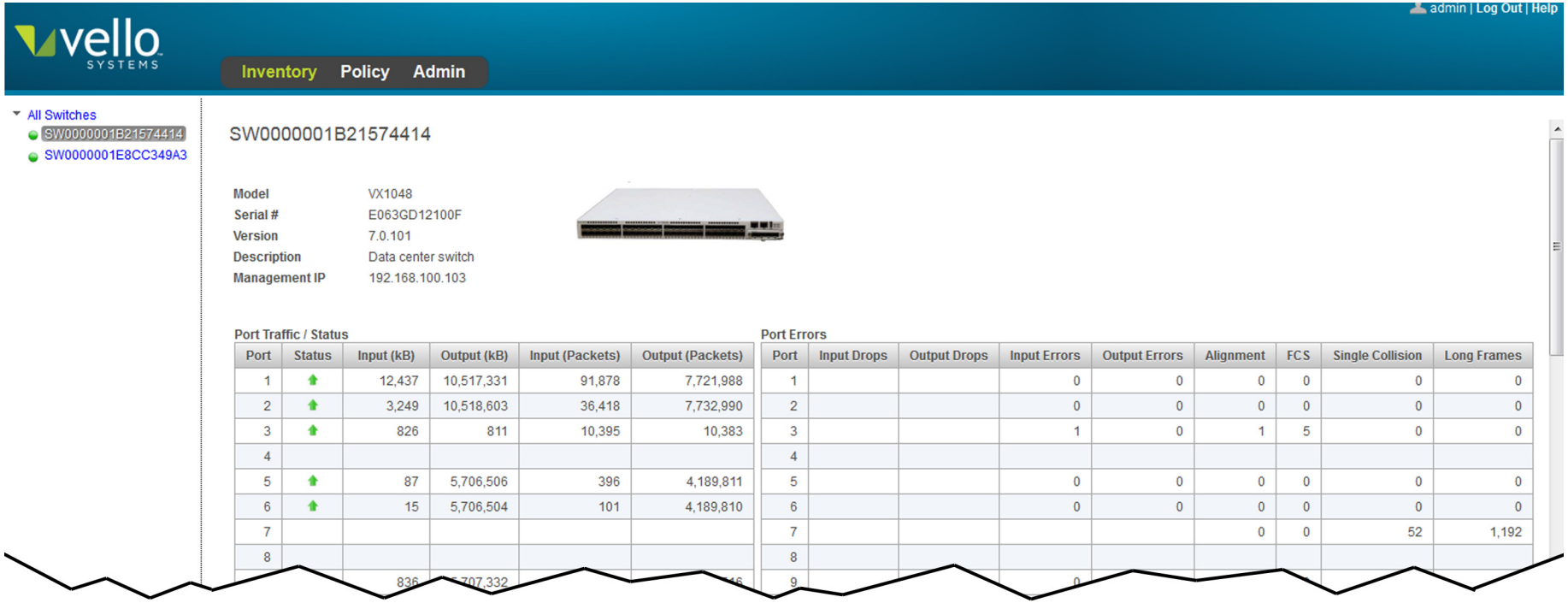
You may sort the **Switch Inventory** table by any column (in ascending or descending order) by clicking the desired column header. The sort lasts until the table is refreshed.

Switch Details Page

Clicking a switch ID in the **All Switches** section of the **Switch Inventory** page opens the **Switch Details** page for that switch. Each switch managed by the NX500 Controller has its own **Switch Details** page. The top of the S**witch Details** page contains the following information:

- **Model #:** Model number of the switch (such as VX1048 or VX3048)
- **Serial #:** Unique serial number for the selected switch
- **Version:** OS version running on the selected switch
- **Description:** Brief description of the selected switch
- **Management IP:** Network management address for the selected switch, which was specified during installation

Figure 5.5: Switch Details page



Port	Status	Input (kB)	Output (kB)	Input (Packets)	Output (Packets)
1	↑	12,437	10,517,331	91,878	7,721,988
2	↑	3,249	10,518,603	36,418	7,732,990
3	↑	826	811	10,395	10,383
4					
5	↑	87	5,706,506	396	4,189,811
6	↑	15	5,706,504	101	4,189,810
7					
8					

Port	Input Drops	Output Drops	Input Errors	Output Errors	Alignment	FCS	Single Collision	Long Frames
1			0	0	0	0	0	0
2			0	0	0	0	0	0
3			1	0	1	5	0	0
4								
5			0	0	0	0	0	0
6			0	0	0	0	0	0
7					0	0	52	1,192
8								

Port Traffic Table

The **Port Traffic** table tracks the amount of data in kB and packets going to and from the switch. This table is read-only and cannot be sorted. It refreshes every 30 seconds to provide real-time data. Within this table:

- On a VX1048 switch:
  - Ports 1-48 are regular 1GbE switch ports.
  - Ports 49-52 are 10GbE network uplink ports.
- On a VX3048 switch:
  - Ports 1-48 are regular 10GbE switch ports.
  - Ports 49-52 are 40GbE network uplink ports.
- **Status:** Lists the status of each port, as follows:
  - **Green up arrow:** Port is connected and operating normally.
  - **Red down arrow:** Port is not passing traffic. This is normal if the port is not connected. If the port is connected, then user investigation and diagnosis are required to resolve the problem.
  - **Blank (no dot):** No information was received for this port.
- **Input/Output:** The **Input (kB)**, **Output (kB)**, **Input (Packets)**, and **Output (Packets)** columns are absolute counters listing cumulative total values since the switch last booted up. The only way to reset the tables to zero is to reboot the switch.

Note: In this table, each kB represents one kilobyte, which equals 1,000 bytes (not 1,024).

Port Errors Table

The **Port Errors** table tracks the data errors in packets going to and from the switch. This table is read only and cannot be sorted. It refreshes every 30 seconds to provide real-time data. Within this table:

- **Input/Output Drops:** The **Input Drops** and **Output Drops** columns list the number of packets dropped by the switch. The switch places all packets with no immediate routing matches into a queue for processing. If the input or output queue is full, the switch drops the packet.
- **Input/Output Errors:** The **Input Errors** and **Output Errors** columns list the number of packets with CRC (byte positioning) errors.
- **Alignment:** Number of packets with byte-alignment errors.
- **FCS:** Number of packets with frame check sequence errors (where the data being received does not match the data that was sent).
- **Single Collision:** Number of packets that have collided. A collision occurs when two or more devices try to transmit on the same bus at the same time.
- **Long Frames:** Number of packets that are larger than 1,518 bytes.

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Removing a Switch

If a switch is inactive, a link appears in the **Switch Details** page to allow you to remove that switch.

Figure 5.6: Inactive switch listing

To remove a switch:

1. Make the switch inactive by powering it down and/or disconnecting it from the NX500 Controller.
2. Click the link in the **Switch Details** page of the switch you want to remove.
3. Click **OK** to confirm the deletion.

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Flows Policy Page

The **Flows** policy page allows users to access flow information for each switch being managed by the NX500 Controller. This page allows users to view, add, edit, or delete flows. Users may also view flow traffic statistics, as well as trace the routes that the flows are taking through the network.

Note: You may add nodes without associating them with a flow, such as adding a new node in anticipation of a future need to include it in a flow (see "Adding a Node" on page 108).

Clicking the **Flows** icon on the left side of a **Policy** page opens the **Flows** policy page (see next page for image). This page contains a table listing all of the flows defined for the ports of the switches being managed by the NX500 Controller. Two graphs appear below this table, tracking flows in packets per second (**Packets/s**) and kilobits per second (**Kbps**).

- The **Flows** page includes a toolbar that allows you to **Add**, **Edit**, **Delete**, **Copy**, and **Paste** flows. See "Adding a Flow" on page 104, "Editing a Flow" on page 104, "Deleting a Flow" on page 105, and "Copying a Flow" on page 105 for more information on these functions.
- The **Filter** field in the toolbar is a free-text search filter that searches for matching strings across all table columns with each keystroke.
- Clicking the **Show Details** button toggles a dialog that displays the definitions of the source and destination nodes. This dialog is on by default.

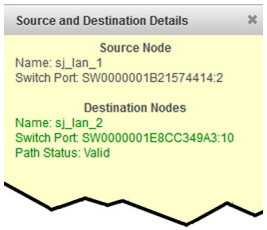

Figure 5.7: Show Details dialog

- Clicking the **Tools** button in the toolbar opens a pull-down menu that allows you to **Trace**, **Print**, or **Export** the path for a selected flow. See "Tracing Flow Paths" on page 102, "Printing Flow Paths" on page 103, and "Exporting Flow Paths" on page 103 for information on these functions.

The table beneath the toolbar contains the following columns:

- **Name:** Lists the name assigned to the flow when that flow was configured.
- **Description:** Lists any user-entered notes made when that flow was configured.
- **Source Node:** Shows the user-defined node name for the flow's packet source. If a flow contains one source node and one destination node, then the flow is unicast and may be either:
  - unidirectional from source node to destination node, or
  - bidirectional, where nodes are both sources and destinations to each other (since traffic is flowing both ways).

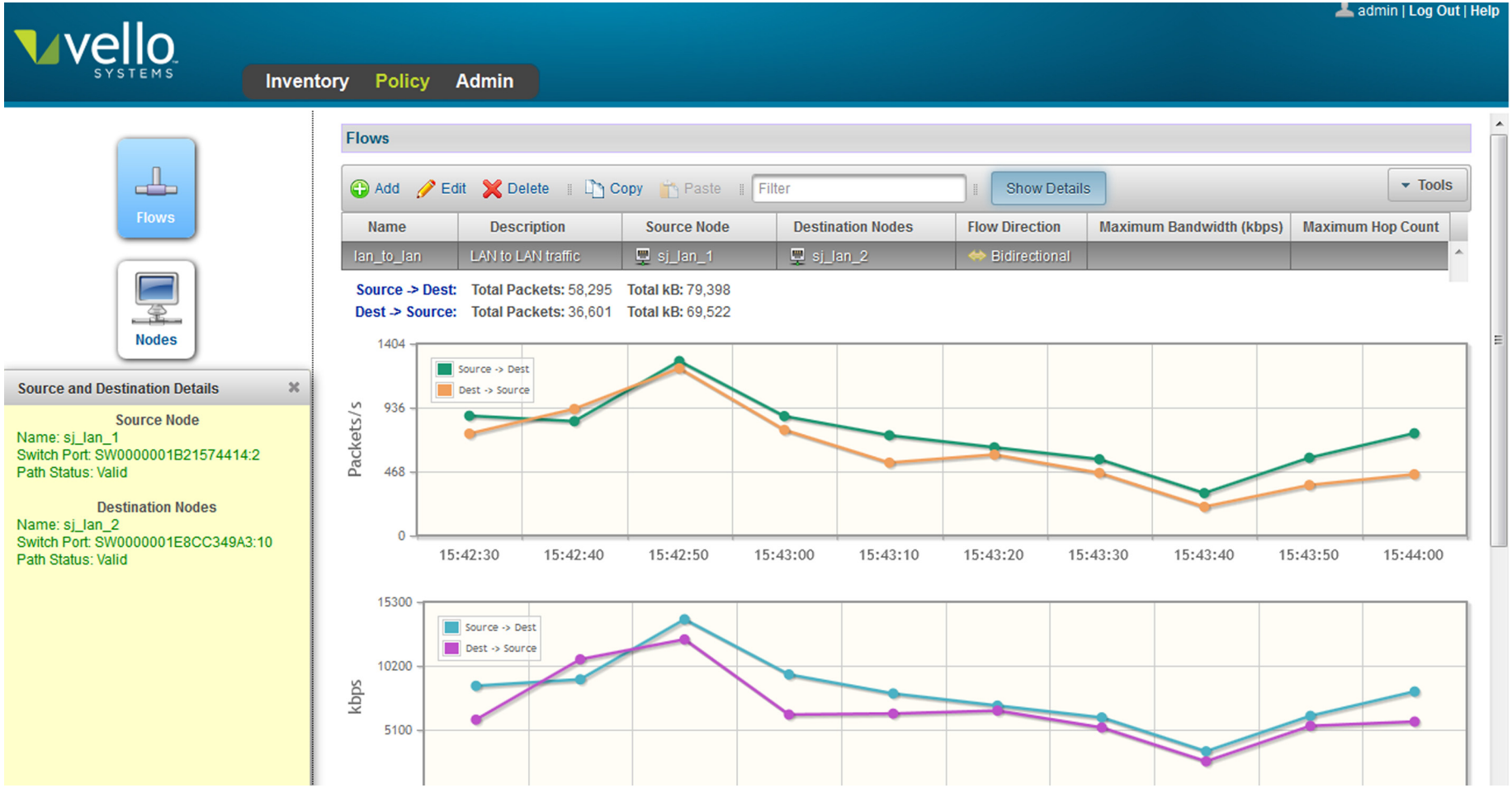

Figure 5.8: Flows policy page

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- **Destination Nodes:** Shows the user-defined node name(s) for the flow's packet destination(s). If there is more than one destination node listed for a single flow, then by definition the flow is:
  - multicast from the source node to all of the destination nodes, and
  - unidirectional from the source node to all of the destination nodes

*Note: The **Nodes** policy page allows you to configure available nodes as sources and/or destinations (see "Nodes Policy Page" on page 107).*

- **Flow Direction:** Displays whether the flow was configured for packets to flow in one (**Unidirectional**) or both (**Bidirectional**) directions from the source node to the destination node(s).

Note: A multicast flow must be unidirectional.

- **Maximum Bandwidth (kbps):** Displays the user-specified maximum bandwidth for data traffic from the source node to the destination node(s).

Note: Users may specify any desired bandwidth limit. Specifying a limit beyond hardware capacity assigns maximum available bandwidth to the selected flow. All traffic that exceeds the specified limit is dropped.

- **Maximum Hop Count:** Displays the user-specified maximum number of switches that packets may traverse in this flow. There are no programmatic upper or lower bounds.

Monitoring Traffic on a Flow

To view traffic graphs for any of the flows listed in the **Flows** page, click the row in the table that corresponds to the flow you want to view.

- If the selected flow has traffic, the flow statistics (**Total Packets** and **Total kB**) will appear, along with two flow graphs (one each for **Packets/s** and **kpbs**). The statistics are absolute counters listing cumulative total values since the flow was created. The only way to reset the statistics to zero is to delete and then recreate the flow. The graphs refresh every 10 seconds.
- If the selected flow has no traffic, the statistics and graphs will not appear.

Note: On this page, each kB represents one kilobyte, which equals 1,000 bytes (not 1,024).

Tracing Flow Paths

Paths are the actual physical routes that packets take through switches and ports to complete flows from source nodes to destination nodes. This function displays the flow path in effect at the time you view it; flows can change over time. To trace a path:

1. From the **Flows** page, select the row in the table that corresponds to the desired flow.
2. Click the **Tools** button in the toolbar to open the pull-down menu.
3. Select **Trace Physical Path** in the pull-down menu to open the **Display Flow Physical Paths** dialog.

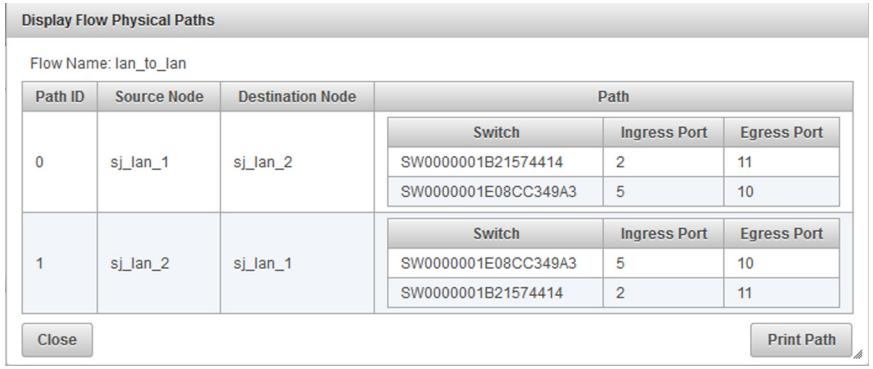


Figure 5.9: Display Flow Physical Paths dialog

The **Display Flow Physical Paths** dialog contains a table with:

- a single row for each path going from source to destination (for uni-directional flows),
- a second row for the path going from destination to source (for bidirectional flows only), and
- additional row(s) for each destination (for multicast flows only).

This table contains the following columns:

- **Path ID:** Unique identifier for the path.
- **Source Node:** Name of the source node.
- **Destination Node:** Name of the desintation node.
- **Path:** Additional table where each row indicates the switch and ports the data passed through. This table lists the following:
  - **Switch:** Switch ID
  - **Ingress Port:** Port where the packet entered the switch
  - **Egress Port:** Port where the packet exited the switch.

Printing Flow Paths

To print a path:

1. From the **Flows** page, select the row in the table that corresponds to the desired flow.
2. Click the **Tools** button in the toolbar to open a pull-down menu.
3. Select **Print Path** in the pull-down menu to open your browser's Print dialog, which will allow you to print the selected path.

Exporting Flow Paths

To export one or more path traces:

1. From the **Flows** page, select either:
   - the row(s) in the table that correspond(s) to the desired flow(s) to export just the selected flow path(s), or
   - no rows, which will export the paths for all flows.

Note: To deselect a row, press and hold [CTRL] (Windows) or [COMMAND] (Macintosh) while clicking the row you want to deselect.

2. Click the **Tools** button in the toolbar to open the pull-down menu.
3. Select **Export Physical Path** in the pull-down menu to open a standard **Save As** dialog, which will allow you to navigate to the desired folder and save the exported path(s) in comma-delimited (CSV) format.

Adding a Flow

There are two ways to create a flow:

- You can create the nodes first and then the flow.
- You can directly create a flow and then create nodes inline using the **Add/Edit Flow** dialog by clicking the **Add Flow** button in the toolbar.

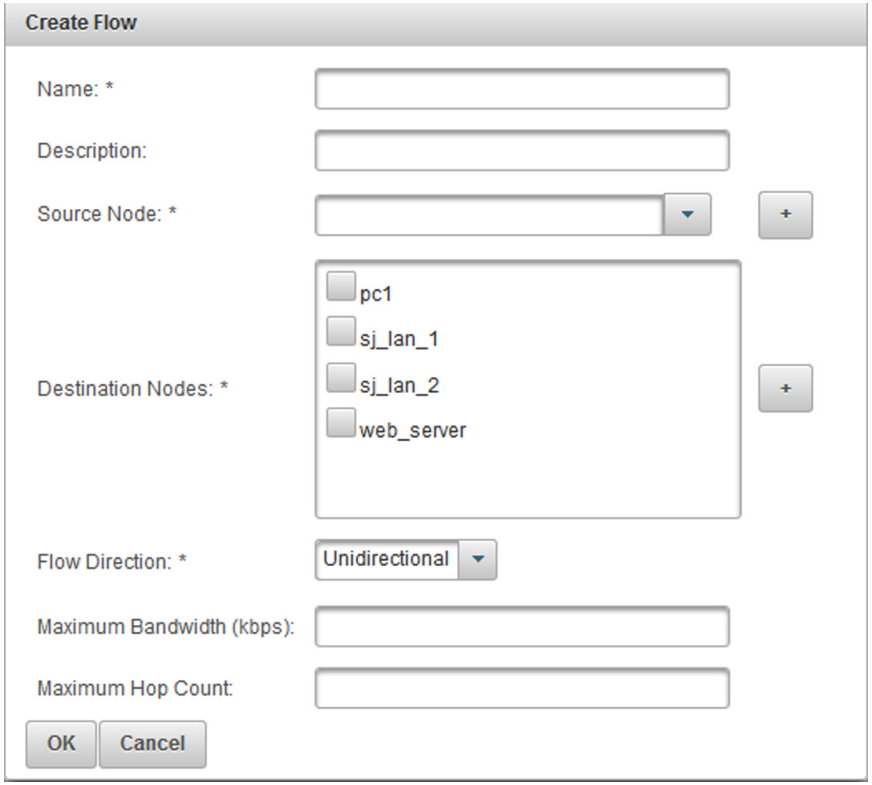


Figure 5.10: Create Flow dialog

To add a flow:

1. Enter a name for the new flow (required).
2. Enter a description that will help you remember what the flow is (optional).
3. Use the **Source Node** pull-down menu to select a source node (required).
4. Select one or more destination node(s) by checking them in the **Destination Nodes** area (required).
5. Select a flow direction using the **Flow Direction** pull-down menu (required).
6. Specify the maximum bandwidth limit and maximum number of hops for this flow, if needed, by entering that information in the appropriate field(s).
7. Click **OK** to finish adding the flow.

Editing a Flow

To edit a flow:

1. Select a flow by clicking its row in the table.
2. Click the **Edit** button to open the **Edit Flow** dialog.
3. Make your desired changes.
4. Click **OK** to save your changes.

Note: The flow name cannot be edited.

Copying a Flow

To copy an existing flow:

1. Select a flow by clicking its row in the table.
2. Click the **Copy** button.
3. Click the **Paste** button to open the **Paste Flow** dialog and paste all values that are not unique to a specific flow.

Note: The flow name is copied with "_copied" appended. For example, "Flow_1" becomes "Flow_1_copied."

4. Click **OK** to save your changes.

Deleting a Flow

To delete a flow:

1. Select a flow by clicking its row in the table.
2. Click the **Delete** button to open a confirmation dialog.
3. Click **Yes** to complete the deletion.

Additional Information

The following information applies when creating, editing, and/or copying a flow:

- The source node and destination node(s) refer to the nodes in the **Nodes** table.
- Specifying more than one destination implies you are configuring a multicast destination. All destination nodes must therefore be defined with multicast IP addresses.
- A unicast flow can be either *unidirectional* (from source to destination) or *bidirectional*. A multicast flow must be unidirectional.
- For bidirectional flows, swapping the source and destination nodes has no effect because data is flowing in both directions.
- You may specify any desired bandwidth limit. Specifying a limit beyond hardware capacity assigns maximum available bandwidth to the selected flow. All traffic that exceeds the specified limit is dropped.
- The maximum hop count specifies the maximum number of switches that packet traffic can traverse en route from source to destination (and vice versa if the flow is configured for bidirectional traffic). If no maximum hop count is specified, packets can take any number of hops to reach their destination.
- The NX500 Controller must be able to determine the correct destination port for forwarding traffic to. Source node definitions must therefore be unique for all flows. For bidirectional flows, the destination node is also treated like a source node and must also be unique.
- The system checks for and rejects duplicate flows where source and destination nodes are identical.

Examples

Assume that the following nodes exist:

- `sw1_node1 - sw1:1`
- `sw1_node1_copied - sw1:1`

- `sw1_node3_10 - sw1:3, IP: 192.168.1.10, Subnet Mask: 255.255.255.255`
- `sw1_node3_11 - sw1:3, IP: 192.168.1.11, Subnet Mask: 255.255.255.255`
- `sw2_node20 - sw2:20`
- `sw2_node21 - sw2:21`

Assume that the following flows exist:

- **Flow1:** `source: sw1_node1, destination: sw2_node20, direction: unidirectional`
- **Flow2:** `source: sw1_node3_10, destination: sw2_node20, direction: unidirectional`

Assuming that the flows are unidirectional unless otherwise noted, configuring the following flows generates the following results:

- **`source: sw1_node1, destination: sw2_node20`**
  Error, because the flow already exists.
- **`source: sw1_node1_cannot duplicate, destination: sw2_node20`**
  Error, because although the node is different, it still refers to source sw1:1, which already exists.
- **`source: sw2_node21, destination: sw2_node20`**
  Permitted, because the destination does not need to be unique when it's unidirectional.
  - **`source: sw2_node21, destination: sw1_node1, direction: bidirectional`**
    Error, because the flow is bidirectional and the destination `sw1_node1` conflicts with 'flow1,' which has the same `sw1_node1` as its source node.
- **`source: sw1_node3_11, destination: sw2_node20`**
  Permissible. Athough `sw1_node3_11` also refers to `sw1:3` as in 'flow2', the IP/mask qualifier specifies a different IP address, making the source node unique. The NX500 Controller can distinguish which port to forward to, based on the IP address.

Nodes Policy Page

The **Nodes** policy page allows users to access flow and node information for each switch being managed by the NX500 Controller. This page allows users to view, add, edit, or delete individual nodes.

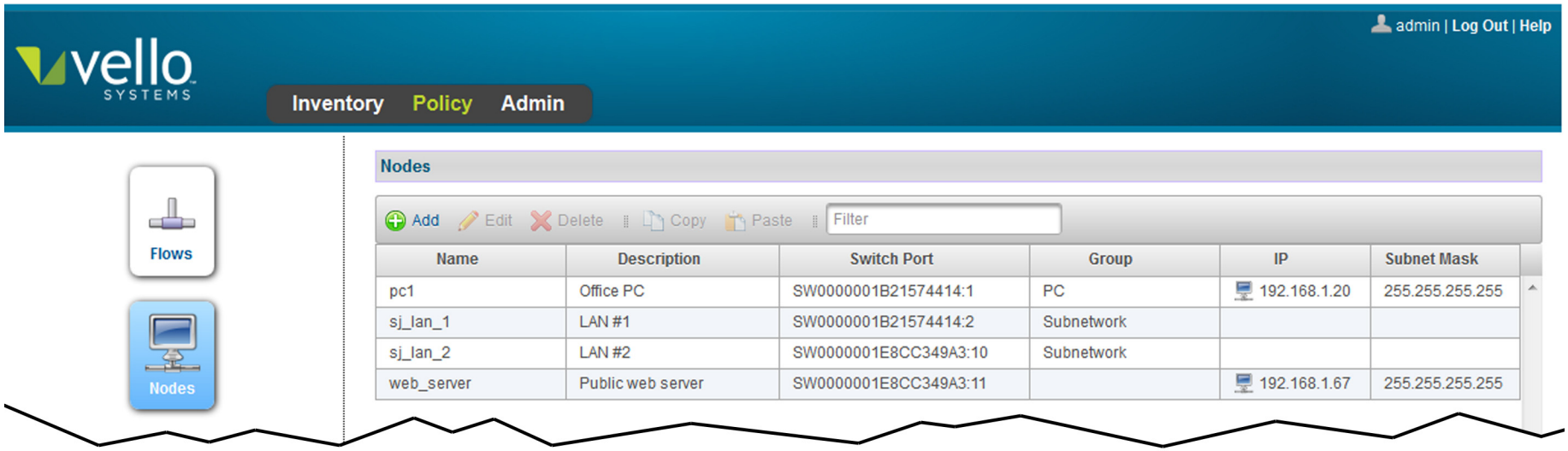
Clicking the **Nodes** icon on the left side of a **Policy** page opens the **Nodes** page. This page contains a table listing all of the flows defined for the ports of the switches being managed by the NX500 Controller.

- The **Nodes** policy page includes a toolbar that allows you to **Add**, **Edit**, **Delete**, **Copy**, and **Paste** nodes. See *"Adding a Node" on page 108*, *"Editing a Node" on page 109*, *"Deleting a Node" on page 109*, and *"Deleting a Node" on page 109* for more information on these functions.
- The **Filter** field in the toolbar is a free-text search filter that searches for matching strings across all table columns with each keystroke.

The table beneath the toolbar contains the following columns:

- **Name:** Lists the name assigned to the node when first configured.
- **Description:** Lists any user-entered notes made when that node was configured.

Figure 5.11: Nodes policy page



- **Switch Port:** Switch ID and port number for each node. The port number is appended to the end of the Switch ID (i.e. `[switch ID]:[Port Number 1 - 48]`).
- **Group:** Displays any optional labels or tags for that node.
- **IP and Subnet Mask:** If a node was configured to be restricted to flows to only certain IP addresses, then these columns will display those restrictions.

Adding a Node

The **Create Node** dialog allows you to add a new node. This node need not be associated with a flow; for example, you may add a node in anticipation of a future need to include it in a flow:

To add a node:

1. Click the **Add** button to open the **Create Node** dialog.
2. Enter the following information in the appropriate fields:
   - **Name:** Enter a unique name for the node (required).
   - **Description:** Enter a useful description for the node (optional).
   - **Switch port number:** Select a switch port from the pull-down menu, or enter the switch and port separated by a colon. This field auto-completes and will filter the choices from the pull-down menu as you enter a value (optional).
   - **Group:** Enter any desired labels or tags for the node (optional).
   - **IP address and Subnet Mask:** These values specify a range of IP addresses that traffic passing through this switch port must match in order to qualify for this node.

Note: Do not confuse node IP addresses and subnet masks with specifying an IP address and a mask for a computer or other device. This is different and happens to use the same field labels.

3. Click **OK** to save your changes.

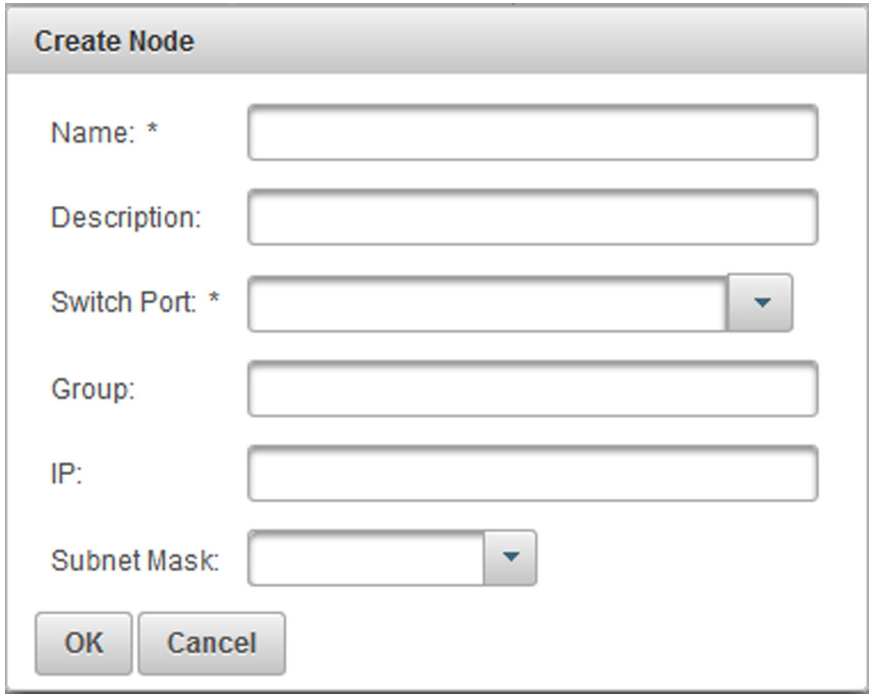


Figure 5.12: Create Node dialog

When specifying an IP address and subnet mask:

If you want to specify a single IP address, use 255.255.255.255 as the mask. If you want to specify a range of addresses, the IP address must refer to a network address; in this case, the mask refers to how many bits should be used for that network address. The **Subnet Mask** pull-down menu does not list discontinuous subnet masks because the controller does not support them.

Examples

- 192.168.1.0 / 255.255.255.0 specifies a range of 192.168.1.0 to 192.168.1.255
- 192.168.1.1 / 255.255.255.255 specifies the single host 192.168.1.1
- 192.168.1.1 / 255.255.255.0 is an error as 192.168.1.1 does not specify a network address
- 172.16.0.0 / 255.255.0.0 specifies a range of 172.16.0.0 to 172.16.255.255
- 172.16.0.0 / 255.255.254.0 specifies a range of 172.16.0.0 to 172.16.1.255

Editing a Node

1. Select a node by clicking its row in the table.
2. Click the **Edit** button to open the **Edit Node** dialog.
3. Make your desired changes.
4. Click **OK** to save your changes.

Note: The node name cannot be edited.

Copying a Node

To copy an existing node:

1. Select a node by clicking its row in the table.
2. Click the **Copy** button.
3. Click the **Paste** button to open the **Paste Node** dialog and paste all values that are not unique to a specific node.

Note: The node name is copied with "_copied" appended. For example, "Node_1" becomes "Node_1_copied." Change the IP address of the new node.

4. Click **OK** to save your changes.

Deleting a Node

You may delete a node that does not have a flow assigned to it. To delete a node:

1. Select a node by clicking its row in the table.
2. Click the **Delete** button to open a confirmation dialog.
3. Click **Yes** to complete the deletion.

Admin Page

The **Admin** page allows you to add, edit, and remove UBM users. This page lists each user authorized to log into UBM and access the REST API. UBM supports a single level of privileges, where all users have the same access to all of the NX500 Controller UBM and REST API functions.

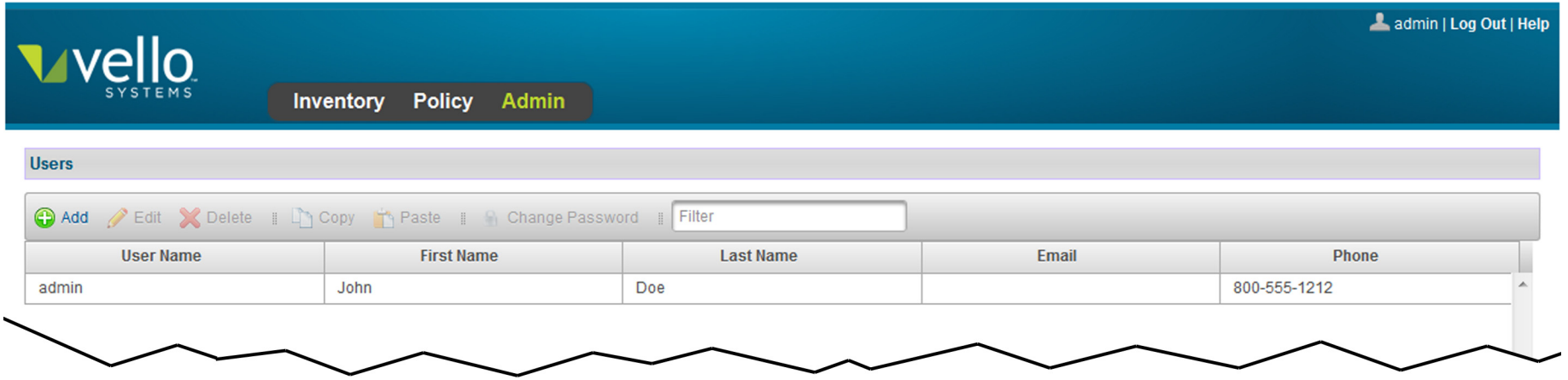
Note: The REST API uses the standard HTTPS Basic Authorization built into all browsers.

- The **Admin** page includes a toolbar that allows you to **Add**, **Edit**, **Delete**, **Copy**, **Paste**, and **Change Password** for each user. See *"Adding a User" on page 111*, *"Editing a User" on page 112*, *"Deleting a User" on page 113*, *"Copying a User" on page 112*, and *"Changing a User's Password" on page 113* for more on these functions.
- The **Filter** field in the toolbar is a free-text search filter that searches for matching strings across all table columns with each keystroke.
- The **Users** table lists all users in alphabetical order by user name.

The table beneath the toolbar contains the following columns:

- **User Name:** Login name for the listed user
- **First Name:** User's first name (optional; for information only)
- **Last Name:** User's last name (optional; for information only)
- **Email:** User's email address (optional; for information only)
- **Phone:** User's phone number (optional; for information only)

Figure 5.13: Admin page.



Adding a User

The **Add User** dialog allows you to add a new UBM user.

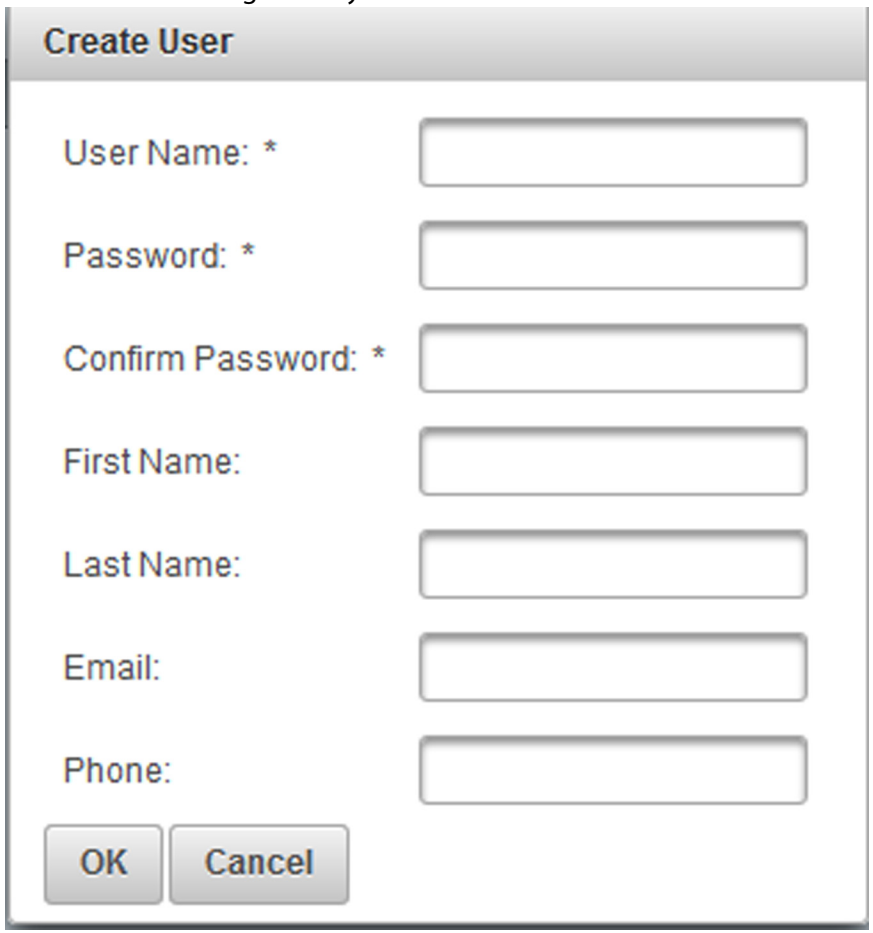


Figure 5.14: Create User dialog

To add a user:

1. Click the **Create User** button to open the **Add User** dialog.
2. Complete all of the fields in the dialog. Asterisks denote required fields; other fields are optional. Remember that:
   - Users can log into both UBM and the REST API; they are the same set of users.
   - All users have the same UBM and REST ASPI privileges on the NX500 Controller.
   - The REST API uses both Basic Authentication and HTTPS for authentication. The NX500 Controller uses only the user name and password; any additional user data you provide is optional and for your information only.
   - UBM verifies that the user's email address is properly formatted.
3. Click **OK** to add the user.

Editing a User

When editing a user, you cannot edit the username and password. You can, however, edit the user's first name, last name, email address, and/or phone number. The NX500 Controller only uses the username and password. Any additional user data you provide is optional and for your information only. See *"Changing a User's Password" on page 113* to change a user's password.

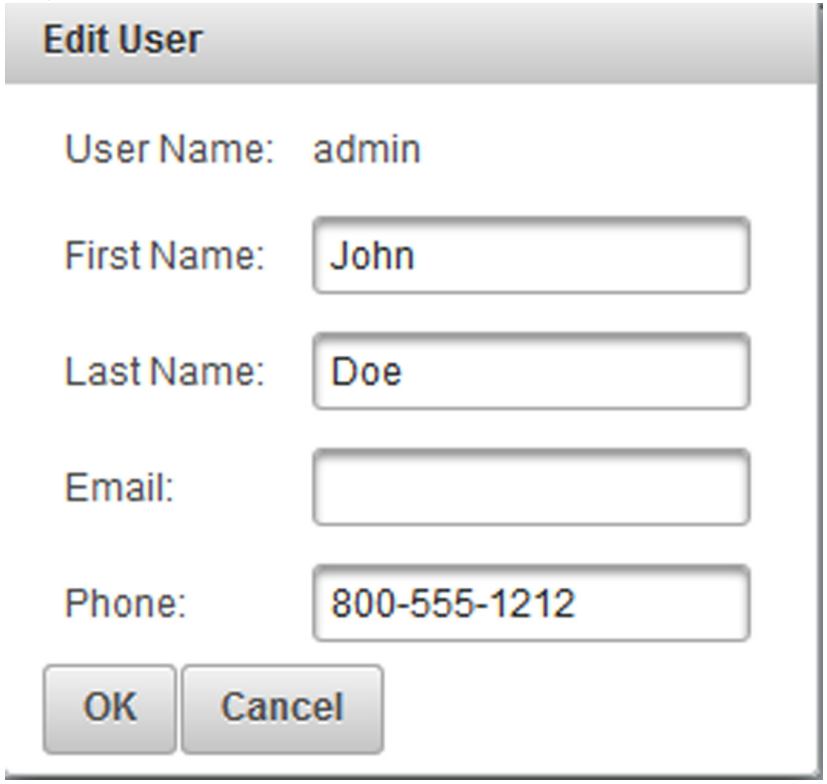


Figure 5.15: Edit User dialog

To edit a user:

1. Select a user by clicking her or his row in the table.
2. Click the **Edit** button to open the **Edit User** dialog.
3. Edit the user's information.
4. Click **OK** to save your changes.

Copying a User

To copy an existing user:

1. Select a user by clicking her or his row in the table.
2. Click the **Copy** button.
3. Click the **Paste** button to open the **Paste User** dialog and paste all values that are not unique to a specific user.

Note: The user name is copied with "_copied" appended. For example, "User_1" becomes "User_1_copied."

4. Click **OK** to save your changes.

Deleting a User

To delete a user:

1. Select a user by clicking her or his row in the table.
2. Click the **Delete** button to open the **Delete User** dialog.
3. Enter your own password (not the password of the user you are deleting) and then click **OK** to open a confirmation dialog.
4. Click **Yes** to complete the deletion.

Note: There must always be at least one UBM user. You cannot delete the last user from the list. You cannot delete the currently logged-in user.

Changing a User's Password

To change a user's password:

1. Select a user by clicking her or his row in the table.
2. Click the **Change Password** button to open the **Change Password** dialog.
3. Enter your password (not the password of the user you are changing). This step prevents someone else from changing the password or deleting a user when you are logged in.
4. Enter the new password for the selected user. You must enter the new password twice for confirmation.
5. Click **OK** to complete the change.

UBM Password Recovery

If you forget the passwords for all users, you can do a password recovery using the CLI to restore the "admin" user with the default password. See *"UBM Admin User Reset (Serial Console Connection)" on page 64*.

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6 - Troubleshooting

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Logging and Alarms

This section describes how to access the system logs generated by the NX500 Controller and the VX1048/VX3048 switches. It also shows you how to configure custom alarms using a remote system log host and monitoring application.

NX500 Controller Logs

The NX500 Controller uses the REST API as the primary feedback channel during normal operation. The UBM (see *"5 - Unified Bandwidth Manager" on page 89*) is built on top of the REST API and uses some of the most common functions, making this a good place to look for high-level operational information. Please see the *REST API Guide* for more information about the REST API.

In addition, the NX500 Controller also produces *syslogs* (system logs) that provide additional detail about events occurring before, during, and after error conditions, to aid in diagnostic and debugging efforts. The **Log** CLI command allows you to customize both the severity level of events added to the syslog and where that data gets saved (see *"Log" on page 58*). Other CLI commands provide various options for retrieving syslog data.

- To specify the severity level of events added to the syslog files, use the command `log <level>`.
- To enable local logging on the NX500 Controller, use the command `log local on`. You may use this with or without remote logging.
- To enable logging on a remote host, use the command `log remote <A.B.C.D>`, where `<A.B.C.D>` is the properly formatted IP address of the remote host. You may send syslogs to a single remote host at a time.

Note: The remote host must be configured to receive syslog messages via UDP on port 514 (the default syslog port). All NX500 Controller syslog messages target the local0 facility. Refer to your remote host documentation for instructions.

- To disable remote logging, use the command `log remote off`.

The **Send** CLI command allows you to retrieve a locally stored syslog or core (crash dump) file (see *"Send" on page 59*).

- To forward a local syslog from the NX500 Controller to a remote host for retrieval, use the command `send log scp <user> <A.B.C.D> <port>`, where:
  - `<user>` is a valid username on the remote host.
  - `<A.B.C.D>` is the properly formatted IP address of the remote host.
  - `<port>` is the appropriate port number on the remote host.

Note: If the selected username has a password associated with it, you will be prompted to enter that password before completing the send operation. A successful transfer deletes the local syslog from the NX500 Controller.

- To view all of the core (crash dump) files currently on the NX500 Controller, use the command `show cores` (see *"Show" on page 56*).

  A list of all core files currently on the NX500 Controller appears.
- To forward all core (crash dump) files from the NX500 Controller to a remote host for retrieval, use the command `send cores scp <user> <A.B.C.D> <port>`, where:
  - `<user>` is a valid username on the remote host.
  - `<A.B.C.D>` is the properly formatted IP address of the remote host.
  - `<port>` is the appropriate port number on the remote host.

Note: If the selected username has a password associated with it, you will be prompted to enter that password before completing the send operation. A successful transfer deletes the local core file(s) from the NX500 Controller

The following example sets the log severity level for an NX500 Controller named NX500 and specifies a remote syslog daemon for event forwarding.

```
nx500# log info
Logging severity levels set to info
nx500# log remote udp 10.1.2.50 3434
Remote logging enabled:
   ip: 10.1.2.50
   port: 3434
   type: udp
nx500#
```

The **Show system log** CLI command displays the system log on screen.

- To view the syslog file, use the command `show system log`.
- To view only the most recent 1 to 1,000 lines in the system log, use the command `show system log tail <1-1000>`.

This command can also display additional information about ports, IP addresses, and more (see *"Show" on page 56*).

VX1048 Logs

The VX1048 switch has extensive logging options (see *"VX1048 Logging Options" on page 72*). In addition, you may also use the **Ovs-ofctl** and **Show** commands as described below.

The **Ovs-ofctl** CLI command allows you to view various OpenFlow statistics (see <ref>). Other CLI commands provide various options for retrieving syslog data.

- To display the OpenFlow description, use the command `ovs-ofctl dump-desc br0`.
- To display OpenFlow flows and statistics, use the command ovs-`ofctl dump-flows br0`.
- To display OpenFlow statistics for the selected port, use the command `ovs-ofctl dump-ports br0 <port name>`, where <port name> is the selected port.
- To display OpenFlow tables attributes and statistics, use the command `ovs-ofctl dump-tables br0`.

The **Show logging buffer** command displays the system log on screen. To use this command:

`show logging buffer <1-1000>]:` Displays the most recent 20 lines of the log file by default. Adding a number between 1 and 1000 displays the specified number of lines from the log file.

This command can also display additional information about ports, IP addresses, and more (see *"Show" on page 66*).

VX3048 Logs

The VX3048 switch produces syslogs that provide additional detail about events occurring before, during, and after error conditions, to aid in diagnostic and debugging efforts. The **Log** CLI command allows you to customize both the severity level of events added to the syslog and where that data gets saved (see <ref>). Other CLI commands provide various options for retrieving syslog data.

- To specify the severity level of events added to the syslog files, use the command `log <level>`.
- To enable local logging on the VX1048/VX3048 switch, use the command `log local on`. You may use this with or without remote logging.
- To enable logging on a remote host, use the command `log remote <A.B.C.D>`, where `<A.B.C.D>` is the properly formatted IP address of the remote host. You may send syslogs to a single remote host at a time.

Note: The remote host must be configured to receive syslog messages via UDP on port 514 (the default syslog port). All VX3048 switch syslog messages target the local0 facility. Refer to your remote host documentation for instructions.

- To disable remote logging, use the command `log remote off`.

The **Ovs-ofctl** CLI command allows you to view various OpenFlow statistics (see <ref>). Other CLI commands provide various options for retrieving syslog data.

- To display the OpenFlow description, use the command `ovs-ofctl dump-desc`.
- To display OpenFlow flows and statistics, use the command ovs-`ofctl dump-flows`.
- To display OpenFlow statistics for the selected port, use the command `ovs-ofctl dump-ports <port name>`, where `<port name>` is the selected port.
- To display OpenFlow tables attributes and statistics, use the command `ovs-ofctl dump-tables`.

The **Send** CLI command allows you to retrieve a locally stored syslog or core (crash dump) file (see *"Send" on page 80*).

- To forward a local syslog from the VX3048 switch to a remote host for retrieval, use the command `send log scp <user> <A.B.C.D> <port>`, where:
  - `<user>` is a valid username on the remote host.
  - `<A.B.C.D>` is the properly formatted IP address of the remote host.
  - `<port>` is the appropriate port number on the remote host.

Note: If the selected username as a password associated with it, you will be prompted to enter that password before completing the send operation. A successful transfer deletes the local syslog from the VX1048/VX3048 switch.

- To view all of the core (crash dump) files currently on the VX3048 switch, use the command `show cores` (see *"Show" on page 76*).

  A list of all core files currently on the VX1048/VX3048 switch appears.

- To forward all core (crash dump) files from the VX1048/VX3048 switch to a remote host for retrieval, use the command `send cores scp <user> <A.B.C.D> <port>`, where:

  - `<user>` is a valid username on the remote host.
  - `<A.B.C.D>` is the properly formatted IP address of the remote host.

The **Show system log** CLI command displays the system log on screen.

- To view the syslog file, use the command `show system log`.
- To view only the most recent 1 to 1,000 lines in the system log, use the command `show system log tail <1-1000>`.

This command can also display additional information about ports, IP addresses, and more (see *"Show" on page 76*).

About Configuring Alarms

Alarms alert you to problems that could impact the network, to help ensure timely corrective actions that minimize or eliminate downtime. The system logs generated by the NX500 Controller and the VX1048/VX3048 switches can be passed to remote hosts with syslog daemons, as described in the preceding sections and in *"4 - Command Line Interface" on page 51*. From there, you can configure custom analytics, reports, and alarms using a third-party system log analysis application. This gives you total flexibility to set up exactly the kind of monitoring and alerts needed to meet your specific needs. Many commercial and open source applications are available. Some of the commercial system log analysis applications include:

- **Adiscon Log Analyzer:** http://loganalyzer.adiscon.com
- **ManageEngine:** http://www.manageengine.com
- **Splunk:** http://www.splunk.com
- **Sumo Logic:** http://www.sumologic.com/

Some of the open source system log analysis applications include:

- **LOGalyze:** www.logalyze.com
- **Sawmill:** www.sawmill.net

Note: The above applications are listed in alphabetical order. Vello cannot endorse or recommend any particular system log analysis application.

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Troubleshooting Network Connections

This section describes how to troubleshoot various network connection issues.

Console Connection Issues

The most common causes of a blank or garbled Console serial connection display are:

- Console port connected to the wrong COM port on the computer or terminal.
- Improper Console cable type used; the VX1048 switch requires a different Console cable than the NX500Controller and VX3048 switch (see *"RJ45 Cable Specifications" on page 31*)
- Improper serial port parameters specified
- RJ45 to DB9 cable not properly connected
- Damaged RJ45 to DB9 cable
- Terminal server issue (if you connec to the NX500 Controller or VX1048/VX3048 switch via a terminal server)

To correct this problem:

1. Verify that the RJ45 to DB9 cable is connected to the proper serial port on the computer or terminal.
2. Verify that the RJ45 to DB9 cable is properly connected at both ends.
3. Set the serial port parameters as follows:
   - **Baud rate:** 115200 (NX500/VX3048) or 9600 (VX1048)
   - **Data bits:** 8
   - **Stop bit:** 1
   - **Parity:** none
   - **Flow control:** none
4. Replace the RJ45 to DB89 cable and retry the connection.
5. Troubleshoot the terminal server and connection according to the manufacturer instructions.

Management Connection Issues

The most common causes of an inoperative Management connection to the NX500 Controller are:

- Management port not correctly configured on the NX500 Controller
- Firewall or other network policy prevents HTTPS connection
- Network congestion

To correct this problem:

1. Use the `show management ip address` command to see the IP address of the Management port.

2. Look for the **eth0** line on the screen and verify that it is displaying the correct IP address.
3. Verify that you can connect to that IP address.
   - If you can connect, then the problem should be resolved.
   - If you cannot connect, then proceed to Step 3.
4. Reconfigure the Management port on the NX500 Controller using one of the two following commands, as appropriate for your network:

- **management ip address <A.B.C.D> netmask <yyy.yyy.yyy.yyy>:** Sets the Management port IP address and net mask to a specified value, where:
  - `<A.B.C.D>` signifies a valid, properly formatted IP address (such as `192.168.1.1`).
  - `<yyy.yyy.yyy.yyy>` signifies a valid, properly formatted net mask. This value must be contiguous, with a prefix of ones followed by zeros.
- **management ip address dhcp:** Sets the Management port IP address and subnet mask to use DHCP (dynamic addressing).

  After reconfiguring:
  - If you can connect, then the problem should be resolved.
  - If you cannot connect, then proceed to Step 4.

Troubleshoot the management network to verify that:

- All ports, cables, and other network devices are functioning correctly.
- The management network has sufficient bandwidth available.
- The management network is properly configured.
- You have appropriate access privileges.

Device Not Responding (TCP)

Vello devices can communicate using either TCP or SSL. This procedure troubleshoots a TCP connection problem, where:

- the NX500 Controller is not reporting a previously configured Vello VX1048 or VX3048 switch, and/or
- a switch is not connecting to the NX500 Controller.

Note: Start here if you are not sure which connection type the NX500 Controller and switches use to communicate.

To troubleshoot a TCP connection:

1. Check whether the devices can ping each other:
   - From the NX500 Controller, ping the affected switch using the command `ping <A.B.C.D>`, where `<A.B.C.D>` is the IP address of the affected switch.
   - From the affected switch, ping the NX500 Controller using the command `ping <A.B.C.D>`, where`<A.B.C.D>` is the IP address of the NX500 Controller.

   If the ping succeeds, proceed to Step 2, else see *"Hardware Issues" on page 126*.
2. Check the control plane IP configuration:

- From the NX500 Controller, check the IP configuration of the Controlplane ports using the command `show control-plane ip address`.
- From the affected switch, check the Management IP configuration using the command `show management ip address`.

The IP addresses on both the NX500 Controller and the affected switch should match.

3. On the NX500 Controller, use the command `show control-plane mode` to determine whether switches should connect using TCP or SSL mode.
   - If TCP mode is used, then proceed to Step 4.
   - If SSL mode is used, then see *"Device Not Responding (SSL)" on page 122*.
4. Reconfigure the switch to connect to the NX500 Controller.
   - Use the command `show openflow controller status`.
   - Verify that the NX500 Controller mode is set to **`tcp`**.
   - Verify that the IP address is the same as when the NX500 Controller was configured.
5. If either the mode or the IP address is incorrect, then:
   - On the VX1048, enter Config mode (not required for the VX3048).
   - Use the command `openflow set controller tcp <A.B.C.D> <port>`, where `<A.B.C.D>` is the correct controller IP address, and `<port>` is 6633.
6. On the VX3048 switch, use the **Reboot** command, else skip to the next step.
7. Verify that the switch is connecting to the NX500 Controller and that the NX500 Controller is reporting the switch as active, by logging into UBM and opening the **All Switches** page (see *"All Switches List" on page 95*). The **Status** entry for the affected switch should read **ACTIVE**.
   - If this succeeds, then the problem is resolved.
   - If this fails, then see *"Hardware Issues" on page 126*.

Device Not Responding (SSL)

Vello devices can communicate using either TCP or SSL. This procedure troubleshoots an SSL connection problem where:

- the NX500 Controller is not reporting a previously configured Vello VX1048/VX3048 switch, and/or
- a switch is not connecting to the NX500 Controller.

Note: If you came to this section from Step 3 of the TCP procedure, then skip ahead to Step 4 of this procedure.

To troubleshoot an SSL connection:

1. Check whether the devices can ping each other:
   - From the NX500 Controller, ping the affected switch using the command `ping <A.B.C.D>`, where `<A.B.C.D>` is the IP address of the affected switch.

- From the affected switch, ping the NX500 Controller using the command `ping <A.B.C.D>`, where`<A.B.C.D>` is the IP address of the NX500 Controller.

If the ping succeeds, proceed to Step 2, else see *"Hardware Issues" on page 126*.

2. Check the control plane IP configuration:
   - From the NX500 Controller, check the IP configuration of the Controlplane ports using the command `show control-plane ip address`.
   - From the affected switch, check the Management IP configuration using the command `show management ip address`.

   The IP addresses on both the NX500 Controller and the affected switch should match.
3. On the NX500 Controller, use the command `show control-plane mode` to determine whether switches should connect using TCP or SSL mode.
   - If SSL mode is used, then proceed to Step 4.
   - If TCP mode is used, then see *"Device Not Responding (TCP)" on page 121*
4. Reconfigure the switch to connect to the NX500 Controller.
   - Use the command `show openflow controller status`.
   - Verify that the NX500 Controller mode is set to **`ssl`**.
   - Verify that the IP address is the same as when the NX500 Controller was configured.
5. If either the mode or the IP address is incorrect, then:
   - On the VX1048, enter Config mode (not required for the VX3048).
   - Use the command `openflow set controller ssl <A.B.C.D> <port>`, where `<A.B.C.D>` is the correct controller IP address, and `<port>` is 6633.
6. On the VX3048 switch, use the **Reboot** command, else skip to the next step.
7. Verify that the switch is connecting to the NX500 Controller and that the NX500 Controller is reporting the switch as active by logging into UBM and opening the **All Switches** page (see *"All Switches List" on page 95*). The **Status** entry for the affected switch should read **ACTIVE**.
   - If this succeeds, then the problem is resolved.
   - If this fails, then proceed to Step 8.
8. From both the NX500 Controller and the affected switch, run the command `tlsshow` to verify that certificates are installed on both devices.
   - If the certificates are missing or mismatched, then proceed to Step 9.
   - If matching certificates are installed on both devices, then skip to Step 10.
9. Reinstall the SSL certificates and keys using the following commands:

- `tlsconfig-ca` to upload a public certificate (see *"Using Keys and Certificates" on page 86*). This is the CA certificate used to validate peer certificates.
- `tlsconfig-cert` to set the TLS public certificate (see *"Using Keys and Certificates" on page 86*). This is the certificate each device presents to its peers.
- `tlsconfig-key` to set the TLS private key (see *"Using Keys and Certificates" on page 86*). This is the key used by the device to encrypt connections to peers.

10. Use the command `show clock` on both the NX500 Controller and the affected switch. Each of the installed certificates shown by the command `tlsshow` has a valid date and time range. The date/time set in the device must be within the upper and lower date/time range for all of the certificates, in order for all of the certificates to be valid. For example, assume that:
    - Certificate A has a valid range from 2010 - 2015.
    - Certificate B has a valid range from 2012 - 2020.

    In this example, the date/time settings on all devices must range from 2012 to 2015. Devices with clock settings that are before 2012 and/or after 2015 will treat one or other certificate as invalid, thus rendering the SSL connection inoperable.
    - If the time is synchronized within the certificate limits (as described in) across all devices, then see *"Hardware Issues" on page 126*.
    - If the time is more than the certificate limit out of synch across all devices, then synchronize the time using the command `clock set datetime` (see *"4 - Command Line Interface" on page 51*).
11. Verify that the switch is connecting to the NX500 Controller and that the NX500 Controller is reporting the switch as active by logging into UBM and opening the **All Switches** page (see *"All Switches List" on page 95*). The **Status** entry for the affected switch should read **ACTIVE**.
    - If this succeeds, then the problem is resolved.
    - If this fails, then see *"Hardware Issues" on page 126*.

Periodic Disconnection

If devices are periodically dropping off and then reconnecting, check all affected devices for IP conflicts (such as two or more devices configured to use the same IP address). If this fails to resolve the problem, then see *"Hardware Issues" on page 126*.

Policy Issues

If the devices are connected but your policies, nodes, and/or flows are not working correctly, then verify the following:

- Node configuration (switch, port, IP address, net mask):
  - If the nodes are properly configured, then check for overlapping policies. For example, a policy configured for 10.1.1.1 with a 32-bit net mask conflicts with a policy configured for 10.0.0.0 with an 8-bit net mask.
  - If any nodes and/or flows are not working correctly, verify that the node correctly defined (switch, port, IP address, mask.)
- Sufficient bandwidth is available to meet policy needs. Setting bandwidth for a policy reserves that amount of bandwidth. For

example, a policy configured to use up to 9GbE on a 10GbE port will reserve those 9GbE; a second policy set to use more than 1GbE on the same port will fail.

- Physical network topology allows the connection. SDNs define bandwidth and routing; however, they remain subject to the physical connections between devices on the network and between networks themselves. A policy set up to run on a network lacking the correct underlying topology will fail.
- Other policy issues may exist, such as:
- Specifying too few hops. For example, if the shortest physical route between two nodes requires 4 hops but your policy specifies a maximum of 3 hops, then the policy will fail.

Note: You may also use the flow-status REST API method to view detailed flow status information that will assist you in troubleshooting these issues. See the REST API Guide.

Additional VX1048 Commands

The Vello VX1048 switch has some additional commands that you can use to troubleshoot connection issues.

Note: These commands are not available on the NX500 Controller and VX3048 switch.

Debug

On the VX1048 switch, you may use the **Debug** CLI command to display OpeFlow messages between the VX1048 switch and the NX500 Controller:

```
debug openflow all
```

Show

The VX1048 switch includes some additional features in the **Show** CLI command that are not available on the NX500 Controller or the VX3048 switch (see *"Show" on page 76*).

Hardware Issues

If a Vello device is unable to connect and all of the previous configuration diagnostics have failed, then there may be a hardware problem. Some of the items you need to check include:

Network Connectivity

Port activity: Check the Port Status LEDs of all affected ports (including any connections between the affected devices, such as other hubs/switches), as follows:

- All Vello RJ45 ports have a Link/Activity LED (see *"RJ45 Ethernet Port Status LEDs" on page 39*). This light should be lit green to indicate a valid connection, and flashing green to indicate traffic flowing through that port. If the Link/Activity LED is not lit, then the port is not connected.
- All 10GbE SFP+ ports (VX1048 and VX3048 switches) have a Link/Activity LED (see *"10GbE SFP+ Port LEDs" on page 40*).
- 40GbE QSFP+ ports (VX3048 switch) have a single green LED. This LED should be lit green to indicate a valid connection and flashing green to indicate traffic flowing through that port. If the Link/Activity LED is not lit, then the port is not connected (see *"40GbE QSFP+ Port LEDs" on page 40*).

If the Port Status LEDs indicate a problem, then check the following:

- Both the NX500 Controller and VX1048/VX3048 switch are powered on.
- All network cables are securely plugged in at both ends.
- All network cables are proper type and length (see *"Step 4: Connecting Network Wiring" on page 30*).
- All network cables and any transceivers are functioning normally.

System Status LEDs

The Vello VX1048 and VX3048 switches include System Status LED, which should be illuminated as follows:

- **VX1048:** Flashing green once every 2 seconds.
- **VX3048:** Solid green.

If a problem exists, the System Status LEDs will indicate the following:

- **VX1048:** The VX1048 switch has several fault indications:
  - **Rapid green flashes (2x/second):** CPU problem.
  - **Solid green:** Other hardware problem.
  - **Slow amber flash (once every 2 seconds):** Switch is initializing. Wait to see if the LED turns green and begins flashing every 2 seconds., then monitor to see if this problem is recurring.
  - **Fast amber flash (2x/second):** Switch is resetting. Wait to see if the LED turns green and begins flashing every 2 seconds, then monitor to see if this problem is recurring.
  - **Solid amber:** Other hardware problem.

- **VX3048:** Amber LED signifies a hardware problem.

If the System Status LEDs indicate a problem that does not self-correct within a few minutes, contact Vello Technical Support. See *"Support" on page 140*.

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Power Supply Troubleshooting & Replacement

This section describes how to troubleshoot and replace the hot-swappable power supplies in the Vello NX500 Controller and the VX1048 and VX3048 switches.

Note: These procedures depict removal and replacement of 120VAC power supplies. The procedures are identical for both 240VAC and DC power supplies.

CAUTION: NEVER ATTEMPT TO REPAIR A DEFECTIVE POWER SUPPLY. THERE ARE NO USER-SERVICEABLE PARTS INSIDE A POWER SUPPLY.

Troubleshooting Power Supplies

Both the NX500 Controller and VX1048/VX3048 switches have LEDs to indicate the status of the power supplies. See *"Power Supply LEDs" on page 39* for diagrams that illustrate the Power LED locations and detailed information about the information provided by the Power LEDs. In general:

- If a Power LED is green, the associated power supply is functioning normally.
- If a Power LED is amber, the power supply has a fault. Attempt to power-cycle the device. If that procedure does not work, replace the affected power supply.
- If a Power LED is off, the power supply is not powered on. Try the following:
  - Verify that the power cord is securely connected to the power supply.
  - Verify that the other end of the power cord is securely connected to a functioning power source.
  - Verify that the power supply is fully and properly seated in the device.
  - Replace the power cord.
  - Replace the power supply as described in the following device-specific section if none of the above troubleshooting steps resolve the problem.

NX500 Power Supply Replacement

To replace a power supply on an NX500 Controller:

1. Disconnect the power cord from the power supply you are going to change.
2. Locate the thumb tab on the power supply to be replaced.

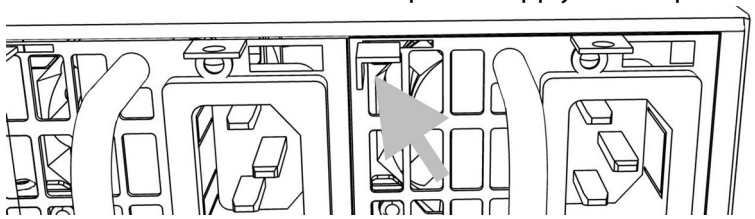

Figure 6.1: Replace NX500 power supply (1 of 3)

3. Press the thumb tab to the right to disengage the power supply from the NX500 Controller.

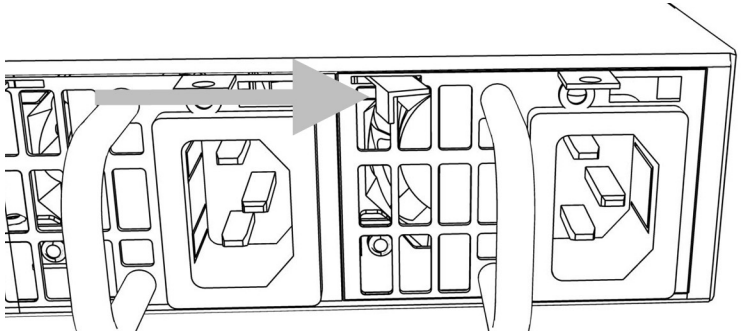

Figure 6.2: Replace NX500 power supply (2 of 3)

4. Grasp the handle and pull the power supply directly out of the NX500 Controller chassis.

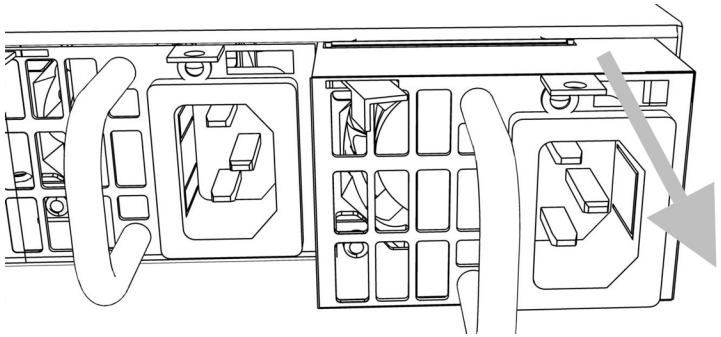

Figure 6.3: Replace NX500 power supply (3 of 3)

5. Slide the replacement power supply into the NX500 Controller chassis until it clicks into place.
6. Connect the power cord and verify that the Power LED lights green.

VX1048 Power Supply Replacement

To replace a power supply on an VX1048 switch:

1. Disconnect the power cord from the power supply you are going to change.
2. Remove the two screws securing the power supply to the VX1048 chassis.

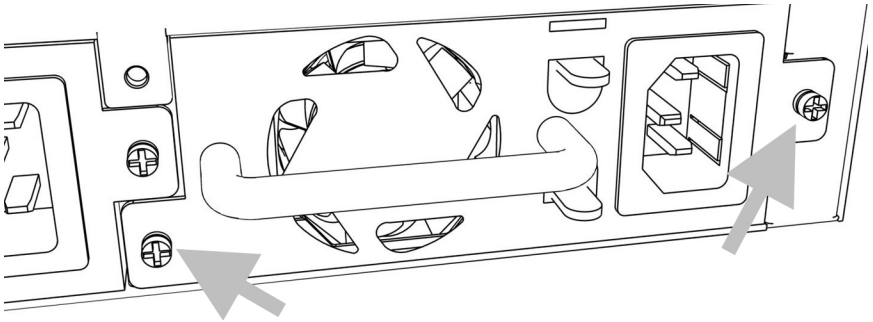

Figure 6.4: Replace VX1048 power supply (1 of 2)

3. Grasp the handle and slide the power supply straight out of the VX1048 chassis.

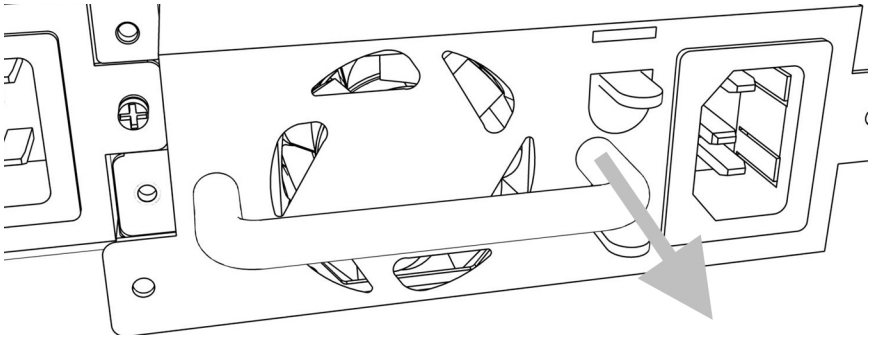

Figure 6.5: Replace VX1048 power supply (2 of 2)

4. Slide the replacement power supply into the VX1048 switch chassis until it is firmly in place.
5. Secure the power supply to the VX1048 chassis using the two screws you removed in Step 2.
6. Connect the power cord and verify that the Power LED lights green.

VX3048 Power Supply Replacement

To replace a power supply on a VX3048 switch:

1. Disconnect the power cord from the power supply you are going to change.
2. Locate the thumb tab on the power supply you are going to replace.

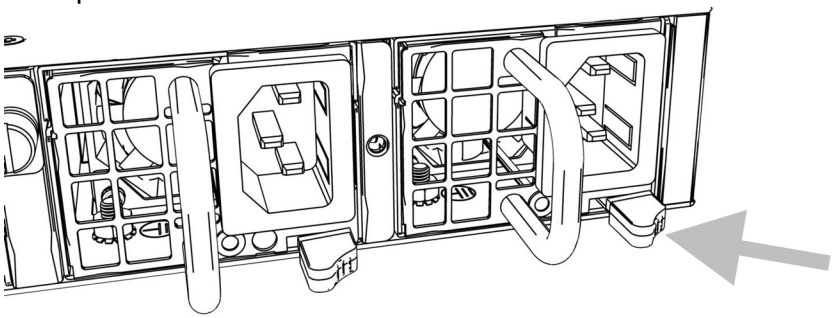

Figure 6.6: Replace VX3048 power supply (1 of 2)

3. Press the thumb tab to the left to disengage the power supply from the VX3048 switch.
4. Grasp the handle and pull the power supply directly out of the VX3048 switch chassis.

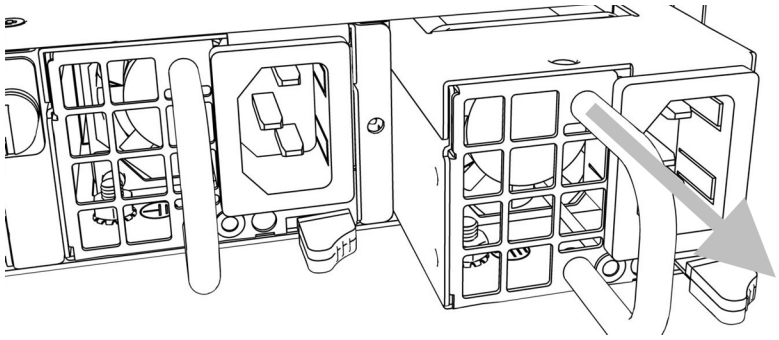

Figure 6.7: Replace VX3048 power supply (2 of 2)

5. Slide the replacement power supply into the VX3048 switch chassis until it clicks into place.
6. Connect the power cord and verify that the Power LED lights green.

Fan Troubleshooting & Replacement

This section describes how to troubleshoot and replace the fans in the Vello NX500 Controller and the VX1048 and VX3048 switches.

Troubleshooting Fans

Both the VX1048 and VX3048 switches have Fan Status LEDs to indicate the status of the fan trays. See *"Fan Status LED Indicators" on page 41* for diagrams that illustrate the Fan Status LED locations and detailed information about the information provided by the Fan Status LEDs.

Note: The NX500 Controller does not have a hot-swappable fan tray. Visually check fan status on a regular basis and replace individual fans as needed.

In general:

- If a Fan Status LED is green, the fans and fan tray are functioning normally.
- If a Fan Status LED is amber, the fans and/or fan tray are faulty. Try the following:
  - Check the fans for blockages and/or excessive contamination. Remove any dirt or obstructions and replace the fan tray.
  - Verify that the fan cable is securely connected to the proper socket (NX500 Controller).
  - Verify that the fan tray is securely seated in the device (VX1048/VX3048).
  - Replace the fan or fan tray if none of the above steps resolve the problem.
- If a Fan Status LED is off, the fans are either not running or not installed.

Fans do not rotate while a device is starting up, or when the internal temperature is below 50° C. Fan speed will also vary depending on the internal temperature. This is normal.

NX500 Fans

The NX500 Controller fans are not hot-swappable. Replacing a fan on the NX500 Controller requires shutting down the device and removing it from the rack. The network should continue to function while you are performing this procedure; however, you should plan your work so as to have the NX500 Controller back up and running as soon as possible.

CAUTION: NEVER ATTEMPT TO REPLACE A FAN ON THE NX500 CONTROLLER WHEN THE DEVICE IS OPERATING.

To replace a fan on the NX500 Controller:

1. Wear a properly connected ESD wristband.
2. Shut down the NX500 Controller and then remove it from the rack.

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3. Remove the three screws from the rear of the top chassis panel, as shown below.

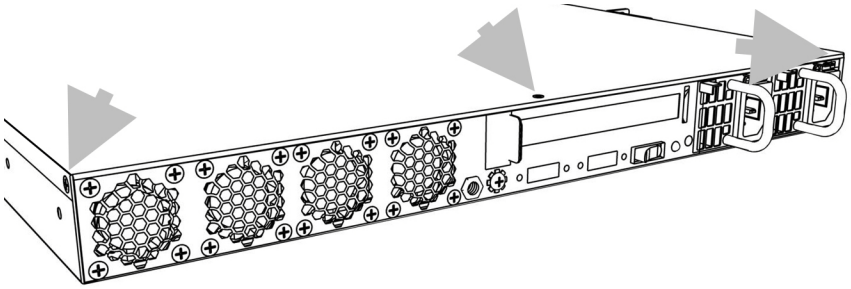

Figure 6.8: Replace NX500 fan (1 of 3)

4. Lift the top chassis panel up and away from the NX500 Controller and set it aside.
5. Remove the four screws securing the fan you are changing.

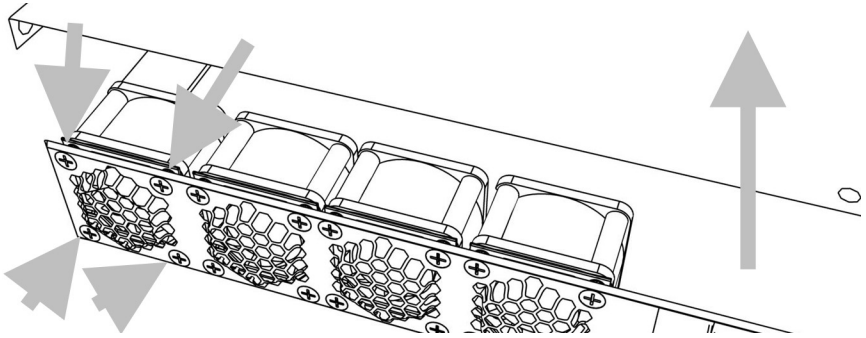

Figure 6.9: Replace NX500 fan (2 of 3)

6. Move the fan away from the opening and then disconnect it from the circuit board inside the NX500 Controller.

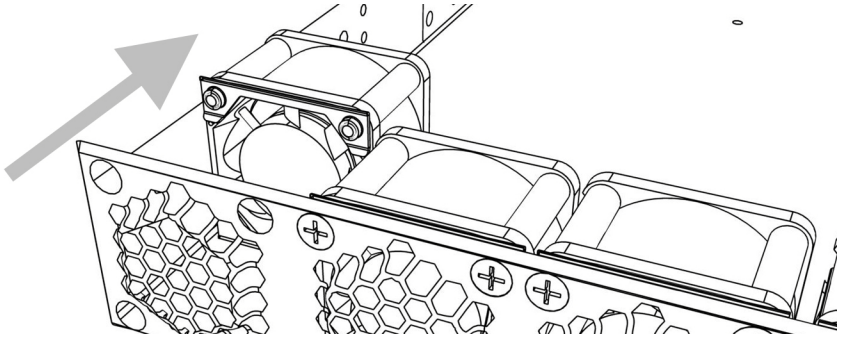

Figure 6.10: Replace NX500 fan (3 of 3)

7. Place the new fan into position inside the NX500 Controller and secure it in place using the screws you removed in Step 5.
8. Connect the fan to the motherboard.
9. Take a moment to verify that the other fans are working properly and remove any excess dust or other contaminants from those fans with compressed air.
10. Replace the top chassis panel and fasten it into place using the three screws you removed in Step 3.
11. Replace the NX500 Controller in the rack and power it on. Verify that all fans are running normally.
12. Reconnect all network cables in the appropriate ports.
13. Log into UBM (see *"Launching and Logging In" on page 93*) to verify that the network is running properly.

VX1048 Fan Tray

The VX1048 switch includes a hot-swappable fan tray. To change the fan tray on a VX1048 switch:

1. Remove the two screws securing the fan tray to the VX1048 switch.

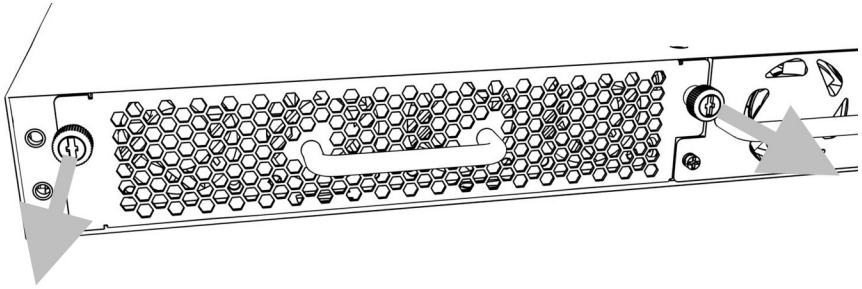

Figure 6.11: Replace VX1048 fan tray (1 of 2)

2. Grasp the handle and pull the fan tray straight out of the VX1048 chassis.

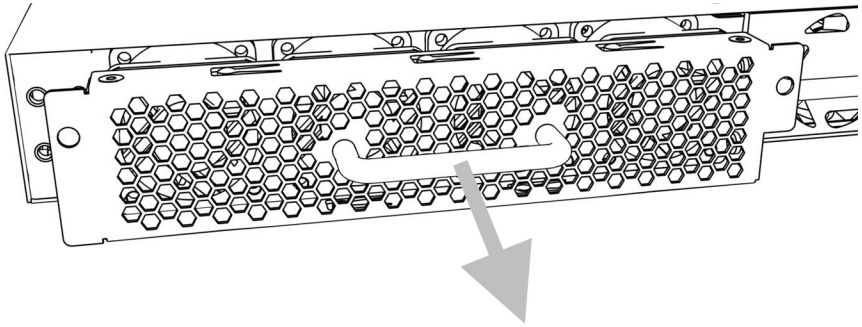

Figure 6.12: Replace VX1048 fan tray (2 of 2)

3. Insert the replacement fan tray in the VX1048 chassis and slide it straight back into position.
4. Replace the two screws that you removed in Step 1.

VX3048 Fan Tray

The VX3048 switch includes a hot-swappable fan tray. To change the fan tray on a VX3048 switch:

1. Remove the two screws securing the fan tray to the VX3048 switch.

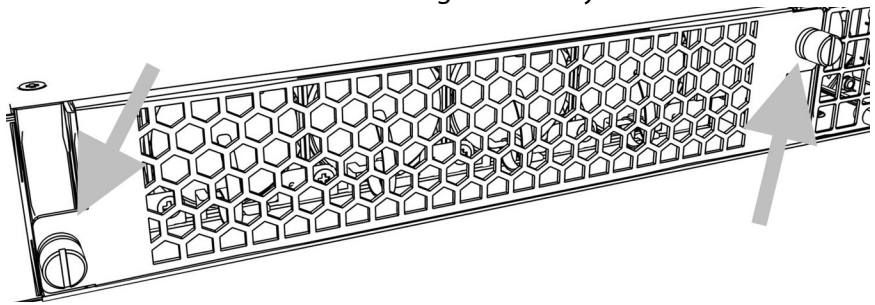

Figure 6.13: Replace VX3048 fan tray (1 of 2)

2. Grasp the handle and pull the fan tray out of the VX3048 chassis.

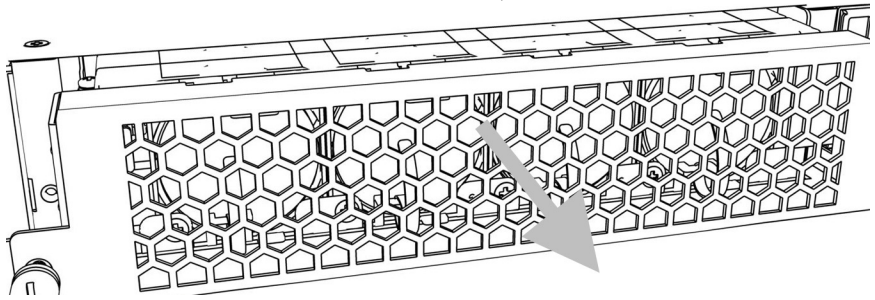

Figure 6.14: Replace VX3048 fan tray (2 of 2)

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3. Insert the replacement fan tray in the VX3048 chassis and slide it straight back into position.
4. Replace the two screws that you removed in Step 1.

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7 - Appendices

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Compliance and Safety Statements

This section contains mandatory regulatory and safety information.

Electromagnetic Compatibility

The Vello NX500 Controller, VX1048 switch, and VX3048 switch meet the following electromagnetic compatibility requirements:

FCC Class A

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void your authority to operate the equipment.

You may use unshielded twisted-pair (UTP) for RJ-45 connections - Category 3 or better for 10 Mbps connections, Category 5 or better for 100 Mbps connections, Category 5, 5e, or 6 for 1000 Mbps connections. For fiber optic connections, you may use 50/125 or 62.5/125 micron multimode fiber or 9/125 micron single-mode fiber.

CE Mark

CE Mark Declaration of Conformance for EMI and Safety (EEC)

This information technology equipment complies with the requirements of the Council Directive 2004/108/EC on the Approximation of the laws of the Member States relating to Electromagnetic Compatibility and 2006/95/EC for electrical equipment used within certain voltage limits and the Amendment Directive 93/68/ EEC.

- **RFI Emission:** Limit according to EN 55022:2010, Class A
- **Immunity:** Product family standard according to EN 55024:2010

Fiber Optic Port Safety Compliance Warning

When using a fiber optic port, never look at the transmit laser while it is powered on. Also, never look directly at the fiber TX port and fiber cable ends when they are powered on.

Equipment Modifications

Unauthorized modifications to the Vello Systems equipment may require additional compliance verification testing to ensure the modified product continues to comply with applicable regulations. Any person or organization performing unauthorized modifications to this product assumes the responsibility and liability for insuring the modified product conforms to the applicable regulations and legal requirements.

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Limited Warranty

The Vello NX500 Controller, VX1048 switch, and VX3048 switch (the "Product") are covered under a one-year product warranty from the date of purchase, subject to the following Warranty Information. This protects the Buyer from any defects or problems the product may have that are solely the fault of VELLO SYSTEMS, INC. Incorrect installation or misuse will void this warranty. Upon the return of a defective Product, VELLO SYSTEMS, INC. will, at its option, either repair or replace the Product.

Warranty Information

1. VELLO SYSTEMS, INC. warrants to the Buyer that the Product will be free from defects in material and workmanship and will perform in full accordance with applicable specifications when shipped. The limit of liability under this warranty is, at VELLO SYSTEMS, INC'S option, to repair or replace any product or part thereof that shall, within ONE YEAR of purchase as determined by examination by VELLO SYSTEMS, INC., prove defective in material or workmanship.
2. Warranty returns must first be authorized in writing by VELLO SYSTEMS, INC. Prior to any return of Products by Buyer to VELLO SYSTEMS, INC., Buyer shall first (A) provide to VELLO SYSTEMS, INC. the serial number, Product code, model number, or part number (as applicable), number of original Purchase Order, and detailed reason for Product return, and (B) request a return material authorization ("RMA") from VELLO SYSTEMS, INC. Upon receipt of the information listed in (A) of the preceding sentence from Buyer and determination by VELLO SYSTEMS, INC., at VELLO SYSTEMS, INC.'s sole discretion, that the conditions of this paragraph are fulfilled, VELLO SYSTEMS, INC. will issue an RMA. VELLO SYSTEMS, INC. shall not be obligated to accept returns unless VELLO SYSTEMS, INC. has issued an RMA.
3. Disassembly of any VELLO SYSTEMS, INC. Product by anyone other than an authorized representative of VELLO SYSTEMS, INC. voids this warranty in its entirety, with the sole exception of components replaced in accordance with the directions contained in this User Guide.
4. VELLO SYSTEMS, INC. reserves the right to make changes in any of its products without incurring any obligation to make the same changes on previously delivered products.
5. As a condition of the warranties provided for herein, the Buyer will prepay the shipping charges for any Product returned to VELLO SYSTEMS, INC. for repair and VELLO SYSTEMS, INC. will pay the return shipping with the exception of Product returned from outside the United States, in which case the Buyer will pay all shipping charges.
6. The Buyer will pay the cost of inspecting and testing any Product returned under the warranty or otherwise that is found to meet the applicable specifications or that is not defective or not covered by this warranty.

7. Products sold by VELLO SYSTEMS, INC. shall not be considered defective or non-conforming to the Buyer's order if they satisfactorily fulfill the performance requirements that were published in the product specification literature, or in accordance with samples provided by VELLO SYSTEMS, INC. This warranty shall not apply to any Products or parts thereof that have been subject to accident, fire, lightning, negligence, alteration, abuse, misuse, improper installation and/or testing, unauthorized repair attempts, or other hazard. VELLO SYSTEMS, INC. makes no warranty whatsoever in respect to accessories or parts not supplied by it.
8. VELLO SYSTEMS, INC. does not warrant the accuracy or completeness of the information, text, graphics, links, or other items transmitted by the Product.
9. Limitations of Warranty, Damages and Liability: EXCEPT AS EXPRESSLY SET FORTH HEREIN, THERE ARE NO WARRANTIES, CONDITIONS, GUARANTEES OR REPRESENTATIONS AS TO MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OTHER WARRANTIES, CONDITIONS, GUARANTEES OR REPRESENTATIONS, WHETHER EXPRESSED OR IMPLIED, IN LAW OR IN FACT, ORAL OR IN WRITING. VELLO SYSTEMS, INC'S AGGREGATE LIABILITY IN DAMAGES OR OTHERWISE SHALL NOT EXCEED THE PAYMENT, IF ANY, RECEIVED BY VELLO SYSTEMS, INC. FOR THE UNIT OF PRODUCT OR SERVICE FURNISHED OR TO BE FURNISHED, AS THE CASE MAY BE, THAT IS THE SUBJECT OF CLAIM OR DISPUTE. IN NO EVENT SHALL VELLO SYSTEMS, INC. BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES, HOWSOEVER CAUSED.
10. All matters regarding this warranty shall be interpreted in accordance with the laws of the State of California, and any controversy that cannot be settled directly shall be settled by arbitration in California in accordance with the rules then prevailing of the American Arbitration Association, and judgment upon the award rendered may be entered in any court having jurisdiction thereof.
11. If one or more provisions provided herein are held to be invalid or unenforceable under applicable law, then such provision shall be ineffective and excluded to the extent of such invalidity or unenforceability without affecting in any way the remaining provisions herein.
12. VELLO SYSTEMS, INC. reserves the right to bill for labor spent on a Product where no defect is found.
13. All Products that are out of warranty are subject to a repair fee and additional freight charges.
14. Defective Products in warranty will be repaired at no additional charge and will be returned with freight paid by VELLO SYSTEMS, INC.

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Support

This section describes how to obtain technical support, return a Vello device, and contact Vello Customer Support. It also includes a brief description of value-added services from Vello Systems, Inc.

Technical Support

Twenty-four hour emergency service from experienced and qualified professionals is available on a callback basis within 60 minutes. To contact Vello at any time (24 x 7 x 365), call your nearest Technical Support number:

- **USA:** +1 (866) 694-4437
- **Canada/Caribbean:** +1 (866) 878-5211
- **Germany:** (+49) 0800 180 2581

Remote support via analog modem or secure Internet tunnel is available when needed, to provide remote diagnosis and troubleshooting. On-site support is also available (additional charge may apply).

RMA Policy

You must obtain an RMA (Return Merchandise Authorization) number before returning a product to Vello for any reasons. Contact Vello Customer Service and provide the following information:

- Your name
- Company name and full address
- Your phone number
- Your email address
- Vello Systems product and part number
- Brief description of the problem you are experiencing

A Customer Service Engineer will assist you with the RMA process.

Customer Service

When your growth expectations require a tailored solution, Vello is ready to help you gather needed information, produce, and model the network design, generate a set of systems recommendations, and prepare a tailored deployment proposal. Contact us to discuss your specific needs with one of our global technical specialists. Vello Customer Service is available between 8 a.m. and 8 p.m. EST.

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1530 O'Brien DR
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USA

Vello also has regional sales and support offices around the world to provide professional services in system design and commissioning, field trials, and ongoing customer support. Please contact Vello Systems, Inc. at the following addresses/phone numbers:

United Kingdom
66 Chiltern STT
London W1U 4JT
T. +44 (0) 7885725192

Germany
Forstring 96
63225 Langen
T. +49 6103 5095225

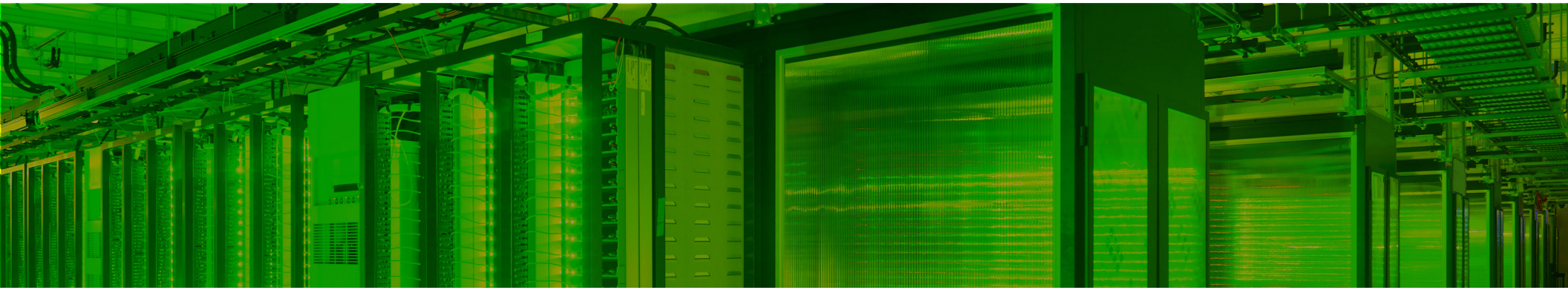
Network and System Planning

Vello is pleased to offer the following additional value-added services:

- **Network evaluation:** Upgrade/engineering consultation and recommendations
- **Network design:** Consultation and detail engineering designs, including proposed network architectures and equipment selection
- **Supporting documentation:** Comprehensive electronic documents and drawings
- **Installation and commissioning:**
  - Site survey
  - On-site commissioning and testing
  - On-site post-installation training
  - Operator manuals
  - Project management is also available

Monitoring Service

The Vello Monitoring Service provides 24×7 active monitoring for your Vello network. This service forwards status information from each of the active Vello components on your network to the Vello Network Operations Center (NOC) via secure connection for analysis. A ticket is opened in the Vello incident tracking system for any alerts that indicate a condition or issue that should be addressed. If action is required, Vello TAC staff will troubleshoot and resolve the issue while communicating with you as needed. The Vello Monitoring Service accelerates issue resolution and eliminates the need for in-house engineering resources responsible for actively managing the Vello network.



NX500, VX1048, VX3048 User Guide, v1.00 (06/2013)

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Website: www.vellosystems.com