Managing Network Virtualization and Network Resources in Oracle® Solaris 11.3

Part No: E54790
April 2018

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Contents

Using This Documentation

- **Overview** – Describes how to configure the Oracle Solaris virtual networking features and monitor network traffic. It also describes the different processes that are used to manage network resources.
- **Audience** – System administrators.
- **Required knowledge** – Basic and some advanced network administration skills.

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♦ ♦ ♦ C H A P T E R 1

Introduction to Network Virtualization and Network Resource Management

This chapter provides an overview of network virtualization and network resource management in Oracle Solaris.

You might need to perform basic network configuration before you perform the configurations described in this book. For information about basic network configuration, see *Configuring and Managing Network Components in Oracle Solaris 11.3*.

For a summary of network configuration features in Oracle Solaris and network virtualization use cases, see *Strategies for Network Administration in Oracle Solaris 11.3*.

For information about datalink administration, see *Managing Network Datalinks in Oracle Solaris 11.3*.

For a quick reference to commonly used network administration commands, see *Oracle Solaris 11.3 Network Administration Cheatsheet*.

This chapter contains the following topics:

- "What's New in Managing Network Virtualization and Network Resources in Oracle Solaris 11.3" on page 13
- "Overview of Network Virtualization" on page 15
- "Overview of Network Resource Management" on page 23

What's New in Managing Network Virtualization and Network Resources in Oracle Solaris 11.3

For existing customers, this section highlights the key changes in this release.

- **Single Root I/O Virtualization (SR-IOV) support for Oracle Solaris Kernel Zones** – Kernel zones can now use the SR-IOV virtual function (VF) of a NIC, which provides better networking performance. When you create or modify the kernel zone with the SR-IOV VF, you can specify the `iov` property for the `anet` resource by using the `zonecfg` command. For more information, see "Configuring Oracle Solaris Kernel Zones With SR-IOV VFs" on page 66.

- **Using large receive offload for datalinks** – The large receive offload (LRO) feature enables the merging of successive incoming TCP packets into a single packet before the packets are delivered to the IP layer. The incoming TCP packets must share the same source IP address and port number, destination IP address and port number and the protocol in use. You can use the `lro` property with the `dladm` and `zonecfg` commands to enable the LRO feature on datalinks. For more information, see "Using the Large Receive Offload Feature in Oracle Solaris" on page 215.
- **Support for Hardware Service-Level Agreements (SLAs) for VNICs** – In certain situations, you can use the new resource management capability, bandwidth shares, on Oracle Solaris Kernel Zones running on a system that is using a NIC that supports SR-IOV PCIe virtual functions (VFs), for example, Intel's Fortville NIC. If a NIC supports hardware SLAs that enable you to set SLA properties for VF VNICs, the SLA implementation is offloaded to the NIC automatically by the system. This behavior helps you to save CPU cycles. The capability is administered through the `dladm` command. For more information, see "Setting Hardware SLA Properties for VF VNICs" on page 70.
- **Elastic Virtual Switch (EVS) enhancements** – EVS now supports multiple uplink ports per compute node, allocation pools by using the `pool` property, and the ability to explicitly set link protection per port. For more information, see "Setting Properties for an EVS Controller" on page 146, "Adding an IPnet to an Elastic Virtual Switch" on page 161, and Table 4, "VPort Properties," on page 125.
- **Flat EVS Network** – You can create a flat L2-type EVS and place all the VM instances on the same segment without a virtual local area network (VLAN) or virtual extensible local area network (VXLAN) so that the VM instances share the same network and therefore the same IP address space as a compute server. For more information, see "Flat EVS Networks" on page 126.
- **Paravirtualized IP over InfiniBand (IPoIB) datalinks support in Kernel Zones** – InfiniBand support is now available for Oracle Solaris Kernel Zones including improved observability and paravirtualized support for the IPoIB protocol. The paravirtualized IPoIB datalink is created as an `anet` resource in the Oracle Solaris Kernel Zone, which you can configure by using the `zonecfg` command. For more information, see "Creating and Viewing Paravirtualized IPoIB Datalinks in Kernel Zones" on page 77.
- **Packet drops accounting and reporting for datalinks** – The `dlstat show-phys` command now displays the input and output packet drops per physical datalink and the number of bytes for each drops. For more information, see "Displaying Network Traffic Statistics of Network Devices" on page 235.
- **Private VLAN (PVLAN) VNIC** – Enables you to configure private VLAN (PVLAN) VNICs that are used to divide a VLAN into sub-VLANs. These sub-VLANs isolate network traffic to provide better usage of the limited number of available VLANs. For more

information, see "How to Configure VNICs as PVLANs" on page 34 and "Modifying PVLAN VNICs" on page 56.

- **Configuring an IPoIB VNIC by using the `dladm` command** – Oracle Solaris 11.3 provides unified administration model between IPoIB partitions and Ethernet VNICs. You can now use the `dladm` command to create IPoIB VNICs that conform to the Ethernet VNIC model and leverage the features offered by the VNICs. In addition, you can use the `dladm delete-vnic` and `dladm show-vnic` commands to delete an IPoIB VNIC and view information about it. For more information, see "Configuring IPoIB VNICs" on page 35.

Overview of Network Virtualization

Virtualization enables multiple virtual machines to run simultaneously on a single physical machine. Virtualization technologies provide isolation between multiple virtual machines, enabling multiple instances of an operating system to run on a single machine. Network virtualization takes server virtualization to the next level - the ability to virtualize entire network topologies of servers, routers, switches, and firewalls all running on a single platform and requiring no additional investment in networking hardware. Network virtualization can be used for a variety of purposes, from prototyping to developing and testing to service deployment.

Note - For a description of the example IP addresses used in this guide, see the `IP address` entry in *Glossary of Networking Terms*.

Network virtualization is an OS-provisioned mechanism that enables you to programmatically create and configure virtual networks that are decoupled from the underlying physical network. A virtual network is therefore a pseudo network that uses the physical network only as a packet forwarding backbone. Virtual networks usually consist of one system using virtual machines or zones whose network interfaces are configured over a physical network interface card (NIC) or an etherstub. These network interfaces are called virtual network interface cards or virtual NICs (VNICs). The virtual machines or zones with VNICs can communicate with each other as though they are on the same local network, effectively becoming a virtual network on a single host.

Benefits of Network Virtualization

Network virtualization provides the following benefits:

- Enables you to achieve better utilization of the available resources by consolidating various applications on a few servers. You can then replace many systems with a single system that has multiple zones or virtual machines without significantly losing separation, security, and flexibility. For a demonstration, see Consolidating the Data Center With Network Virtualization (`http://download.oracle.com/otndocs/tech/OTN_Demos/data-center-consolidation.html`).

- Is cost effective because you can virtualize a hardware NIC at the MAC layer.
- Reduces the time to provision your network, thereby reducing the time to deploy applications.
- Provides base for building a fully automated cloud environment.
- Provides isolated networks because you can create VLANs, VXLANs, or PVLANs based virtual networks.
- Overcomes the limitations in current network topologies (such as scalability issues in VLANs).
- Using SR-IOV VF VNICs reduces system overhead.
- Improves system performance by allocating hardware resources such as NIC rings and CPUs to VNICs.
- Provides better network resource management by enforcing service-level agreements on the VNICs.
- Provides observability into the network at the level of virtual ports and flows

Network Virtualization Technologies That Are Supported by Oracle Solaris

Oracle Solaris supports the following network virtualization technologies:

- **Edge Virtual Bridging (EVB)** – Enables a host to exchange information related to virtual links on a system with an external switch. EVB is used to exchange information about all the virtual links behind a port whereas data center bridging (DCB) is used to exchange information about the port. For more information about EVB, see Chapter 4, "Administering Server-Network Edge Virtualization by Using Edge Virtual Bridging".
- **Virtual Extensible Local Area Network (VXLAN)** – VXLAN addresses the 4K limitation of virtual local area network (VLAN) and also reduces the demand of virtualization on physical infrastructure such as switches. It uses physical server resources effectively in a data center that spans multiple L2 networks and provides scalability and network isolation for virtual networks. For more information, see Chapter 3, "Configuring Virtual Networks by Using Virtual Extensible Local Area Networks".
- **Single Root I/O Virtualization (SR-IOV)** – Enables the creation of a virtual function (VF) based VNIC on a network device that supports SR-IOV. For more information, see "Using Single Root I/O Virtualization With VNICs" on page 63.

- **Private Virtual Local Area Network (PVLAN) VNICs** – Enables you to configure PVLAN VNICs that are used for dividing a VLAN into sub-VLANs to isolate the network traffic thereby providing better usage of the limited number of available VLANs.

Network Virtualization Components

The components of network virtualization are as follows:

- Virtual Network Interface Card (VNIC)
- Virtual switch
- Etherstub
- Elastic virtual switch

Virtual Network Interface Card (VNIC)

A *VNIC* is an L2 entity or virtual network device that behaves just like a physical NIC when configured. You can either configure a VNIC by using the `dladm` command or system creates the VNICs which are known as system-created VNICs. You configure a VNIC over an underlying datalink to share it between multiple zones or VMs. In addition, the system's resources treat VNICs as if they were physical NICs. All physical Ethernet interfaces support the creation of VNICs. For more information about how to configure a VNIC, see "How to Configure VNICs and Etherstubs" on page 30.

A VNIC has an automatically generated MAC address. Depending on the network interface in use, you can assign a MAC address to a VNIC other than the automatically generated MAC address. For more information, see "Modifying VNIC MAC Addresses" on page 56.

In addition to the VNICs that you can create by using the `dladm create-vnic` command, the system also creates VNICs known as system-created VNICs that help in virtual network I/O for Oracle VM Server for SPARC `vnet`. The system-created VNICs follow the naming convention `<entity>-<name>`, where `entity` refers to the system entity that created the VNIC and `name` refers to the VNIC name within the system entity. The user-created VNIC name cannot contain a hyphen (-). Only a system-created VNIC contains a hyphen (-), which helps you to differentiate between a system-created VNIC and a user-created VNIC. You cannot modify, rename, plumb, or delete system-created VNICs. For more information, see *Oracle VM Server for SPARC 3.1 Administration Guide*.

You can use the `dlstat` and `snoop` commands to monitor network traffic on system-created VNICs. You can also create flows over system-created VNICs by using the `flowadm` command. Flows help you to not only manage network resources but also to monitor network traffic statistics. You can monitor network traffic statistics on flows by using the `flowstat` command. For more information about flows, see "Configuring Flows" on page 220.

Virtual Switch

A *virtual switch* is an entity that facilitates communication between virtual machines (VMs) that share the same datalink. The virtual switch loops traffic between virtual machines (inter-VM traffic) within the physical machine and does not send this traffic out on the wire. A virtual switch is implicitly created whenever you create a VNIC on top of an underlying datalink. The VNICs configured with the VMs need to be on the same VLAN or VXLAN for inter-VM communication. Virtual switches can be managed by EVS. For information about EVS, see Chapter 5, "About Elastic Virtual Switches".

As per Ethernet design, if a switch port receives an outgoing packet from the host connected to that port, that packet cannot go to a destination on the same port. This Ethernet design is a limitation for systems that are configured with virtual networks because the virtual networks share the same NIC. This Ethernet design limitation is overcome by using the virtual switches, which enable VMs to communicate with one another.

In certain cases, communication between VMs in a system might require the use of a switch. For example, communication between VMs might need to be subjected to access control lists (ACLs) that are configured on the switch. By default, a switch cannot send packets on the same port where the packets are received. Therefore, reflective relay is enabled on the switch for communication between VMs that use a switch. Reflective relay enables the switch to forward the packets on the same port where the packets are received. For more information, see "Reflective Relay" in *Managing Network Virtualization and Network Resources in Oracle Solaris 11.3*.

Etherstub Virtual NIC

An *etherstub* is a pseudo Ethernet NIC that is configured at the datalink layer (L2) of the Oracle Solaris network stack. You can create VNICs over an etherstub instead of over a physical NIC. With etherstubs, you can construct a private virtual network that is isolated both from the other virtual networks on the system and from the external network. For example, you can use etherstubs to create a network environment without the external connectivity or resources.

Elastic Virtual Switch

Oracle Solaris network virtualization capabilities are expanded to enable managing virtual switches directly. The Oracle Solaris Elastic Virtual Switch (EVS) feature provides virtual networking infrastructure within a data center or a multitenant cloud environment to

interconnect virtual machines that reside on multiple systems. EVS enables centralized management of virtual switches on multiple hosts and hence VNICs connected to the elastic virtual switch. Virtual machines connected to the same elastic virtual switch can communicate with each other. For more information, see Chapter 5, "About Elastic Virtual Switches".
For more information about how to administer elastic virtual switches, see Chapter 6, "Administering Elastic Virtual Switches".

Types of VMs for Network Virtualization in Oracle Solaris

Although you can assign VNICs to resources in a single instance of the Oracle Solaris OS, you can extend their use in network virtualization by using them in virtualized environments such as Oracle Solaris Zones, Oracle Solaris Kernel Zones, or Oracle VM Server for SPARC.

Oracle Solaris Zones

A *zone* is a virtualized operating system environment created within a single instance of the Oracle Solaris operating system. Etherstubs and VNICs are only a part of the virtualization features of Oracle Solaris. By assigning VNICs or etherstubs for use by Oracle Solaris zones, you can create a network within a single system. For more information about zones, see *Introduction to Oracle Solaris Zones*.

Oracle Solaris Kernel Zones

An Oracle Solaris Kernel Zone, also called a `solaris-kz` branded zone, uses the branded zones framework to run a zone with a separate kernel and operating system (OS) installation from the global zone. The separate kernel and OS installation provide for greater independence and enhanced security of operating system instances and applications.

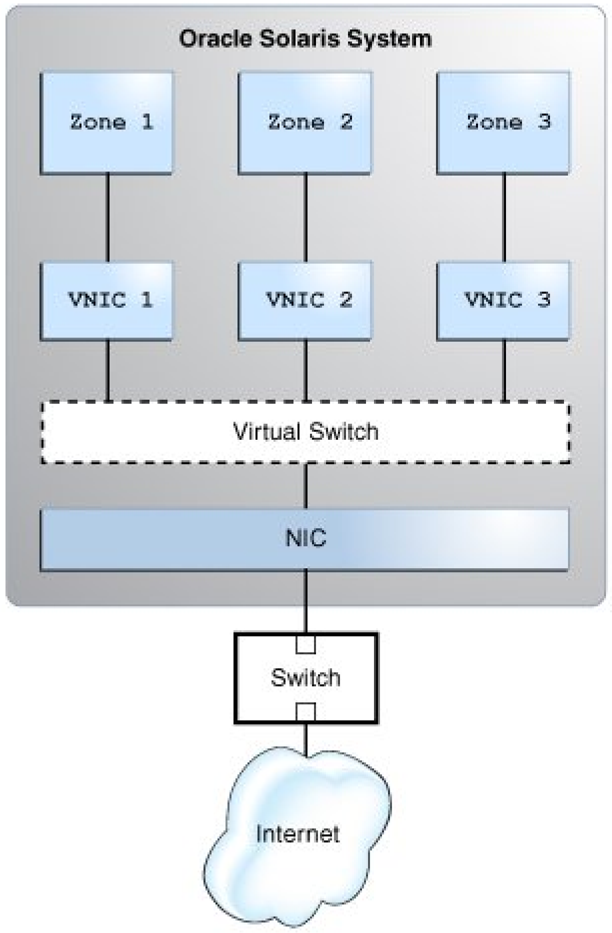
Oracle VM Server for SPARC

Oracle VM Server for SPARC provides highly efficient, enterprise-class virtualization capabilities for SPARC T-Series, SPARC M5, Fujitsu SPARC M12, and Fujitsu M10 platforms. You can create virtual servers called "logical domains" that can run an instance of an operating system to enable multiple operating systems on the same computer. For more information, see *Oracle VM Server for SPARC 3.3 Administration Guide*.

How a Virtual Network Works

The following figure shows the working of a virtual network and its components in a system.

FIGURE 1 Working of a Virtual Network



The figure shows a single system with one NIC. The NIC is configured with three VNICs. Each VNIC is assigned to a zone. `Zone 1`, `Zone 2`, and `Zone 3` are the three zones configured for use in the system. The zones communicate with each other and with the external network by using their respective VNICs. The three VNICs connect to the underlying physical NIC through the virtual switch. The function of a virtual switch is equivalent to the function of a physical switch as both provide connectivity to the systems.

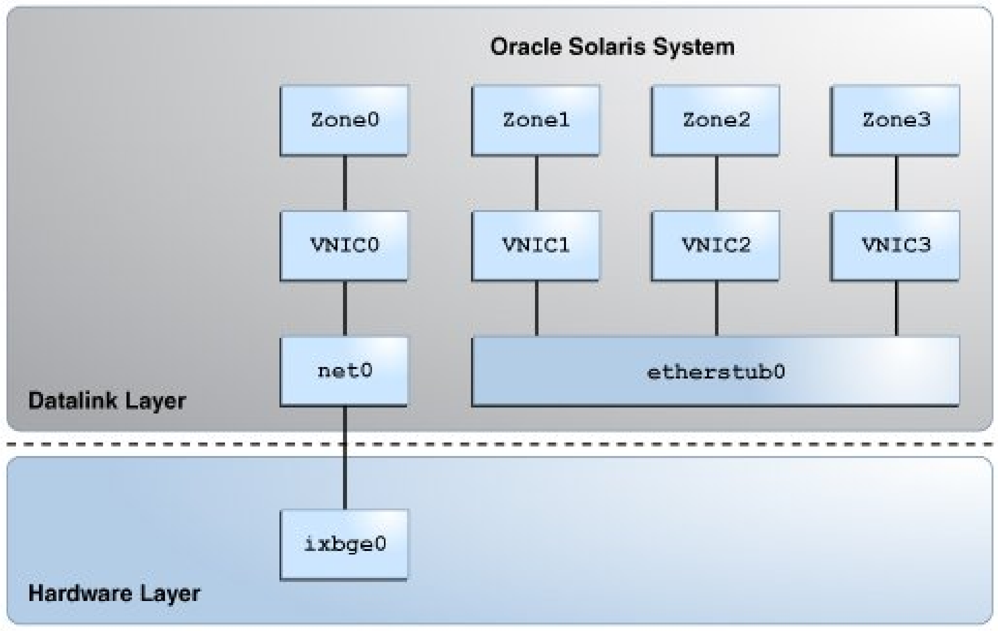
When a virtual network is configured, a zone sends traffic to an external host in the same way as a system without a virtual network. Traffic flows from the zone, through the VNIC to the virtual switch, and then to the physical interface, which sends the data to the network.

The zones can also exchange traffic with one another inside the system if all the VNICs configured to the zones are part of the same VLAN. For example, packets pass from `Zone 1` through its dedicated `VNIC 1`. The traffic then flows through the virtual switch to `VNIC 3`. `VNIC 3` then passes the traffic to `Zone 3`. The traffic never leaves the system, and therefore never violates the Ethernet restrictions.

Alternatively, you can create a virtual network based on the etherstub. Etherstubs are entirely software based and do not require a network interface as the basis for the virtual network.

The following figure shows a private virtual network based on the etherstub.

FIGURE 2 Private Virtual Network



This figure shows `etherstub0` over which `VNIC1`, `VNIC2`, and `VNIC3` are configured. Each VNIC is assigned to a zone. The private virtual network based on the etherstub cannot be accessed by external networks. For more information, see "Use Case: Configuring a Private Virtual Network" on page 46.

Oracle also provides the Oracle Enterprise Manager Ops Center for managing some aspects of network virtualization, for example, the ability to create virtual networks inside a virtual data center. For more information about the Oracle Enterprise Manager Ops Center, see `http://www.oracle.com/pls/topic/lookup?ctx=oc122&id=OPCCM`.

With the release of Oracle Virtual Networking Drivers for Oracle Solaris, Oracle Virtual Networking now supports Oracle Solaris on x86 and SPARC servers. For more information about Oracle Virtual Networking, see Oracle Virtual Networking Documentation (`http://docs.oracle.com/cd/E38500_01/`).

Overview of Network Resource Management

In Oracle Solaris, quality of service (QoS) is obtained more easily and dynamically by managing network resources. Network resource management is comparable to creating dedicated lanes for traffic. When you combine different resources to provide to the specific types of network packets, those resources form a network lane for those packets. Resources can be assigned differently for each network lane. For example, you can allocate more resources to a lane where network traffic is the heaviest. By configuring network lanes where resources are distributed according to the actual need, you increase the system's efficiency in processing network packets. For more information about network lanes, see "Overview of Monitoring Network Traffic Statistics of Datalinks and Flows" on page 231.

By using network resource management, you can isolate, prioritize, track, and control data traffic on an individual system without the complex QoS rule definitions.

Network resource management is helpful for the following tasks:

- Provisioning the network
- Establishing service-level agreements
- Billing clients
- Diagnosing security problems

The following network resources are used to increase the system's efficiency in processing packets:

- **Bandwidth** – You can limit the bandwidth of the datalink according to the actual need of the networking processes using by the datalink.
- **Priority** – You can prioritize the order in which the packets are processed. The latency is reduced for the packets with higher priority because they are processed ahead of the other packets.
- **NIC rings** – If a NIC supports ring allocation, its transmit and receive rings can be dedicated for use by datalinks. For more information, see "Managing NIC Rings" on page 200.
- **CPU pools** – Pools of CPUs are created and associated with specific zones. These pools can be further assigned to datalinks to manage the network processes of their associated zones. For more information, see "Managing Pools and CPUs" on page 210.
- **CPUs** – On a system with multiple CPUs, you can dedicate a given number of CPUs for specific network processing. For more information, see "Managing Pools and CPUs" on page 210.

Network resources on a system can be managed by using either datalink properties or flows.

Network Resource Management by Using Datalink Properties

Managing network resources by using datalinks improves the system's efficiency in processing packets. You can allocate resources when you create the link. Alternatively, you can allocate resources to a datalink, for example, after studying resource usage over time and determining how to better allocate the resource. By allocating network resources, you can decide the amount of a given resource can be used for the networking processes. The procedures for allocating resources apply to the virtual network as well as the physical network. For more information about datalink properties and how to configure them, see “Managing Network Resources by Using Datalink Properties” on page 199.

Network Resource Management by Using Flows

A *flow* is a customized way of categorizing network packets based on a single attribute or a combination of attributes. Flows help you to differentiate different services on the same datalink. The attributes that serve as the basis for creating flows are derived from the information in a network packet's header. After setting datalink properties for network resource management, flows can be used to further control how resources are used to process network packets. Flows alone can also be used to manage network resources without setting datalink properties.

Using flows for managing resources involves the following steps:

1. Creating a flow based on a single attribute or a combination of attributes.
2. Customizing a flow's use of resources by setting properties that pertain to network resources. Currently, bandwidth, priority, and rank properties can be associated with flows.

For more information about configuring flows, see “Managing Network Resources by Using Flows” on page 219.

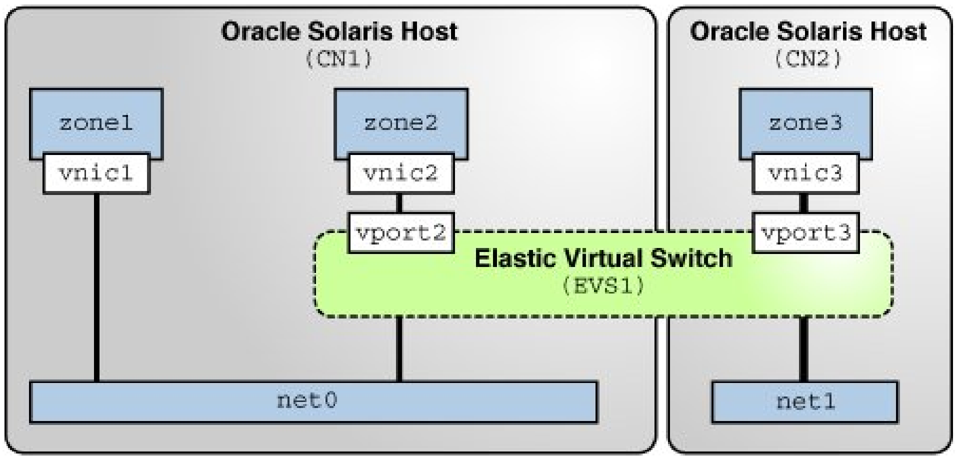
Scenario: Combining Network Virtualization and Network Resource Management

Network virtualization with network resource management helps you to manage flow control, improve system performance, and configure the network utilization needed to achieve OS virtualization, utility computing, and server consolidation. This section uses a scenario to show

how to use network virtualization with network resource management to optimize system performance.

The following figure shows the network virtualization setup that is used in this scenario.

FIGURE 3 Use Case: Network Virtualization Setup



The setup consists of the following components:

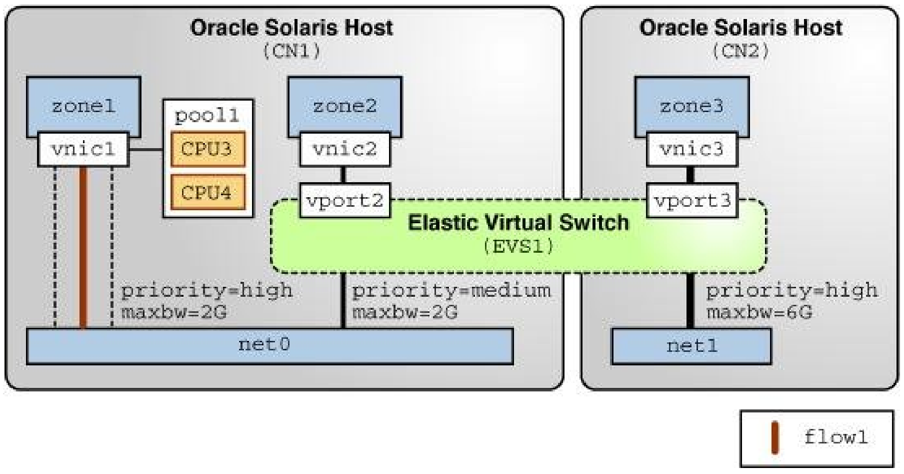
- Oracle Solaris hosts `CN1` and `CN2` that are configured with the datalinks `net0` and `net1` respectively.
- Oracle Solaris Zones `zone1` and `zone2` that are configured on `CN1` and `zone3` that is configured on `CN2`.
- Zones `zone1`, `zone2`, and `zone3` that are configured with the VNICs `vnic1`, `vnic2`, and `vnic3` respectively.
- Elastic virtual switch `EVS1` that is set up between `zone2` on `CN1` and `zone3` on `CN2`. Zones `zone2` and `zone3` are in the same network and hence are configured on the same elastic virtual switch.
- Virtual ports `vport2` and `vport3` that are the points of attachment between the VNICs and `EVS1`.

You can allocate network resources based on the priority and the rate of processing packets of different applications that run on zones. You can use datalink properties and flows to allocate network resources for the VNICs appropriately. This scenario is based on the following assumptions for allocating network resources:

- `zone1` hosts the applications `app1` and `app2`. You need to configure a flow on `vnic1` to isolate traffic and implement control over how packets belonging to the flows use resources. You also need to configure a separate pool of CPUs for `vnic1`.
- `zone2` hosts the application `app3` that communicates with a database on `zone3`.
- `zone3` hosts a database that communicates with `zone2`. Because `vnic3` receives and transmits more packets than the other VNICs, it uses more bandwidth. So, you need to set a higher bandwidth limit to cap the bandwidth usage of `vnic3`. You can also set a high priority for packet processing.

Based on these assumptions, the network resources are allocated for the VNICs that are configured on the Oracle Solaris hosts. The following figure shows the allocation of network resources for the VNICs by using the datalink properties and flows.

FIGURE 4 Use Case: Network Virtualization With Flows and Resource Allocation



This figure shows the datalink and flow properties that are set for the VNICs and `flow1`. The following table describes these properties and their values.

TABLE 1 Datalink and Flow Properties of VNICs

VNICs	Datalink Properties	Flow Properties	Description

`vnic1`	`pool=pool1`	`priority=high`
		
		`maxbw=2G`
			`flow1` is created on `vnic1` based on the transport protocol and IP address. The `priority` and `maxbw`

VNICs	Datalink Properties	Flow Properties	Description
			properties are set to `flow1` to control the flow packets. Additionally, the `pool` property is set to allocate a pool of CPUs to `vnic1`.

`vnic2`	`priority=medium`
	
	`maxbw=2G`
			The `maxbw` property is set to `vnic2` to allocate bandwidth. The `priority` property is set to `medium` by default.

`vnic3`	`priority=high`
	
	`maxbw=6G`
			The properties `maxbw` and `priority` are set to `vnic3` to allocate bandwidth and prioritize the order in which the packets are processed.

♦ ♦ ♦ CHAPTER 2

Creating and Managing Virtual Networks

This chapter describes tasks for configuring the components of a virtual network, building virtual networks, and managing VNICs in a single system. This chapter also describes how to create a virtual function (VF) based VNIC on a network device that supports single root I/O virtualization (SR-IOV). For an introduction to virtual networks, see Chapter 1, "Introduction to Network Virtualization and Network Resource Management".

This chapter contains the following topics:

- "Configuring the Components of a Virtual Network" on page 29
- "Building Virtual Networks" on page 38
- "Managing VNICs" on page 50
- "Using Single Root I/O Virtualization With VNICs" on page 63
- "Creating and Viewing Paravirtualized IPoIB Datalinks in Kernel Zones" on page 77

Configuring the Components of a Virtual Network

In Oracle Solaris, VNICs and etherstubs are the basic components of a virtual network. This section describes the steps to configure these components in preparation for building the virtual network. For a description of these components, see "Network Virtualization Components" on page 17.

You can configure the following components:

- Configure VNICs and etherstubs. For more information, see "How to Configure VNICs and Etherstubs" on page 30.
- Configure VNICs with VLAN IDs to host VLAN traffic. For more information, see "How to Configure VNICs as VLANs" on page 33.
- Configure VNICs with primary VLAN IDs and secondary VLAN IDs of private VLANs (PVLANs) to host PVLAN traffic. For more information, see "How to Configure VNICs as PVLANs" on page 34.

- Configure IPoIB VNICs. For more information, see "How to Configure IPoIB VNICs" on page 36.
- Configure properties for a VNIC, such as MAC addresses and CPUs to be associated with the VNIC.

When configuring VNICs, note the following:

- Certain property modifications work only with VNICs. For example, with the `dladm create-vnic` command, you can configure a MAC address as well as assign a VLAN ID to create a VNIC as a VLAN. However, you cannot configure a MAC address directly for a VLAN by using the `dladm create-vlan` command.
- You can create only one VNIC at a time over a datalink. Like datalinks, VNICs have link properties that you can further configure as needed. For information about the different types of link properties, see "Network Resource Management by Using Datalink Properties" on page 24.

A virtual network device in a Oracle VM Server for SPARC can support multiple Oracle Solaris 11 VNICs. The virtual network device must be configured to support multiple MAC addresses, one for each VNIC that the virtual network device supports. Oracle Solaris zones in the logical domain connect to the VNICs. For more information, see "Using Virtual NICs on Virtual Networks" in *Oracle VM Server for SPARC 3.3 Administration Guide*.

▼ How to Configure VNICs and Etherstubs

The VNIC connects the virtual network to the external network. The VNIC also enables the zones to communicate with one another through the virtual switch that is automatically created with the VNIC. For a virtual network to host traffic internally between zones, an external LAN, and the Internet, each zone must have its own VNIC. Therefore, you must repeat this procedure as many times as the number of zones that belong to the virtual network.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **(Optional) Create an etherstub.**

   ```
   # dladm create-etherstub etherstub
   ```

   where *etherstub* is the name of the etherstub that you want to create.

   Perform this step only if you are creating a private virtual network. For a description of a private virtual network, see "Overview of Network Virtualization" on page 15. For more information about how to configure a private virtual network, see "Use Case: Configuring a Private Virtual Network" on page 46.

Like a datalink, you can name the etherstub in any way that is meaningful to your network setup. For the guidelines about how to create customized names, see "Rules for Valid Link Names" in *Configuring and Managing Network Components in Oracle Solaris 11.3*.

3. **Create a VNIC.**

```
# dladm create-vnic -l link [-v VLAN-ID[,PVLAN-SVID[,PVLAN-type]]] VNIC
```

link	The name of the link over which the VNIC is configured. If you are creating the VNIC for a private virtual network, then provide the name of the etherstub.
VLAN-ID	The VLAN ID of the VNIC if you want to create the VNIC as a VLAN. Include the `-v` option in the command only if you are creating the VNIC as a VLAN or a PVLAN. To configure a VNIC with a VLAN ID, see "How to Configure VNICs as VLANs" on page 33.
PVLAN-SVID	The PVLAN secondary VLAN ID that is associated with the VLAN when you want to create a PVLAN VNIC. To create a PVLAN VNIC, see "How to Configure VNICs as PVLANs" on page 34. For more information about VLANs and PVLANs, see Chapter 4, "Configuring Private Virtual Local Area Networks" in *Managing Network Datalinks in Oracle Solaris 11.3*.
PVLAN-type	The PVLAN type associated with the VLAN, which can be either `isolated` or `community`. The default value is `isolated`.
VNIC	The name of the VNIC. For the guidelines about how to create customized names, see "Rules for Valid Link Names" in *Configuring and Managing Network Components in Oracle Solaris 11.3*.

4. **Create an IP interface over the VNIC.**

```
# ipadm create-ip interface
```

interface	The VNIC that you created in the previous step.

5. **Assign an IP address to the VNIC interface.**

```
# ipadm create-addr -a address interface
```

-a *address*	Specifies the IP address, which can be in Classless Inter-Domain Routing (CIDR) notation.

The IP address can be either IPv4 or IPv6 addresses. For more information, see "How to Configure an IPv4 Interface" in *Configuring and Managing Network Components in Oracle Solaris 11.3*.

6. **(Optional) Verify the VNIC that has been created.**

```
# dladm show-link
```

Example 1 Configuring a VNIC

This example shows how to configure `vnic1` over the datalink `net0`.

```
# dladm create-vnic -l net0 vnic1
# ipadm create-ip vnic1
# ipadm create-addr -a 192.0.2.10/24 vnic1
# dladm show-link
LINK          CLASS     MTU    STATE    OVER
net0          phys      1500   up       --
vnic1         vnic      1500   up       net0
```

Example 2 Creating an Etherstub and Configuring VNICs Over the Etherstub

This example shows how you can create an etherstub `etherstub0` and configure VNICs `vnic1` and `vnic2` over the etherstub.

```
# dladm create-etherstub etherstub0
# dladm create-vnic -l etherstub0 vnic1
# dladm create-vnic -l etherstub0 vnic2
# ipadm create-ip vnic1
# ipadm create-addr -a 192.0.2.20/24 vnic1
# ipadm create-ip vnic2
# ipadm create-addr -a 192.0.2.30/24 vnic2
# dladm show-etherstub -o all
LINK          ZONE
etherstub0    global
# dladm show-link
LINK          CLASS     MTU      STATE       OVER
net0          phys      1500     up          --
etherstub0    etherstub 9000     unknown     --
vnic1         vnic      9000     up          etherstub0
vnic2         vnic      9000     up          etherstub0
```

▼ How to Configure VNICs as VLANs

You can configure VNICs with VLAN IDs to host VLAN traffic. If a VNIC needs to be a part of a VLAN and receive traffic for that VLAN, then you need to assign the VLAN ID of that VLAN to the VNIC. You also set the link property `vlan-announce` to propagate the VLAN configurations of each individual VNIC to the network.

Unlike a regular VLAN link, the VNIC configured as a VLAN has its own MAC address. For information about regular VLANs, see Chapter 3, "Configuring Virtual Networks by Using Virtual Local Area Networks" in *Managing Network Datalinks in Oracle Solaris 11.3*.

This procedure contains only the steps to create the VNIC with a VLAN ID and to set the appropriate properties that enable the VNIC to service VLAN traffic. Although the intermediary ports and switches are automatically updated when you enable the `vlan-announce` property, the intermediary ports and switches must be separately configured to define VLANs at these points.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create a VNIC with a VLAN ID.**

   ```
   # dladm create-vnic -l link -v vid VNIC
   ```

3. **(Optional) Broadcast the VNIC's VLAN configuration to the network.**

   ```
   # dladm set-linkprop -p vlan-announce=gvrp link
   ```

   This step enables a GARP VLAN Registration Protocol (GVRP) client system that automatically registers VLAN IDs with attached switches. By default, the `vlan-announce` property is set to `off` and no VLAN broadcast messages are sent to the network. After you set the property to `gvrp`, the VLAN configuration for that link is propagated to enable automatic VLAN port configuration of the network devices. VLAN traffic can then be accepted and forwarded by these devices. For more information about GVRP, see "Configuring GVRP," in *Sun Ethernet Fabric Operating System*.

4. **(Optional) Set the `gvrp-timeout` property to configure the wait period between VLAN broadcasts.**

   ```
   # dladm set-linkprop -p gvrp-timeout=time link
   ```

time	Refers to the value of the `gvrp-timeout` property in milliseconds. The default value is 250 milliseconds. A system with a heavy load might

require a shorter interval when rebroadcasting VLAN information. This property enables you to adjust the interval.

5. **(Optional) Display the value of the properties `vlan-announce` and `gvrp-timeout`.**

```
# dladm show-linkprop -p vlan-announce,gvrp-timeout
```

Example 3 Configuring a VNIC as a VLAN

This example shows how to create a VNIC named `vnic0` on the datalink `net0` with a VLAN ID `123` and how to enable the VLAN configuration to be announced to the network.

```
# dladm create-vnic -l net0 -v 123 vnic0
# dladm set-linkprop -p vlan-announce=gvrp net0
# dladm set-linkprop -p gvrp-timeout=250 net0
# dladm show-linkprop -p vlan-announce,gvrp-timeout net0
LINK     PROPERTY        PERM   VALUE     EFFECTIVE    DEFAULT   POSSIBLE
net0     vlan-announce   rw     gvrp      gvrp         off       off,gvrp
net0     gvrp-timeout    rw     250       250          250       100-100000
```

The output shows the following information:

`LINK`	Physical datalink, identified by a name.
`PROPERTY`	Property of the link. A link can have several properties.
`PERM`	Permissions of the property, which can be one of the following: ■ `ro` refers to read only permission of the link property. ■ `rw` refers to read and write permissions of the link property.
`VALUE`	Current (or persistent) link property value. If the value is not set, it is shown as `--`. If it is unknown, the value is shown as `?`.
`DEFAULT`	Default value of the link property. If the link property has no default value, `--` is shown.
`POSSIBLE`	A comma-separated list of the values that the link property can have. If the possible values are unknown or unbounded, `--` is shown.

▼ How to Configure VNICs as PVLANs

You can configure VNICs with primary and secondary VLAN IDs of a PVLAN to host the PVLAN traffic. For more information about PVLANs, see Chapter 3, “Configuring Virtual

Networks by Using Virtual Local Area Networks” in *Managing Network Datalinks in Oracle Solaris 11.3*.

1. **Become an administrator.**

2. **Create a PVLAN VNIC by specifying the primary VLAN ID and secondary VLAN ID.**

    `# dladm create-vnic -l` *link* **`[-v`** *VLAN-ID***`[,`***PVLAN-SVID***`[,`***PVLAN-type***`]]]`** *VNIC*

link	Specifies the Ethernet link over which the VLAN is created.
VLAN-ID	Primary ID associated with a VLAN.
PVLAN-SVID	Secondary VLAN ID associated with the PVLAN.
PVLAN-type	The PVLAN type associated with the VLAN, which can be either `isolated` or `community`. The default value is `isolated`.
VNIC	Name of the VNIC.

3. **(Optional) Display the PVLAN or PVLAN VNIC that is created.**

    ```
    # dladm show-vnic -v
    ```

Example 4 Creating a PVLAN VNIC

The following example shows how to create a PVLAN with the primary VLAN ID as `4`, secondary VLAN ID as `110`, and PVLAN type as `isolated`.

```
# dladm create-vnic -v 4,110,community -l net1 vnic2
# dladm show-vnic -v
LINK       VID  SVID PVLAN-TYPE  OVER
vnic2      4    110  community   net1
```

Configuring IPoIB VNICs

IP over IB (IPoIB) devices enable transporting IP packets over IB connections. You configure IPoIB VNICs by specifying the partition key. Although you can migrate IPoIB VNICs from one underlying datalink to another underlying datalink, IPoIB partition links do not support migration. For more information, see “About InfiniBand Devices” in *Managing Devices in Oracle Solaris 11.3*.

▼ How to Configure IPoIB VNICs

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **(Optional) Check the information about the IB physical link over which you want to create the IPoIB datalink.**

   ```
   # dladm show-ib link
   ```

   The output shows the datalinks and information about their partition keys.

3. **Create an IPoIB VNIC by specifying the partition key.**

   ```
   # dladm create-vnic [-f] -l link -P pkey -p [prop=value] VNIC
   ```

`-f`	Optional. Forces the creation of the IPoIB VNIC even though the partition key is absent on the port, the multicast group is absent, or the port is down.
`-P` *pkey*	The partition key that needs to be used. This option is mandatory for IPoIB VNICs and not applicable for other types of datalinks. When you specify the partition key, it is always considered a hexadecimal, regardless of whether it has the `0x` prefix.
`-p` *prop=value*	Used to specify the value of the `linkmode` property of the IPoIP VNIC, which enables you to set the link transport service type on an IB partition datalink. You can set the following values for the `linkmode` property: ■ `cm` - connected mode. This mode uses a default MTU of 65520 bytes and supports a maximum MTU of 65535 bytes. If connected mode is not available for a remote node, unreliable datagram mode is automatically used. `cm` is the default value. ■ `ud` - unreliable datagram mode. This mode uses a default MTU of 2044 bytes and supports a maximum MTU of 4092 bytes.

4. **(Optional) Display the IPoIB VNIC that is created.**

   ```
   # dladm show-vnic
   ```

   You can use the `dladm show-vnic` command to display only IPoIB VNICs that you create by using the `dladm create-vnic` command. The IPoIB datalinks that you create by using the `dladm create-part` command are not considered VNICs and you can display them by using the `dladm show-part` command.

5. **Plumb and assign an IP address to an IPoIB VNIC.**

```
# ipadm create-ip interface
# ipadm create-addr -a address interface [address-object]
```

interface	The name of the IPoIB VNIC that you created.
-a *address*	Specifies the IP address.
address-object	A name that identifies the IP address in association with the IP interface. If *address-object* is not specified, the OS automatically assigns a name by using the format *IP-name/protocol*.

Example 5 Creating IPoIB VNICs

The following example shows how to create an IPoIB VNIC over the datalink `net4` by using the partition key `0xffff`.

```
# dladm show-ib net4
LINK      HCAGUID        PORTGUID       PORT STATE GWNAME GWPORT  PKEYS
net4      21280001A0A58C 21280001A0A58D 1    up      --     --    FFFF
# dladm create-vnic -l net4 -P 0xffff ipoib_vnic0
# dladm show-vnic
LINK         OVER    SPEED  MACADDRESS        MACADDRTYPE IDS
eth_vnic0    net0    1000   2:8:20:ef:d2:77   random      VID:0
ipoib_vnic0  net4    32000  80:0:0:4a:fe:..   fixed       PKEY:0xFFFF
# dladm create-ip ipoib_vnic0
# ipadm create-addr -a 192.0.2.10 ipoib_vnic0/v4
```

You can also use the `dladm show-vnic` command with the `-o` option to display the entire MAC address of a VNIC or an IPoIB VNIC.

```
# dladm show-vnic -o link,macaddress
LINK            MACADDRESS
eth_vnic0       2:8:20:ef:d2:77
ipoib_vnic0     80:0:0:4a:fe:80:0:0:0:0:0:0:0:21:28:0:1:a0:a5:8e
```

The following example shows how to create the IPoIB VNIC `vnic1` with the `linkmode` property set to `ud`.

```
# dladm create-vnic -l net4 -P 0xffff -p linkmode=ud vnic1
```

Managing IPoIB VNICs

You migrate and delete IPoIB VNICs just as you would with Ethernet VNICs. For more information, see "Migrating VNICs" on page 58 and "Deleting VNICs" on page 60.

The following example shows how to migrate `ipoib_vnic0` to the datalink `net5`.

```
# dladm modify-vnic -l net5 ipoib_vnic0
```

The following example shows how to delete `ipoib_vnic0`.

```
# dladm delete-vnic ipoib_vnic0
```

Building Virtual Networks

A virtual network enables you to use VNICs rather than physical devices for configuring a network. Since you can configure more than one VNIC on a physical device, you can create a multinode network on top of a few physical devices or even on a single device thereby building a network within a single system. This capability enables you to configure several VNICs on top a single physical device thereby enabling you to build several virtual servers (zones) that the system can support. These servers are connected by a network within a single operating system instance.

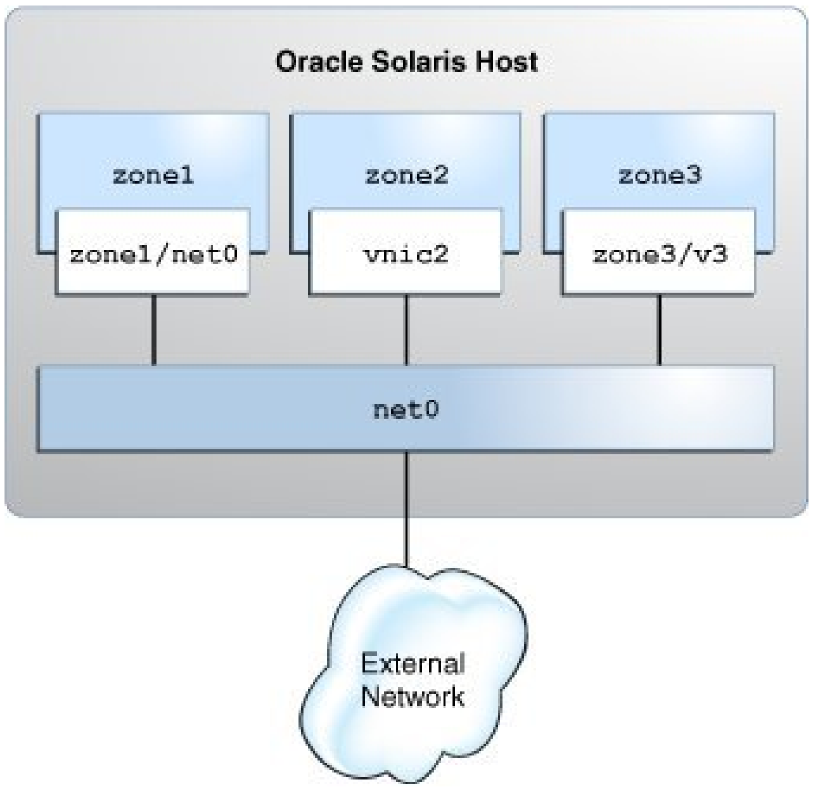
In Oracle Solaris, you must create a zone to build a virtual network. You can create any number of zones that you require based on the system support. Each zone has its own virtual interface. The zones in the system that are part of the same Layer 2 broadcast domain can communicate with each other. The virtual network as a whole connects to destinations on the larger external network.

To build a virtual network, you have to configure VNICs and zones. You can either configure a VNIC and assign it to a zone or configure the zone with the VNIC `anet` resource.

Alternatively, you can create a private virtual network based on the etherstub that is entirely software based and does not require a physical network interface as the basis for the virtual network. In a private virtual network, the VNICs that are assigned to the zones are configured over an etherstub. Thus, they are isolated from the traffic on the physical NIC. For more information, see "Use Case: Configuring a Private Virtual Network" on page 46.

The following figure shows the virtual network setup in an Oracle Solaris host.

FIGURE 5 Virtual Network Setup



The procedures in this section are based on the following assumptions:

- The virtual network on the system consists of three zones. The procedures in this section are based on the following zone configurations:
  - The first zone `zone1` is created as a new zone with an `anet` resource. For information, see "How to Configure a Zone for the Virtual Network" on page 40.
  - The second zone `zone2` already exists on the system and needs to be reconfigured to use a VNIC. For information, see "How to Reconfigure a Zone to Use a VNIC" on page 42.
  - The third zone `zone3` already exists on the system. You need to temporarily create the VNIC `zone3/v3` in `zone3` from the global zone. For information, see "How to Temporarily Create VNICs in Zones" on page 44.

- The system's physical interface is configured with the IP address `192.0.2.20`.
- The router's IP address is `192.0.2.25`.

When building the virtual network, some steps are performed in the global zone and some steps are performed in a non-global zone. For clarity, the prompts in the examples after each step indicate in which zone a specific command is issued. However, the actual path that the prompts display might vary depending on the prompts specified for your system.

For a demonstration of configuring a virtual network, see Configuring a Virtual Network in Oracle Solaris - Part 1 (`https://www.oracle.com/webfolder/technetwork/tutorials/tutorial/solaris/11/VirtualDemo_Part1/VirtualDemo_Part1.htm`) and Configuring a Virtual Network in Oracle Solaris - Part 2 (`https://www.oracle.com/webfolder/technetwork/tutorials/tutorial/solaris/11/VirtualDemo_Part2/VirtualDemo_Part2.htm`).

▼ How to Configure a Zone for the Virtual Network

This procedure explains how to configure a new zone with the VNIC `anet` resource. Note that only the steps related to network virtualization are included in the procedure. For more information about how to configure zones, see Chapter 1, “How to Plan and Configure Non-Global Zones” in *Creating and Using Oracle Solaris Zones*.

1. **Become an administrator.**

   For more information, see “Using Your Assigned Administrative Rights” in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create the zone.**

   ```
   global# zonecfg -z zone
   zonecfg:zone> create -t SYSsolaris
   ```

   When you create a zone, a VNIC `anet` resource is added to the zone by default. The lower link for the VNIC `anet` resource is selected automatically. You can manually set the lower link for the VNIC `anet` resource as described in the next step.

3. **Select the default VNIC `anet` resource of the zone and set the lower link.**

   ```
   zonecfg:zone> select anet linkname=net0
   zonecfg:zone:anet> set lower-link=NIC
   ```

4. **Configure the IP address and the default router for the `anet` resource of the zone.**

```
zonecfg:zone:anet> set allowed-address=IP-address-of-the-anet-resource
zonecfg:zone:anet> set defrouter=IP-address-of-the-default-router
zonecfg:zone:anet> end
```

5. **Verify and commit the changes that you have implemented and then exit the zone.**

```
zonecfg:zone> verify
zonecfg:zone> commit
zonecfg:zone> exit
```

6. **Install and boot the zone.**

```
global# zoneadm -z zone install
global# zoneadm -z zone boot
```

7. **Log in to the zone and complete the zone configuration.**

```
global# zlogin -C zone
```

During the zone configuration, you can specify most of the information by selecting from a list of choices. Usually, the default options suffice. You can skip the network configuration because you have already set the `allowed-address` and `defrouter` properties for the `anet` resource.

Example 6 Configuring a Zone for the Virtual Network

In this example, `zone1` is created for the virtual network with the VNIC `anet` resource. Note that only the zone parameters that are relevant to the creation of a virtual network are listed.

```
global # zonecfg -z zone1
Use 'create' to begin configuring a new zone.
zonecfg:zone1> create -t SYSsolaris
zonecfg:zone1> select anet linkname=net0
zonecfg:zone1:anet> set lower-link=net0
zonecfg:zone1:anet> set allowed-address=192.0.2.10/24
zonecfg:zone1:anet> set defrouter=192.0.2.1
zonecfg:zone1:anet> end
zonecfg:zone1> verify
zonecfg:zone1> commit
zonecfg:zone1> exit
global# zoneadm -z zone1 install
.
.
.
global# zoneadm -z zone1 boot
```

```
global# zlogin -C zone1
```

Specify the information for the zone as you are prompted. For more information about zone configuration, see *Creating and Using Oracle Solaris Zones*.

▼ How to Reconfigure a Zone to Use a VNIC

This procedure refers to the second zone in the virtual network. This zone already exists but its current configuration prevents it from becoming a part of the virtual network. Specifically, the zone's IP type is a shared type and its current interface is `net0`. Both of these configurations must be changed.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create the VNIC.**

   ```
   global# dladm create-vnic -l link VNIC
   ```

   You will configure the VNIC's interface later in this procedure.

3. **Change the zone's IP type from `shared` to `exclusive`.**

   ```
   global# zonecfg -z zone
   zonecfg:zone> set ip-type=exclusive
   ```

4. **Change the zone's interface to use a VNIC.**

   ```
   zonecfg:zone> remove net physical=NIC
   zonecfg:zone> add net
   zonecfg:zone:net> set physical=VNIC
   zonecfg:zone:net> end
   ```

5. **Verify and commit the changes that you have implemented and then exit the zone.**

   ```
   zonecfg:zone> verify
   zonecfg:zone> commit
   zonecfg:zone> exit
   ```

6. **Reboot the zone.**

   ```
   global# zoneadm -z zone reboot
   ```

7. **Log in to the zone.**

   ```
   global# zlogin zone
   ```

8. **In the zone, create an IP interface over the VNIC that is now assigned to the zone.**

   ```
   zone# ipadm create-ip interface
   ```

9. **Configure the VNIC with a static IP address or a Dynamic Host Configuration Protocol (DHCP) IP address.**

   - **Assign a static IP address.**

     ```
     zone# ipadm create-addr -a address interface
     ```

`-a` *address*	Specifies the IP address, which can be in CIDR notation.

   - **Assign a DHCP IP address.**

     ```
     zone# ipadm create-addr -T dhcp interface
     ```

10. **Exit the zone.**

    ```
    zone# exit
    ```

11. **From the global zone, add the address information to the `/etc/hosts` file.**

Example 7 Reconfiguring a Zone to Use a VNIC

In this example, `zone2` already exists as a shared zone. The zone also uses the primary interface of the system rather than a virtual link. You need to modify `zone2` to use `vnic2`. To use `vnic2`, `zone2`'s IP type must first be changed to `exclusive`. Note that some of the output is truncated to focus on the relevant information that relates to virtual networks.

```
global# dladm create-vnic -l net0 vnic2

global# zonecfg -z zone2
zonecfg:zone2> set ip-type=exclusive
zonecfg:zone2> remove net physical=net0
zonecfg:zone2> add net
zonecfg:zone2:net> set physical=vnic2
zonecfg:zone2:net> end
zonecfg:zone2> verify
zonecfg:zone2> commit
zonecfg:zone2> exit
```

```
global# zoneadm -z zone2 reboot

global# zlogin zone2
zone2# ipadm create-ip vnic2
zone2# ipadm create-addr -a 192.0.2.85/24 vnic2
ipadm: vnic2/v4

zone2# exit

global# pfedit /etc/hosts
#
::1             localhost
127.0.0.1       localhost
192.0.2.20    loghost   #For net0
192.0.2.80    zone1   #using vnic1
192.0.2.85    zone2   #using vnic2
```

How to Temporarily Create VNICs in Zones

VNICs can be created directly in a non-global zone from a global zone by specifying the link as *zone*/*link*. This method creates the VNIC directly in the namespace of the non-global zone. The -t option is used to specify that the VNIC is temporary. Temporary VNICs persist until the next reboot of the zone. The global zone and other non-global zones can also have VNICs with the same name. VNICs can be created only temporarily by using this method.

In addition to temporarily creating VNICs, you can also temporarily create VLANs and IP over InfiniBand (IPoIB) partitions. See the dladm(1M) man page for complete instructions.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create and boot a non-global zone from the global zone.**

   ```
   global# zoneadm -z zone boot
   ```

3. **Create a temporary VNIC for the non-global zone.**

   ```
   global# dladm create-vnic -t -l link zone/VNIC
   ```

-t	Specifies that the VNIC is temporary. Temporary VNICs persist until the next reboot of the *zone*. This option must be specified if the VNIC is created in a non-global zone's namespace.

`-l`	Specifies the link, which can be a physical link or an etherstub.

For an example of the command syntax that you would use to create a VLAN or IPoIB partition in a non-global zone from a global zone, see Example 8, "Temporarily Creating VNICs, VLANs, and IPoIB Partitions in Zones," on page 45.

4. **Verify that the VNIC was created in the zone.**

```
global# dladm show-link -Z
```

5. **Log in to the zone.**

```
global# zlogin zone
```

6. **Verify that the VNIC was successfully created.**

```
zone# dladm show-link
```

Example 8 Temporarily Creating VNICs, VLANs, and IPoIB Partitions in Zones

The following example shows how to create a VNIC named `vnic1` in a non-global zone from the global zone.

```
global# zoneadm -z zone1 boot
global# dladm create-vnic -t -l net0 zone1/vnic1
global# dladm show-link -Z
LINK                ZONE      CLASS     MTU    STATE    OVER
net0                global    phys      1500   up        --
zone1/vnic1         zone1     vnic      1500   down     net0
```

The following example shows the output of the `dladm show-link` command from `zone1`.

```
zone1# dladm show-link
LINK                CLASS     MTU    STATE     OVER
vnic1               vnic      1500   down      ?
```

The following example shows how to create a VLAN named `vlan3` in a non-global zone from a global zone.

```
global# dladm create-vlan -t -l net0 -v 3 zone1/vlan3
```

The `-v` option specifies the VLAN-ID of the VLAN over the Ethernet link.

The following example shows how to create an IPoIB partition named `part1` in a non-global zone from a global zone.

```
global# dladm create-part -t -l net1 -P FFFF zone1/part1
```

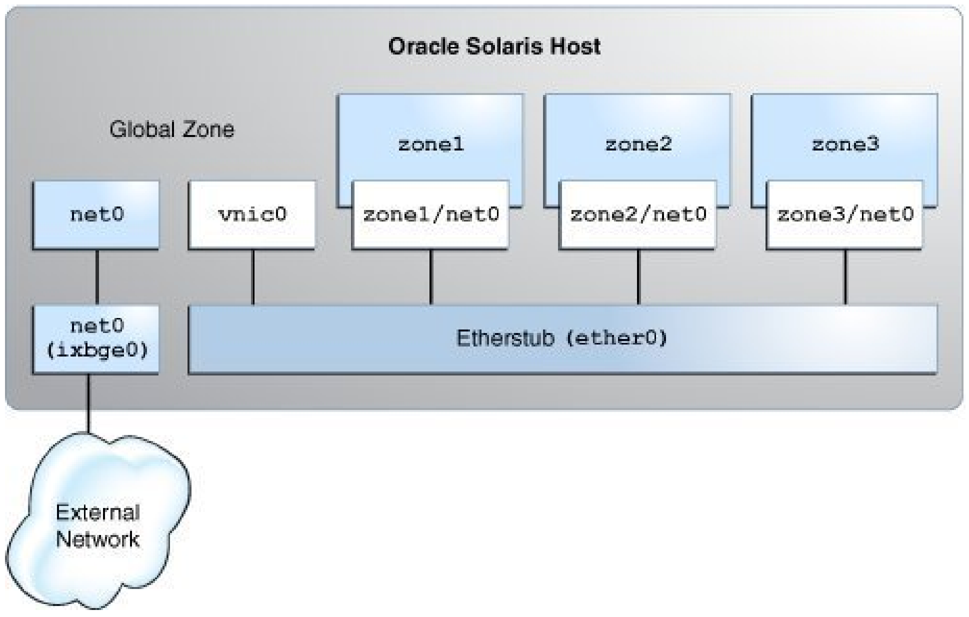
The `-P` option specifies the partition key that is used for creating a partition link.

Use Case: Configuring a Private Virtual Network

This use case shows how to create a private virtual network and enable it to send network traffic outside the system.

This use case is based on the configuration shown in the following figure.

FIGURE 6 Use Case: Private Virtual Network Setup



The configuration on the Oracle Solaris host is as follows:

- The primary interface of the global zone is `net0`.
- The zones, `zone1`, `zone2`, and `zone3`, are configured with the VNIC `anet` resources and the etherstub `ether0` is set as the lower link for the zones.

- The VNIC `vnic0` is configured over the etherstub `ether0`.

This use case is based on the following assumptions:

- The primary interface, `net0`, is configured for the system with the IP address `192.0.2.20/27` and the default router IP address `192.0.2.1/27`.
- The first zone, `zone1`, is created as a new zone. The second zone `zone2` already exists on the system and needs to be reconfigured with an `anet` resource.
- The third zone, `zone3`, is reconfigured by using Live Zone Reconfiguration. For more information, see Chapter 6, "Live Zone Reconfiguration" in *Creating and Using Oracle Solaris Zones*.

The following table shows the IP addresses that are configured for the zones and their respective default routers in the private virtual network setup.

TABLE 2 IP Addresses Configured for the Zones in the Private Virtual Network Setup

Zone	IP Address of the `anet` Resource	IP Address of the Default Router
`zone1`	`192.0.2.34/27`	`192.0.2.33/27`
`zone2`	`192.0.2.35/27`	`192.0.2.33/27`
`zone3`	`192.0.2.36/27`	`192.0.2.33/27`

Planning for the Private Virtual Network Setup

▼ How to Configure a Private Virtual Network (Use Case)

The global zone performs routing and NAT, so you need to connect the global zone to both the private virtual network and the physical NIC. You connect the global zone to the physical NIC by configuring the primary interface in the global zone. You connect the global zone to the private virtual network by creating `vnic0` over the etherstub `ether0`.

1. **Become an administrator.**

2. **Create the etherstub `ether0`.**

```
# dladm create-etherstub ether0
```

3. **Create the VNIC `vnic0` over `ether0` and configure `192.0.2.33/27` as the IP address for `vnic0`.**

```
# dladm create-vnic -l ether0 vnic0
# ipadm create-ip vnic0
# ipadm create-addr -a 192.0.2.33/27 vnic0
```

The VNIC `vnic0` acts as the default router for the zones.

4. **Create the zone `zone1` with the VNIC `anet` resource and set `ether0` as the lower link. Configure `zone1` with the IP addresses that are displayed in Table 2, "IP Addresses Configured for the Zones in the Private Virtual Network Setup," on page 47.**

```
global# zonecfg -z zone1
Use 'create' to begin configuring a new zone.
zonecfg:zone1> create -t SYSsolaris
zonecfg:zone1> select anet linkname=net0
zonecfg:zone1:anet> set lower-link=ether0
zonecfg:zone1:anet> set allowed-address=192.0.2.34/27
zonecfg:zone1:anet> set defrouter=192.0.2.33/27
zonecfg:zone1:anet> end
zonecfg:zone1> commit
zonecfg:zone1> exit
```

5. **Install and boot `zone1`.**

```
global# zoneadm -z zone1 install
global# zoneadm -z zone1 boot
```

6. **Log in to `zone1` and complete the zone configuration.**

```
global# zlogin -C zone1
```

7. **Reconfigure `zone2` with an `anet` resource and set `ether0` as the lower link. Configure `zone2` with the IP addresses that are displayed in Table 2, "IP Addresses Configured for the Zones in the Private Virtual Network Setup," on page 47.**

```
global# zonecfg -z zone2
zonecfg:zone2> select anet linkname=net0
zonecfg:zone2:anet> set lower-link=ether0
zonecfg:zone2:anet> set allowed-address=192.0.2.35/27
zonecfg:zone2:anet> set defrouter=192.0.2.33/27
zonecfg:zone2:anet> end
zonecfg:zone2> commit
zonecfg:zone2> exit
```

8. **Reboot and log in to the zone `zone2`.**

```
global# zoneadm -z zone2 reboot
global# zlogin zone2
```

9. **Use Live Zone Reconfiguration to reconfigure `zone3` and set `ether0` as the lower link.**

```
global# zonecfg -z zone3
zonecfg:zone3> select anet linkname=net0
zonecfg:zone3:anet> set lower-link=ether0
zonecfg:zone3:anet> end
zonecfg:zone3> commit
zonecfg:zone3> exit
```

10. **Configure the IP address and default gateway manually for `zone3` because Live Zone Reconfiguration does not support the setting of the `allowed-address` property. Configure `zone3` with the IP addresses that are displayed in Table 2, "IP Addresses Configured for the Zones in the Private Virtual Network Setup," on page 47.**

```
global# zoneadm -z zone3 apply
global# zlogin zone3
zone3# ipadm create-ip net0
zone3# ipadm create-addr -a 192.0.2.36/27 net0/v4
zone3# route -p add default 192.0.2.33/27
```

▼ How to Enable IP Forwarding and NAT (Use Case)

You can enable the private virtual network to send network traffic outside the system by enabling IP forwarding and network address translation (NAT) in the global zone.

1. **Enable IP forwarding in the global zone.**

```
global# ipadm set-ifprop -p forwarding=on -m ipv4 net0
global# ipadm set-ifprop -p forwarding=on -m ipv4 vnic0
```

2. **From the global zone, configure NAT in the `/etc/ipnat.conf` file for the primary interface.**

```
global# cat /etc/ipf/ipnat.conf
map net0 192.0.2.0/2 -> 0/32  portmap tcp/udp auto
map net0 192.0.2.0/27 -> 0/32
```

3. **Start the IP filter service to enable NAT.**

```
global# svcadm enable network/ipfilter
```

4. **(Optional) Check whether you can send the network traffic outside the system by pinging the default router of the system from any of the zones.**

```
# ping 192.0.2.1/27
```

Managing VNICs

This section describes tasks that you can perform on VNICs after performing basic configuration. For information about how to perform basic configuration of VNICs, see "How to Configure VNICs and Etherstubs" on page 30.

You can modify the VLAN ID, the MAC address, and the underlying datalink of a VNIC. Modifying the underlying datalink means moving a VNIC to another datalink. You can either globally modify the attribute of all the VNICs on a datalink or selectively modify the attribute of only specified VNICs.

This section covers the following topics:

- "Displaying VNICs" on page 50
- "Modifying the VLAN IDs of VNICs" on page 54
- "Modifying PVLAN VNICs" on page 56
- "Modifying VNIC MAC Addresses" on page 56
- "Migrating VNICs" on page 58
- "Deleting VNICs" on page 60

Displaying VNICs

To obtain information about the VNICs on your system, use the `dladm show-vnic` command.

EXAMPLE 9 Displaying VNICs on a System

```
# dladm show-vnic
LINK      OVER     SPEED      MACADDRESS          MACADDRTYPE       IDS
vnic1     net0     1000       2:8:20:c2:39:38     random            VID:123
vnic2     net0     1000       2:8:20:5f:84:ff     random            VID:456
```

The output shows the following information:

`LINK`	Virtual datalink, identified by a name.

`OVER`	Physical or virtual datalink over which the VNIC is configured.
`SPEED`	Maximum speed of the VNIC, in megabits per second.
`MACADDRESS`	MAC address of the VNIC.
`MACADDRTYPE`	MAC address type of the VNIC, which can be one of the following: ■ `random` – The random address assigned to the VNIC ■ `factory` – The factory MAC address of the NIC used by the VNIC ■ `fixed` – The MAC address assigned by the user
`VID`	VLAN ID of the VNIC.

You can use any `dladm` command that shows information about datalinks to include information about VNICs if they exist on the system. For example, the `dladm show-link` command displays VNICs with other datalinks. You can use the `dladm show-linkprop` command to display the properties of VNICs.

To obtain information about the datalink property of a single VNIC, specify the VNIC in the following command syntax:

```
# dladm show-linkprop [-p property] vnic
```

EXAMPLE 10 Displaying VNICs That Are Attached to Zones

In this example, information is displayed for the primary datalink and VNICs that are attached to the zones. The primary datalink `net0` is attached to the global zone. The VNICs, `vnic1` and `vnic2`, are attached to `zone1` and `zone2` respectively.

```
# dladm show-link -Z
LINK                ZONE      CLASS     MTU    STATE    OVER
net0                global    phys      1500   up        --
zone1/vnic1         zone1     vnic      1500   up       net0
zone2/vnic2         zone2     vnic      1500   up       net0
```

Displaying VNICs With Multiple MAC Addresses

Multiple MAC addresses are associated with system-created VNICs in Oracle VM Server for SPARC and the `anet` resources in Oracle Solaris Kernel Zones. In Oracle VM Server for SPARC, you need to create a `vnet` with the `alt-mac-addrs` property to support VNICs and zones inside a guest domain. In this case, the system automatically creates a VNIC with multiple MAC addresses. These multiple MAC addresses are obtained from the `vnet` that you created. For more information, see *Oracle VM Server for SPARC 3.1 Administration Guide*.

To support zones or VNICs inside kernel zones, you configure the `anet` resources with multiple MAC addresses. You use the `zonecfg` command to specify multiple MAC addresses to the `anet` resources created for network access in kernel zones. For more information, see the `solaris-kz`(5) man page. For information about configuring kernel zones, see *Creating and Using Oracle Solaris Kernel Zones*.

When multiple MAC addresses are associated with VNICs, one MAC address is used by the virtual network driver. You can use the remaining MAC addresses to create VNICs inside kernel zones or a guest domain. For example, if a VNIC is associated with three MAC addresses, one MAC address is assigned for the virtual network driver. Hence, you can create only two VNICs with the remaining two MAC addresses.

You can use the following command to display multiple MAC addresses associated with VNICs:

```
# dladm show-vnic -m
```

EXAMPLE 11 Displaying VNICs With Multiple MAC Addresses in Kernel Zones

```
# dladm show-vnic -m
LINK                OVER       MACADDRESSES      MACADDRTYPES     IDS
gz_vnic0            net0       2:8:20:d7:27:9d   random           VID:0
zone1/net0          net0       2:8:20:70:52:9    random           VID:0
                               2:8:20:c9:d:4c    fixed
                               2:8:20:70:db:3    random
zone1/net1          net0       0:1:2:3:4:5       fixed            VID:0
                               0:1:2:3:4:6       fixed
```

In this example, kernel zone `zone1` has two `anet` resources: `net0` and `net1`. Both resources have more than one MAC address configured. Therefore, inside kernel zone `zone1`, you can create up to two VNICs on top of the virtual NIC driver `zvnet` associated with datalink `net0`. You can create only one VNIC on top of the virtual NIC driver `zvnet` associated with datalink `net1`.

EXAMPLE 12 Displaying System-Created VNICs With Multiple MAC Addresses

```
# dladm show-vnic -m
LINK                OVER       MACADDRESSES      MACADDRTYPES     IDS
ldoms-vsw0.vport0   net1       0:14:4f:fb:e1:8f  fixed            VID:0,21
                               0:14:4f:f8:6b:9   fixed
                               0:14:4f:fa:48:7f  fixed
ldoms-vsw0.vport1   net1       0:14:4f:f9:1b:8d  fixed            VID:45,44
                               0:14:4f:f9:27:4   fixed
```

In this example, you can create up to two VNICs on top of the guest domain's virtual network driver `vnet` associated with `ldoms-vsw0.vport0`. You can create up to one VNIC on top of the virtual NIC driver `vnet` associated with `ldoms-vsw0.vport1`.

Displaying the Physical and Virtual Link State of Datalinks

The physical link state of a datalink identifies whether the physical device has connectivity with the external network. If the cable is plugged in and the state of the port on the other end of the cable is `up`, then the physical device has connectivity with the external network.

You can use the following commands to display the physical link state of a datalink:

```
# dladm show-phys [link]
```

```
# dladm show-ether [link]
```

For more information, see the `dladm`(1M) man page.

EXAMPLE 13 Displaying the Physical Link State of Datalinks

The following example displays the physical link state of datalinks on a system by using the `dladm show-phys` command.

```
# dladm show-phys
LINK        MEDIA         STATE      SPEED  DUPLEX    DEVICE
net1        Ethernet      down       0      unknown   e1000g1
net2        Ethernet      down       0      unknown   e1000g2
net3        Ethernet      down       0      unknown   e1000g3
net0        Ethernet      up         1000   full      e1000g0
```

The following example displays the physical link state of datalinks on a system by using the `dladm show-ether` command.

```
# dladm show-ether
LINK        PTYPE    STATE    AUTO  SPEED-DUPLEX    PAUSE
net1        current  down     yes   0M              bi
net2        current  down     yes   0M              bi
net3        current  down     yes   0M              bi
net0        current  up       yes   1G-f            bi
```

When multiple VNICs are created over a NIC, a virtual switch is created internally to enable VNICs and the primary datalink to communicate when they are on the same VLAN. These datalinks can communicate with each other even if the physical datalink has no connection with the external network. This forms the virtual link state of the datalink, which can be `up`, `down`, or `unknown`. The virtual link state of a datalink identifies whether a datalink has connectivity with internal networks within the system even if the physical cable is unplugged.

You use the following command to display the virtual link state of a datalink:

```
# dladm show-link [link]
```

EXAMPLE 14 Displaying the Virtual Link State of Datalinks

This example displays the virtual link state of datalinks on a system.

```
# dladm show-link
LINK        CLASS     MTU    STATE    OVER
net0        phys      1500   up       --
net2        phys      1500   down     --
net4        phys      1500   down     --
net1        phys      1500   up       --
net5        phys      1500   up       --
vnic0       vnic      1500   up       net5
vnic1       vnic      1500   up       net5
vnic2       vnic      1500   up       net1
```

Modifying the VLAN IDs of VNICs

VNICs can be configured as VLANs. You need to modify the VLAN IDs of VNICs on a datalink when you want the VNICs to host a specific VLAN's traffic.

The `dladm` subcommand that you use depends on whether you are modifying VLANs or VNICs configured as VLANs:

- For VLANs that are created with the `dladm create-vlan` command, use the `dladm modify-vlan` command. To display these VLANs, use the `dladm show-vlan` command.
- For VLANs that are created with the `dladm create-vnic` command, use the `dladm modify-vnic` command. To display these VNICs, including those with VLAN IDs, use the `dladm show-vnic` command.

You can modify the VLAN ID of a single VNIC or multiple VNICs that are configured on the datalink. You can also modify the VLAN IDs of VNICs as a group by configuring all the VNICs with the same VLAN ID.

If only one VNIC is configured on the datalink, use the following command syntax to modify the VLAN ID of the VNIC:

```
# dladm modify-vnic -v vid -L link
```

where *vid* is the new VLAN ID that you assign to the VNIC.

EXAMPLE 15 Modifying the VLAN ID of a VNIC on a Datalink

In this example, the VLAN ID of `vnic0` that is configured over the datalink `net0` is modified.

```
# dladm modify-vnic -v 123 -L net0
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS          MACADDRTYPE        IDS
vnic0     net0     1000         2:8:20:c2:39:38     random             VID:123
```

If multiple VNICs are configured on the datalink, use the following command syntax to modify the VLAN IDs of the VNICs:

```
# dladm modify-vnic -v vid VNIC
```

Because each VLAN ID is unique for VNICs on the same datalink, you must change the VLAN IDs one at a time.

EXAMPLE 16 Modifying the VLAN ID of Multiple VNICs on a Datalink

In this example, the VLAN IDs of `vnic0`, `vnic1`, and `vnic2` are modified.

```
# dladm modify-vnic -v 123 vnic0
# dladm modify-vnic -v 456 vnic1
# dladm modify-vnic -v 789 vnic2
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS         MACADDRTYPE         IDS
vnic0     net0     1000         2:8:20:c2:39:38    random              VID:123
vnic1     net0     1000         2:8:20:5f:84:ff    random              VID:456
vnic2     net0     1000         2:8:20:5f:84:ff    random              VID:789
```

If each VNIC is configured on a different datalink, use the following command syntax to modify the VLAN ID of VNICs as a group:

```
# dladm modify-vnic -v vid VNIC,VNIC,[...]
```

EXAMPLE 17 Modifying the VLAN IDs of VNICs as a Group

In this example, the VLAN IDs of `vnic0`, `vnic1`, and `vnic2` are modified as a group. These VNICs are configured over the datalinks `net0`, `net1`, and `net2` respectively.

```
# dladm modify-vnic -v 123 vnic0,vnic1,vnic2
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS          MACADDRTYPE        IDS
vnic0     net0     1000         2:8:20:c2:39:38     random             VID:123
```

```
vnic1     net1     1000         2:8:20:5f:84:ff     random            VID:123
vnic2     net2     1000         2:8:20:5f:84:ff     random            VID:123
```

Modifying PVLAN VNICs

You can modify the primary and secondary VLAN IDs and the PVLAN type of PVLAN VNICs by using the `dladm modify-vnic` command. The syntax is as follows:

```
# dladm modify-vnic [-v VLAN-ID[,PVLAN-SVID[,PVLAN-type]] VNIC
```

EXAMPLE 18 Modifying a PVLAN VNIC

The following example modifies the primary VLAN ID to `5`, the secondary VLAN ID to `102`, and the PVLAN type to `isolated`.

```
# dladm show-vnic -v
LINK       VID  SVID  PVLAN-TYPE  OVER
vnic2      4    101   community   net1
# dladm modify-vnic -v 5,102,isolated vnic2
# dladm show-vnic -v
LINK       VID  SVID  PVLAN-TYPE  OVER
vnic2      5    102   isolated    net1
```

For information about the PVLANs, see Chapter 3, "Configuring Virtual Networks by Using Virtual Local Area Networks" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Modifying VNIC MAC Addresses

Any VNIC that a user creates can only have one MAC address. You can modify the MAC address by using the `dladm modify-vnic` command. You can configure the VNICs created for kernel zones with one or more MAC addresses.

You can modify the existing MAC address of a VNIC configured on a datalink. You can either modify the MAC addresses of all the VNICs or selectively modify the MAC addresses of the specified VNICs. You can also modify the VLAN ID and the MAC address of a VNIC simultaneously.

To modify the MAC address of a VNIC, use the following command syntax:

```
# dladm modify-vnic -m MAC-address VNIC
```

where *MAC-address* is the new MAC address that you want to assign to the VNIC.

EXAMPLE 19 Modifying the MAC Address of a VNIC

In this example, `vnic0` is assigned a specific MAC address.

```
# dladm modify-vnic -m 3:8:20:5f:84:ff vnic0
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS         MACADDRTYPE       IDS
vnic0     net0     1000        3:8:20:5f:84:ff     fixed             VID:0
```

To modify the MAC addresses of all the VNICs on a datalink, use the following command syntax:

```
# dladm modify-vnic -m random -L link
```

In this command syntax, the `-m random` option is equivalent to the `-m auto` option. The MAC address is assigned automatically to the VNICs on a random basis.

EXAMPLE 20 Modifying the MAC Addresses of All the VNICs on a Datalink

In this example, the MAC addresses of all the VNICs configured over the datalink `net0` are automatically modified on a random basis.

```
# dladm modify-vnic -m random -L net0
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS           MACADDRTYPE       IDS
vnic0     net0     1000         2:8:20:22:9d:bb      random            VID:0
vnic1     net0     1000         2:8:20:72:2e:9       random            VID:0
vnic2     net0     1000         2:8:20:2f:e5:83      random            VID:0
```

To modify the MAC addresses of VNICs on a selective basis, use the following command syntax:

```
# dladm modify-vnic -m random VNIC,VNIC,[...]
```

For both the global and selective modifications, you specify `random` for the `-m` option.

EXAMPLE 21 Modifying the MAC Addresses of VNICs on Selective Basis

In this example, the MAC addresses of `vnic0` and `vnic2` that are configured over the datalink `net0` are selectively modified.

```
# dladm modify-vnic -m random vnic0,vnic2
# dladm show-vnic
LINK      OVER     SPEED        MACADDRESS         MACADDRTYPE        IDS
```

```
vnic0     net0     1000         2:8:20:2f:e5:83     random            VID:0
vnic1     net0     1000         2:8:20:5f:84:ff     fixed             VID:0
vnic2     net0     1000         2:8:20:2f:e5:83     random            VID:0
```

To modify the VLAN ID and the MAC address of a VNIC simultaneously, use the following command syntax:

```
# dladm modify-vnic -m random -v vid VNIC
```

Caution - Modifying multiple attributes of the VNICs globally might cause unexpected behavior with the VNICs. Instead, modify the multiple attributes of the VNICs separately.

EXAMPLE 22 Modifying the VLAN ID and the MAC Address of a VNIC

In this example, the VLAN ID and the MAC address of `vnic0` are modified simultaneously.

```
# dladm modify-vnic -m random -v 123 vnic0
# dladm show-vnic vnic0
LINK      OVER     SPEED  MACADDRESS        MACADDRTYPE    IDS
vnic0     net0     1000   2:8:20:2f:e5:83   random         VID:123
```

Migrating VNICs

You can move one or more VNICs from one underlying datalink to another underlying datalink without deleting and reconfiguring the VNICs. The underlying datalink can be a physical link, a link aggregation, or an etherstub.

You usually migrate a VNIC in any of the following situations:

- When you need to replace the existing NIC with a new NIC
- When the target NIC has more bandwidth than the existing NIC
- When the target NIC implements certain features in hardware, such as a large receive offload (LRO), a large segment offload (LSO), and checksum

To successfully migrate VNICs, the target datalink to which the VNICs are moved must be able to accommodate the datalink properties of the VNICs. If those properties are not supported, then migration fails and the user is notified. After a successful migration, all the applications that use the VNICs continue to operate normally, provided that the target datalink is connected to the network.

Certain hardware-dependent properties might change after a VNIC migration, such as the datalink state, link speed, and MTU size. The values of these properties are inherited from the datalink to which the VNICs are migrated. You can migrate all the VNICs that are configured over a datalink or selectively migrate the specified VNICs. You can also migrate the VNICs and modify their VLAN IDs simultaneously.

To migrate all the VNICs configured over the source link to the target link, use the following command syntax:

```
# dladm modify-vnic -l target-link -L source-link
```

`-l` *target-link*	Refers to the link over which the VNICs are migrated
`-L` *source-link*	Refers to the link over which the VNICs were previously configured

EXAMPLE 23 Migrating All the VNICs From a Source Link to a Target Link

In this example, all the VNICs from the source link `ether0` are moved to the target link `net1`.

```
# dladm modify-vnic -l net1 -L ether0
# dladm show-vnic
LINK      OVER      SPEED         MACADDRESS         MACADDRTYPE        IDS
vnic0     net1      1000         2:8:20:c2:39:38     random             VID:321
vnic1     net1      1000         2:8:20:5f:84:ff     random             VID:656
vnic2     net1      1000         2:8:20:5f:84:ff     random             VID:0
```

To migrate the specified VNICs configured over the source link to the target link, use the following command syntax:

```
# dladm modify-vnic -l target-link VNIC,VNIC,[...]
```

To perform selective VNIC migration, you need to specify only the target link.

EXAMPLE 24 Migrating Specified VNICs From a Source Link to a Target Link

In this example, `vnic0`, `vnic1`, and `vnic2` are selectively moved to the target link `net1` from the source link `net0`.

```
# dladm modify-vnic -l net1 vnic0,vnic1,vnic2
# dladm show-vnic
LINK      OVER      SPEED         MACADDRESS         MACADDRTYPE        IDS
vnic0     net1      1000         2:8:20:c2:39:38     random             VID:321
vnic1     net1      1000         2:8:20:5f:84:ff     random             VID:656
vnic2     net1      1000         2:8:20:5f:84:ff     random             VID:0
vnic3     net0      1000         2:8:20:5f:84:ff     random             VID:345
```

To modify the VLAN IDs of the VNICs configured over the source link and migrate them to the target link simultaneously, use the following command syntax:

```
# dladm modify-vnic -l target-link -v vid VNIC
```

To assign new VLAN IDs, you must migrate the VNICs one at a time.

EXAMPLE 25 Migrating and Modifying the VLAN IDs of VNICs

In this example, `vnic0`, `vnic1`, and `vnic2` are migrated to the target datalink `net1`. With the migration, the VLAN IDs of all the VNICs are also modified simultaneously.

```
# dladm modify-vnic -l net1 -v 123 vnic0
# dladm modify-vnic -l net1 -v 456 vnic1
# dladm modify-vnic -l net1 -v 789 vnic2
# dladm show-vnic
LINK      OVER      SPEED        MACADDRESS         MACADDRTYPE        IDS
vnic0     net1      1000        2:8:20:c2:39:38     random             VID:123
vnic1     net1      1000        2:8:20:5f:84:ff     random             VID:456
vnic2     net1      1000        2:8:20:5f:84:ff     random             VID:789
```

When you migrate VNICs from the source link to the target link, randomly assigned MAC addresses are unaffected and retained by their respective VNICs after migration. See Example 25, "Migrating and Modifying the VLAN IDs of VNICs," on page 60.

However, the MAC address will change if the VNIC is using a factory MAC address from the source link. If you do not specify a MAC address during migration, the factory MAC address of the VNIC is replaced by a randomly assigned MAC address. If you specify a MAC address with `-m` during migration, the factory MAC address of the VNIC is replaced by the specified MAC address.

You have multiple MAC addresses associated with VNICs created by kernel zones. When you migrate VNICs created by kernel zones, all the multiple MAC addresses associated with VNICs are migrated to the target NIC.

Deleting VNICs

This section describes how to delete a VNIC.

▼ How to Delete a VNIC

1. **Become an administrator.**

2. **(Optional) Check whether the VNIC is busy.**

   You can delete a VNIC only when it is not busy. A VNIC can be busy for multiple reasons. You need to perform the following steps to check whether the VNIC busy:

- **Check whether the VNIC is plumbed and associated with an IP address.**

  ```
  # ipadm show-if
  # ipadm show-addr
  ```

  If the VNIC is plumbed and associated with IP addresses, remove the IP interface.

  ```
  # ipadm delete-ip interface
  ```

- **Check whether there are any flows configured over the VNIC.**

  ```
  # flowadm
  ```

  If flows are configured over the VNIC, remove the flow.

  ```
  # flowadm remove-flow flowname
  ```

- **Check whether the VNIC is assigned to a zone.**

  ```
  # dladm show-link -Z
  ```

  For more information about how to delete a VNIC that is attached to a zone, see "How to Delete a VNIC Attached to a Zone" on page 62.

- **Check whether the VNIC is created by the system.**

  ```
  # dladm show-vnic
  ```

  Only a system-created VNIC contains a hyphen (-), which helps you to differentiate between a system-created VNIC and a user-created VNIC. You cannot modify, rename, plumb, or delete system-created VNICs.

- **Check whether the VNIC is snooped.**

  ```
  # snoop
  # tshark
  ```

  If the VNIC is snooped by using the `snoop` command, kill the process.

  ```
  # pkill snoop
  ```

  If the VNIC is snooped by using the `tshark` command, kill the process.

  ```
  # pkill tshark
  ```

3. **Delete the VNIC.**

```
# dladm delete-vnic VNIC
```

How to Delete a VNIC Attached to a Zone

This procedure assumes that the VNIC is attached to a zone. You must be in the global zone to perform this procedure.

1. **Halt the zone.**

   ```
   global# zoneadm -z zone halt
   ```

   Note - To determine the links used by a zone, use the `dladm show-link` command.

   ---

2. **Remove or detach the VNIC from the zone.**

   ```
   global# zonecfg -z zone remove net physical=VNIC
   ```

3. **Delete the VNIC from the system.**

   ```
   global# dladm delete-vnic VNIC
   ```

4. **Reboot the zone.**

   ```
   global# zoneadm -z zone boot
   ```

Example 26 Deleting a VNIC Attached to a Zone

In this example, `vnic1` is removed from `zoneB` and from the system.

```
global# dladm show-link
LINK            CLASS   MTU    STATE   OVER
net0            phys    1500   up      --
net2            phys    1500   up      --
net1            phys    1500   up      --
net3            phys    1500   up      --
zoneA/net0      vnic    1500   up      net0
zoneB/net0      vnic    1500   up      net0
vnic0           vnic    1500   up      net1
zoneA/vnic0     vnic    1500   up      net1
vnic1           vnic    1500   up      net1
zoneB/vnic1     vnic    1500   up      net1

global# zoneadm -z zoneB halt
global# zonecfg -z zoneB remove net physical=vnic1
```

```
global# dladm delete-vnic vnic1
global# zoneadm -z zoneB boot
```

Using Single Root I/O Virtualization With VNICs

Starting with the Oracle Solaris 11.2 release, you can manage network devices that support single root I/O virtualization (SR-IOV) by using the `dladm` command. SR-IOV is a standard that is implemented in the hardware and it enables efficient sharing of Peripheral Component Interconnect Express (PCIe) devices among virtual machines. For more information, see Chapter 21, "SR-IOV Drivers" in *Writing Device Drivers for Oracle Solaris 11.3*.

For information about using Oracle VM Server for SPARC Direct I/O (DIO) and SR-IOV features, and assigning Direct I/O devices or SR-IOV virtual functions to logical domains, refer to the MOS article Oracle VM Server for SPARC PCIe Direct I/O and SR-IOV Features (Doc ID 1325454.1) (`https://support.oracle.com/epmos/faces/DocumentDisplay?_afrLoop=181092870858172&id=1325454.1&_afrWindowMode=0&_adf.ctrl-state=fx25uncl3_53`).

Enabling the SR-IOV Mode of Datalinks

In Oracle Solaris, you can associate the virtual function (VF) of a network device that supports SR-IOV with a VNIC or a VLAN. A VF VNIC is a VNIC that owns a dedicated VF. A VF VNIC differs from a regular VNIC in the sharing of resources. A regular VNIC needs to share resources with other regular VNICs, but a VF VNIC need not share resources. Each VF is a separate hardware resource for the VF VNIC.

You can create VF VNICs only over datalinks that support the SR-IOV mode. By default, the SR-IOV mode of a datalink is disabled. You can enable the SR-IOV mode of a datalink by setting the `iov` property to `on`. For information about creating VF VNICs after you enable the SR-IOV mode of a datalink, see "Creating VF VNICs" on page 64.

You can check the SR-IOV mode of a datalink by specifying the link property `iov` with the `dladm show-linkprop` command. If the value under the `EFFECTIVE` column of the output is `off`, the SR-IOV mode of the datalink is disabled.

The following example shows how you can check the SR-IOV mode of the datalink `net0`.

```
# dladm show-linkprop -p iov net0
LINK     PROPERTY   PERM     VALUE     EFFECTIVE     DEFAULT      POSSIBLE
net0     iov        rw       auto      off           auto         auto,on,off
```

In this example, the SR-IOV mode of the datalink `net0` is disabled. The output shows the following information:

`VALUE`	Specifies the value that you have set for the `iov` link property. If you have not modified the `iov` link property, the default value of the `iov` link property is `auto`. The value of `auto` means that the OS determines whether the SR-IOV mode is enabled by default on a particular physical datalink.
`EFFECTIVE`	The actual SR-IOV mode of the datalink. By default, all SRIOV-capable NICs show the value `off` under the `EFFECTIVE` column.

You can enable the SR-IOV mode of the datalink `net0` by setting the `iov` property to `on` as follows:

```
# dladm set-linkprop -p iov=on net0
# dladm show-linkprop -p iov net0
LINK     PROPERTY   PERM     VALUE     EFFECTIVE     DEFAULT      POSSIBLE
net0     iov        rw       on        on            auto         auto,on,off
```

Similarly, you can disable the SR-IOV mode of a datalink by setting the `iov` link property to `off`. For more information about the `dladm` command, see the `dladm`(1M) man page.

Creating VF VNICs

To create a VF VNIC on a datalink, you need to enable the SR-IOV mode of a datalink. For more information, see "Enabling the SR-IOV Mode of Datalinks" on page 63. After you enable the SR-IOV mode of a datalink, VFs are automatically allocated to VNICs when you create VNICs by using the `dladm create-vnic` command. Similarly, VFs are automatically allocated to VLANs when you create VLANs by using the `dladm create-vlan` command.

You can also explicitly specify whether a VF needs to be allocated to a VNIC or a VLAN by specifying the `iov` VNIC link property with the `dladm create-vnic` or the `dladm create-vlan` commands.

You use the following command syntax to explicitly create a VF VNIC:

```
# dladm create-vnic [-p iov=value] -l link VNIC
```

When you are creating a VF VNIC, specifying the `iov` VNIC link property is optional. If you do not specify the `iov` VNIC link property, then the default value `inherit` is assigned to this property. You can specify the following values for the `iov` VNIC link property:

`inherit`	Default value of the `iov` VNIC link property. Determines whether a VF needs to be allocated based on the effective `iov` property value of the underlying datalink: ■ `off` – Does not allocate a VF for a VNIC. ■ `on` – Tries to allocate a VF for a VNIC. If not possible, a regular VNIC is created.
`on`	Allocates a VF. If a VF is not found, the creation of a VNIC fails.
`off`	Creates a VNIC without a VF.

The effective value of a datalink property is the value displayed under the `EFFECTIVE` column when you use the `dladm show-linkprop` command for a datalink.

The difference between the `iov` VNIC link property and other datalink properties is that you can specify the `iov` VNIC link property only when you are creating a VNIC or a VLAN. You cannot modify the `iov` VNIC link property after you create a VNIC or a VLAN.

The `iov` VNIC link property has an effective value that indicates whether a VF is allocated for the VNIC or VLAN. The value `on` under the `EFFECTIVE` column means that the VF is allocated and the value `off` under the `EFFECTIVE` column means that the VF is not allocated.

EXAMPLE 27 Creating a VF VNIC

The following example shows how to create the VF VNIC `vfvnic1` and the regular VNIC `vnic1` on the datalink `net0` by explicitly specifying the `iov` VNIC link property. This example assumes that you have enabled the SR-IOV mode of the datalink `net0`.

```
# dladm show-linkprop -p iov net0
LINK     PROPERTY  PERM    VALUE  EFFECTIVE  DEFAULT   POSSIBLE
net0     iov       rw      on     on         auto      auto,on,off
# dladm create-vnic -l net0 vfvnic1
# dladm show-linkprop -p iov vfvnic1
LINK      PROPERTY   PERM   VALUE    EFFECTIVE   DEFAULT    POSSIBLE
vfvnic1   iov        r-     inherit  on          inherit    inherit,on,off
# dladm create-vnic -p iov=off -l net0 vnic1
# dladm show-linkprop -p iov vnic1
LINK    PROPERTY   PERM   VALUE    EFFECTIVE   DEFAULT     POSSIBLE
vnic1   iov        r-     off      off         inherit     inherit,on,off
```

This example provides the following information:

- You need to set the `iov` property for the datalink `net0` to `on` before you create the VF VNICs.

- If you do not specify a value for the `iov` property when creating a VNIC, then the default value `inherit` is assigned to the `iov` property. The VF VNIC `vfvnic1` is created with a VF.
- If you explicitly specify the value `off` for the `iov` property when creating a VNIC, a regular VNIC is created without a VF even though the `iov` property of the underlying datalink `net0` is `on`. The VNIC `vnic1` is created without a VF.

Migrating VF VNICs

You can move VF VNICs or VF VLANs from one datalink to another datalink. Note the following requirements:

- The target datalink must support SR-IOV and the `iov` property must be set to `on`. For more information about how to check the status of the `iov` property for a datalink, see "Enabling the SR-IOV Mode of Datalinks" on page 63.
- A VF must be available on the target datalink. For more information about how to check the number of VFs available on a datalink, see "Displaying VF Information" on page 68.

If these requirements are not met, then the VF VNIC is migrated to the target datalink as a regular VNIC without a VF.

If you migrate a VF VNIC, that was created by specifying `iov=inherit`, the migration succeeds even if the target datalink does not support the `iov` property or the `iov` property is disabled. If you try to migrate a VF VNIC, that was created with `iov=on`, the migration succeeds only if the SR-IOV mode is enabled on the target datalink.

For more information about how to migrate a VNIC, see "Migrating VNICs" on page 58.

Configuring Oracle Solaris Kernel Zones With SR-IOV VFs

You can configure the `anet` resource of a kernel zone with the available SR-IOV VF by setting the `zonecfg` property `iov`.

`auto`	Allocates a VF if it is available. Otherwise, uses a paravirtual device.
`on`	Allocates a VF. If a VF is not available, the `anet` resource creation fails. For information about how to check the available VFs on a datalink, see Example 29, "Displaying VFs Information for Datalinks," on page 69.

`off`	VF is not allocated. The `off` value is the default value for the `iov` property.

For more information about SR-IOV on kernel zones, see "Managing Single-Root I/O NIC Virtualization on Kernel Zones" in *Creating and Using Oracle Solaris Kernel Zones*.

EXAMPLE 28 Configuring Kernel Zones With SR-IOV VFs

This example shows how to configure the `anet` resource of the kernel zone `kz1` with a SR-IOV VF.

```
# zonecfg -z kz1
zonecfg:kz1> select anet id=0
zonecfg:kz1:anet> set iov=auto
zonecfg:kz1:anet> end
zonecfg:kz1> exit
```

If you configure the `anet` resource over the lower datalink `net1`, you must ensure that the `iov` link property for `net1` is set to `on` before booting the kernel zone `kz1`. You can check the `iov` property for the lower datalink `net1`.

```
# dladm show-linkprop -p iov net1
LINK     PROPERTY     PERM   VALUE     EFFECTIVE    DEFAULT   POSSIBLE
net1     iov          rw     off       off          auto      auto,on,off
```

The output shows that the value of the `iov` property is `off` for the lower datalink `net1`. Set the `iov` property to `on`.

```
# dladm set-linkprop -p iov=on net1
```

After you boot the kernel zone, a VF is successfully allocated to the `anet` resource. Verify whether the VF is added to the kernel zone `kz1`.

```
# zlogin kz1
kz1# dladm show-phys
LINK              MEDIA                STATE      SPEED  DUPLEX    DEVICE
net0              Ethernet             up         10000  full      ixgbevf0
```

The limitations of using the `iov` property with kernel zones are as follows:

- You cannot use the `iov` property with native zones because the `iov` property does not provide any benefit for native zones.
- You cannot set the `iov` property to `auto` or `on` if the `anet` resource is configured with any of the following properties:
  - `allowed-address`

  - `configure-allowed-address`
  - `defrouter`
  - `allowed-dhcp-cids`
  - `link-protection`
  - `vlan-id`
  - `txrings`
  - `rxrings`
  - `mtu`
  - `rxfanout`
  - `vsi-typeid`
  - `vsi-vers`
  - `vsi-mgrid`
  - `etsbw-lcl`
  - `cos`
  - `evs`
  - `vport`

  Similarly, you cannot set these properties if you have already set the `iov` property to `auto` or `on`.
- After you create a VF `anet` resource, it appears as a VNIC in the host similar to the other regular `anet` resources. The only difference is that you cannot modify any link property for the VF `anet` resource.
- You can add multiple VF `anet` resources to a kernel zone. However, the VF physical links that appear in a kernel zone cannot be aggregated.
- If you set the `iov` property to `on` or `auto`, the kernel zone does not support live migration and suspend or resume operations. The `zoneadm migrate` or `zoneadm suspend` commands fail.

Displaying VF Information

You can display information about the availability of VFs on a datalink by using the following command:

```
# dladm show-phys -V
```

The output shows the following information:

`LINK`	Name of the datalink.
`VFS-AVAIL`	Number of VFs available on a datalink that can be assigned to a VNIC. If the datalink does not support SR-IOV, `VFS-AVAIL` is shown as `--`.
`VFS-INUSE`	Number of VFs that are used by a datalink. If the datalink does not support SR-IOV, `VFS-INUSE` is shown as `--`.
`FLAGS`	The `l` flag indicates that the datalink is managed by Oracle VM Server for SPARC.

EXAMPLE 29 Displaying VFs Information for Datalinks

```
# dladm show-phys -V
LINK      VFS-AVAIL      VFS-INUSE      FLAGS
net0      30             1              -----
net1      0              0              l----
net2      --             --             -----
```

In this example, the datalink `net0` has 30 available VFs and one VF in use. The datalink `net1` has zero (`0`) available VFs and it is currently being used by Oracle VM Server for SPARC. The datalink `net2` does not support SR-IOV.

You can display the VF devices assigned to VNICs on a system by using the following command:

```
# dladm show-vnic -V
```

The output shows the following information:

`LINK`	Name of the VNIC.
`VF-ASSIGNED`	VF device assigned to the VNIC. If the VNIC does not have a VF, `VF-ASSIGNED` is shown as `--`.

EXAMPLE 30 Displaying VF Devices Assigned to VNICs

```
# dladm show-vnic -V
LINK        VF-ASSIGNED
vnic1       ixgbevf0
vnic2       --
vnic3       ixgbevf1
```

In this example, the VF device `ixgbevf0` is assigned to `vnic1`. The VNIC `vnic2` does not have an allocated VF device. The VF device `ixgbevf1` is assigned to `vnic3`.

Setting Hardware SLA Properties for VF VNICs

If a NIC supports hardware SLAs that enable you to set SLA properties for VF VNICs, the SLA implementation is offloaded to the NIC automatically by the system. This behaviour helps you to save CPU cycles.

You can use the `dladm show-linkprop` command with the `-H` option to check the capabilities of the underlying datalink. The command syntax is:

```
# dladm show-linkprop -H -p prop link
```

where *prop* refers to the SLA properties such as `maxbw`, `priority`, and `bwshare`.

The output displays the following columns:

`HWPOSSIBLE`	Displays a value if there is hardware support for the property. The physical NIC does not support the property if the value is displayed as `--`.
`SWPOSSIBLE`	Displays a value if there is software support in the networking stack for the property. The datalink does not support the property if the value is displayed as `--`.

Note - For both the `HWPOSSIBLE` and `SWPOSSIBLE` columns, the step value requirement for the value is displayed after the number range followed by a colon (:), for example, `50-40000:50`. Currently, only the `maxbw` property shows a value for the step value.

`MODE`	Displays the current mode that is used for the datalink to implement the property. The possible values are `sw` for software only, `hw` for hardware only, and `none` for no support. Note that `MODE` can be `none` even though there is hardware or software support.
`HWFLAGS` or `SWFLAGS`	Displays `o` for outbound, `i` for inbound, and `oi` for outbound and inbound. Currently, these flags are displayed for the SLA properties `maxbw`, `bwshare`, and `priority`.

If the datalink supports hardware SLAs, you can set the hardware SLA properties on the datalink by using the following command:

```
# dladm set-linkprop -p prop=value link
```

where *prop* refers to the SLA properties such as `maxbw`, `priority`, and `bwshare`.

EXAMPLE 31 Displaying the Hardware and Software Capabilities of Datalinks

The following example shows the output of the `maxbw` property for the VF VNIC `z1/net1` that is configured over the Intel XL710 10/40 Gigabit Ethernet controller NIC. The output shows that there is both hardware and software support because values are displayed under the columns `HWPOSSIBLE` and `SWPOSSIBLE`.

```
# dladm show-linkprop -H -p maxbw z1/net1
LINK          PROPERTY       MODE  HWPOSSIBLE   HWFLAGS SWPOSSIBLE     SWFLAGS
z1/net1       maxbw          hw    50-40000:50  o       0-40000:0.001  oi
```

The following example shows the output of the `maxbw` property for the VF VNIC `z2/net2` that is configured over the Niantic NIC. The output shows that there is only software support for the VF VNIC `z2/net2` because values are displayed under the column `SWPOSSIBLE`.

```
# dladm show-linkprop -H -p maxbw z2/net2
LINK          PROPERTY       MODE  HWPOSSIBLE   HWFLAGS SWPOSSIBLE     SWFLAGS
z2/net2       maxbw          none  --                   0-10000:0.001  oi
```

The following example shows the output of the `bwshare` property for the VF VNIC `z1/net1` that is configured over the Intel XL710 10/40 Gigabit Ethernet controller NIC. For information about the `bwshare` property, see "Bandwidth Share for VNICs" on page 72. The output shows that there is only hardware support for the VF VNIC `z1/net1` for the `bwshare` property. The values are displayed under the column `HWPOSSIBLE`.

```
# dladm show-linkprop -H -p bwshare z1/net1
LINK          PROPERTY       MODE  HWPOSSIBLE   HWFLAGS SWPOSSIBLE     SWFLAGS
z1/net1       bwshare        hw    1-100        o       --
```

The following example shows the output of the `bwshare` property for the VF VNIC `z2/net2` that is configured over the Niantic NIC. The output shows that there is no support for the VF VNIC `z2/net2` for the `bwshare` property. The values are not displayed under the columns `HWPOSSIBLE` and `SWPOSSIBLE`.

```
# dladm show-linkprop -H -p bwshare z2/net2
LINK          PROPERTY       MODE  HWPOSSIBLE   HWFLAGS SWPOSSIBLE     SWFLAGS
z2/net2       bwshare        none  --                   --
```

EXAMPLE 32 Setting Maximum Bandwidth for a VF VNIC

The following example shows how to set the `maxbw` property for the VF VNIC `z1/net21`.

```
# dladm set-linkprop -p maxbw=20 -t z1/net21
# dladm show-linkprop -p maxbw z1/net21
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
z1/net21 maxbw           rw   20           50           --        --
```

In certain cases, the effective value for the `maxbw` property can be different from the set value for the VF VNIC that is configured over a hardware SLA capable link as shown in this example.

Bandwidth Share for VNICs

Bandwidth share for a VNIC is the minimum share of the bandwidth that the VNIC will get when there is competition from other VNICs on the same datalink. You use the `bwshare` property to allocate the bandwidth share for a VNIC. You can allocate the bandwidth share only on the datalink that supports the `bwshare` property. Currently, only the Intel XL710 10/40 Gigabit Ethernet controller NIC supports the `bwshare` property. You can check whether a datalink supports the `bwshare` property by using the `dladm show-linkprop` command. See Example 33, "Determining Whether a Datalink Supports the `bwshare` Property," on page 73.

Note that the bandwidth is allocated among all the active VNICs. The amount of bandwidth that is allocated to a VNIC is proportional to the bandwidth share that is set for the VNIC. For example, consider two VNICs, `vnic1` and `vnic2`, configured on a 1 gigabits per second (Gbps) link. You set the `bwshare` property on `vnic1` and `vnic2` as follows:

```
# dladm set-linkprop -p bwshare=40 vnic1
# dladm set-linkprop -p bwshare=10 vnic2
```

In this example, the bandwidth share of `vnic1` is `40` and `vnic2` is `10`. Because the VNICs are configured on a 1 Gbps link, `vnic1` can use up to 800 megabits per second (Mbps) of bandwidth (1Gbps * 40/(40+10)) and `vnic2` can use up to 200 Mbps of bandwidth (1Gbps * 10/(40+10)).

This example assumes that both the VNICs have network traffic to consume their share of the bandwidth. However, if `vnic1` uses only 100 Mbps, then `vnic2` can use up to 900 Mbps. By using bandwidth shares, no bandwidth is wasted when there is a VNIC that can use the bandwidth. At the same time, bandwidth shares ensure an allocated share for a VNIC when there is competition from other VNICs.

Considerations for the `bwshare` Property

Note the following considerations when using the `bwshare` property:

- You can assign a value from `1` to `100` for the `bwshare` property. The value is a relative share value and does not indicate a percentage of the bandwidth. The value can be indicated as a percentage if you keep the sum of the values for the `bwshare` property for all the VNICs on a link at or below `100`.

- For the `dladm show-linkprop` command output, the effective value for the `bwshare` property is displayed as a percentage. The effective value is the minimum percentage of the bandwidth guaranteed to the VNIC when there is competition from other VNICs on the same datalink. The effective value changes depending on the other VNICs that are configured on the datalink.
- If you have set the `maxbw` property for the VNIC, the traffic is limited by the `maxbw` value. The `maxbw` property is enforced on the VNIC before the `bwshare` property is applied.
- You can have VNICs that are set with the `bwshare` property and VNICs that are not set with `bwshare` property on the same datalink. In this case, the share of the bandwidth is undefined for the VNICs that are not set with the `bwshare` property. There is no change to the current behavior, if you have not set the `bwshare` on any VNIC on a link.

EXAMPLE 33 Determining Whether a Datalink Supports the `bwshare` Property

The following example shows how to check whether a datalink supports the `bwshare` property. In this example, the `z1/net1` datalink is a VF VNIC. The value `1-100` under the `POSSIBLE` column in the output indicates that the underlying datalink supports the `bwshare` property.

```
# dladm show-linkprop -p bwshare
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
z1/net1  bwshare         rw   --           --           --        1-100
```

The following example shows the output for a `net0` datalink that does not support the `bwshare` property.

```
# dladm show-linkprop -p bwshare
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
net0     bwshare         r-   --           --           --        --
```

EXAMPLE 34 Setting the `bwshare` Bandwidth Property for a VNIC

The following example shows how to set the `bwshare` property for the VF VNIC `z1/net1`.

```
# dladm set-linkprop -t -p bwshare=60 z1/net1
# dladm show-linkprop -p bwshare
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
z1/net1  bwshare         rw   60           100%         --        1-100
```

The value under the `EFFECTIVE` column indicates that the VNIC `z1/net1` uses `100%` of the bandwidth. However, the effective value changes when you set the `bwshare` property for the VNIC `z1/net2` configured on the same underlying datalink.

```
# dladm show-linkprop -p bwshare
LINK      PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
z1/net1   bwshare         rw   60           50%          --        1-100
z1/net2   bwshare         rw   60           50%          --        1-100
```

The output shows that the effective value for `z1/net1` has changed from `100%` to `50%`.

Interaction of the `bwshare` Property With DCB Bandwidth Shares

The `etsbw_lcl` property supports the setting of the bandwidth share as a fixed percentage of the bandwidth of the physical NIC. However, it is supported only if the NIC is in DCB mode. DCB mode is not `on` by default and DCB is only used when the switch supports DCB.

You cannot set the `bwshare` property if the NIC is in DCB mode. The `bwshare` property is not effective if you set the `bwshare` property and then set DCB mode to `on`. In this case, the `EFFECTIVE` value is displayed as `--` for the `dladm show-linkprop` command output.

Bandwidth Share for VNIC `anet` Resources

You can set the `bwshare` property for a VNIC `anet` resource that is configured with a zone. The `bwshare` property does not have a default value. You can assign a value from `1` to `100`. The booting of the zone fails if you specify a lower link that does not support the `bwshare` property. For information about how to check whether a link supports `bwshare`, see Example 33, "Determining Whether a Datalink Supports the `bwshare` Property," on page 73.

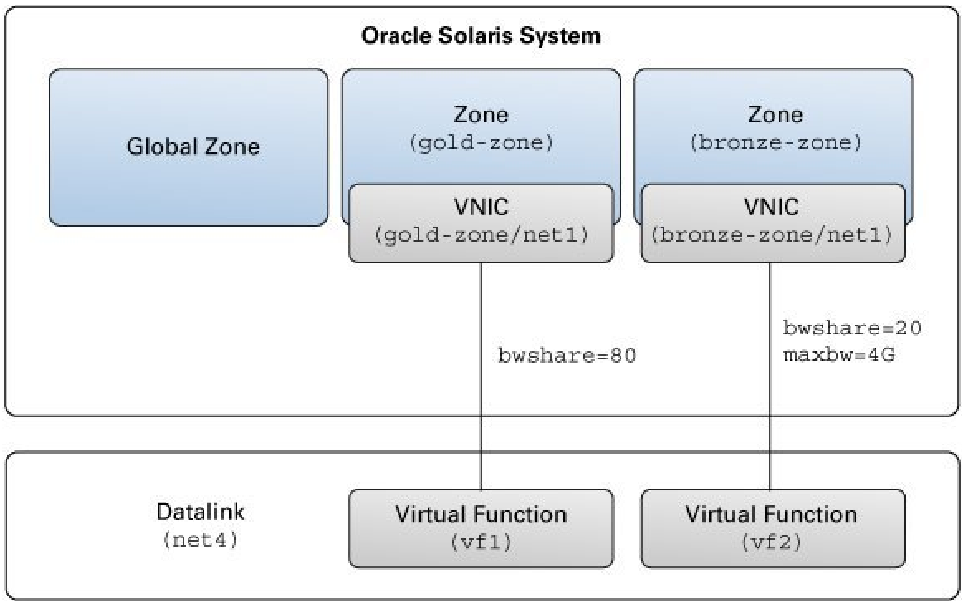
Use Case: Offloading Hardware SLAs to a NIC

Objective - This use case shows how to configure two kernel zones with VF VNICs and offload the SLAs of the VF VNICs to the underlying physical NIC.

Typically, you cannot set SLA properties such as `maxbw` and `priority` on the VF VNIC because the VF VNIC bypasses the global zone. However, you can offload the SLA implementation to the NIC if it is supported by the NIC. The Intel XL710 10/40 Gigabit Ethernet controller NIC supports the offloading of SLAs and supports bandwidth shares in addition to the `maxbw` property. For information about bandwidth shares, see "Bandwidth Share for VNICs" on page 72.

The following figure shows the Oracle Solaris system setup used in this use case.

FIGURE 7 Use Case: Kernel Zones With SR-IOV VF VNICs



The setup is as follows:

- An Oracle Solaris system with a global zone.
- The datalink `net4`, which is configured over the Intel XL710 10/40 Gigabit Ethernet controller NIC with 10 Gbps bandwidth.
- Two kernel zones: `gold-zone` and `bronze-zone`.
- `gold-zone` is assigned a bandwidth share of 80% (`bwshare=80`). The kernel zone `bronze-zone` is assigned a bandwidth share of 20% (`bwshare=20`) and maximum bandwidth of 4 Gbps (`maxbw=4G`).

▼ How to Offload Hardware SLAs to a NIC (Use Case)

You need to perform the following steps to offload the SLA properties to the NIC:

1. **Set the `iov` property for the datalink `net4` to `on` before you create the VF VNICs.**

```
# dladm set-linkprop -p iov=on net4
```

2. **Check whether the datalink `net4` supports the `bwshare` property.**

```
# dladm show-linkprop -H -p bwshare net4
LINK     PROPERTY        MODE HWPOSSIBLE    HWFLAGS SWPOSSIBLE SWFLAGS
net4     bwshare         none 1-100         --      --         --
```

The output shows that the physical datalink `net4` supports the `bwshare` property because the value `1-100` is displayed under the column `HWPOSSIBLE`.

3. **Create a VF VNIC for `gold-zone` and set the bandwidth share to `80`.**

```
# zonecfg -z gold-zone
zonecfg:gold-zone> add anet
zonecfg:gold-zone:anet> set lower-link=net4
zonecfg:gold-zone:anet> set iov=on
zonecfg:gold-zone:anet> set bwshare=80
zonecfg:gold-zone:anet> end
zonecfg:gold-zone> verify
zonecfg:gold-zone> commit
zonecfg:gold-zone> exit
```

4. **Create a VF VNIC for `bronze-zone` and set the bandwidth share to `20` and the maximum bandwidth to `4G`.**

```
# zonecfg -z bronze-zone
zonecfg:bronze-zone> add anet
zonecfg:bronze-zone:anet> set lower-link=net4
zonecfg:bronze-zone:anet> set iov=on
zonecfg:bronze-zone:anet> set bwshare=20
zonecfg:bronze-zone:anet> set maxbw=4G
zonecfg:bronze-zone:anet> end
zonecfg:bronze-zone> verify
zonecfg:bronze-zone> commit
zonecfg:bronze-zone> exit
```

5. **Boot the kernel zones.**

```
# zoneadm -z gold-zone boot
# zoneadm -z bronze-zone boot
```

6. **Check the bandwidth share of the VF VNICs.**

```
# dladm show-linkprop -p bwshare
LINK            PROPERTY    PERM  VALUE     EFFECTIVE    DEFAULT   POSSIBLE
gold-zone/net1  bwshare     rw    80        80%          --        1-100
```

```
bronze-zone/net1 bwshare     rw    20        20%          --        1-100
```

Note - In this use case, the total bandwidth share is kept at 100. A relative share is assigned to the VF VNICs if the total bandwidth share exceeds 100. For more information, see the `dladm(1M)` man page.

7. **Check the maximum bandwidth allocated to the VF VNICs.**

```
# dladm show-linkprop -p maxbw
LINK              PROPERTY    PERM  VALUE      EFFECTIVE    DEFAULT    POSSIBLE
gold-zone/net1    maxbw       rw    --         --           --         --
bronze-zone/net1  maxbw       rw    4000       4000         --         --
```

Creating and Viewing Paravirtualized IPoIB Datalinks in Kernel Zones

Paravirtual (PV) drivers are high-performance network and disk drivers that significantly reduce the overhead of the traditional implementation of I/O device emulation. These drivers provide improved network performance, disk throughput, and system efficiency because these drivers do no not emulate other devices such as physical NICs. The paravirtualized network driver `ZVNET` for Oracle Solaris Kernel Zones, interact with the hypervisor in the host OS through hypercall to achieve low-delay and high-throughput network performance.

Starting with Oracle Solaris 11.3, the paravirtualized IPoIB datalink is created as an `anet` resource in Oracle Solaris Kernel Zone and you can configure this datalink by using the `zonecfg` command. The `anet` resource creates an IPoIB VNIC when the kernel zone boots up. The IPoIB VNIC is created over a partition of the lower link Infiniband host channel adapter (IB HCA) and the port tuple in the global zone. Each IPoIB VNIC has one-to-one match and communicates with paravirtualized IPoIB datalink in the kernel zone. Each of these VNICs have a unique MAC address and can have a unique or different partition key (`pkey`). For each `anet` resource, you can configure the mode over which the IPoIB datalinks are run. Connected mode (CM) and unreliable datagram (UD) mode are supported and you can configure these modes by using the using the `zonecfg` command. For more information, see "Resource Type Properties" in *Oracle Solaris Zones Configuration Resources*.

Note - You cannot create an IPoIB VNIC over the paravirtualized IPoIB datalink.

To display the configured IPoIB datalinks within the kernel zone, use the `dladm` command.

EXAMPLE 35 Creating a Paravirtualized IPoIB Datalink

You create a paravirtualized IPoIB datalink by creating an automatic network (`anet`) in the kernel zone and specifying the mandatory properties `lower-link` and `pkey`. Set the property `lower-link` to one of the valid IB partitions and set `pkey` to one of the partition keys provided by that partition. The property `linkmode`, which can be either `cm` or `ud`, is optional. If you do not specify a value, the value is set to `cm` by default.

```
# zonecfg -z kzone0
zonecfg:kzone0> add anet
zonecfg:kzone0:anet> set lower-link=net1
zonecfg:kzone0:anet> set pkey=0x8001
zonecfg:kzone0:anet> set linkmode=cm
zonecfg:kzone0:anet> end

# zoneadm -z kzone0 boot
```

EXAMPLE 36 Displaying Physical Device Information in Kernel Zones

The following example displays the physical device and attributes of all physical datalinks in a kernel zone including the Infiniband devices.

```
root@solariskzone0:~# dladm show-phys
LINK             MEDIA                STATE      SPEED DUPLEX    DEVICE
net0             Ethernet             up         1000  full      zvnet0
net1             Infiniband           up         32000 full      zvnet1
```

The following example displays the physical device and all the key attributes of physical links in a kernel zone.

```
root@solariszone1:~# dladm show-phys -o all
LINK   MEDIA        STATE    SPEED DUPLEX    DEVICE    VFS-AVAIL   VFS-INUSE   FLAGS
net0   Ethernet       up     1000  full      zvnet0     --          --         -----
net1   Infiniband     up     32000 full      zvnet1     --          --         -----
```

EXAMPLE 37 Displaying MAC Addresses for the Physical Device

The following example displays the MAC addresses for the physical device in a kernel zone.

```
root@solariszone1:~# dladm show-phys -m
LINK                SLOT     ADDRESS            INUSE  CLIENT
net0                primary  2:8:20:5:32:5a      yes    net0
net1                primary  80:0:0:4a:fe:80:... yes    net1
```

EXAMPLE 38 Displaying the IPoIB VNIC in the Host

The following example displays the IPoIB VNIC in the host.

```
root@solaris:~# dladm show-vnic
LINK            OVER     SPEED  MACADDRESS      MACADDRTYPE IDS
kzone1/net0     net0     1000   2:8:20:5:32:5a  random      VID:0
kzone1/net1     net4     32000 80:0:0:4a:fe:..  fixed       PKEY:0x8001
```

In this example, the notation `PKEY` in the `IDS` field indicates that the VNIC is an IPoIB VNIC.

The following example displays the MAC addresses of the IPoIB VNICs.

```
root@solaris:~# dladm show-vnic -o macaddress
MACADDRESS
2:8:20:5:32:5a
80:0:0:4a:fe:80:0:0:0:0:0:0:0:21:28:0:1:a0:e5:55
```

EXAMPLE 39 Displaying Datalinks in the Host

The following example displays the data links in the host including the IPoIB VNIC created on the kernel zone.

```
root@solaris:~# dladm show-link

LINK                CLASS     MTU    STATE    OVER
net0                phys      1500   up       --
net1                phys      1500   unknown  --
kzone1/net0         vnic      1500   up       net0
kzone1/net1         vnic      65520  up       net1
```

For more information, see the `dladm`(1M) man page.

Configuring a Virtual Network Interface

Virtual network interface is a software-only interface that does not have any hardware associated with it. This interface does not send or receive any data because there is no physical hardware associated with it. This interface provides a datalink provider interface (DLPI) and identifies itself with an IP address with a private media type. The virtual network interface is configured by using the `ipadm` command.

The virtual network interface can handle both IPv4 and IPv6 packets. By default, the interface is enabled for both IPv4 and IPv6 addresses when the interface is created. The virtual network interfaces are persistent.

This interface is useful in hosting an IP address when you use it in conjunction with the `usesrc` interface property of the IP interface. The virtual interface is also useful in hosting a virtual IP address that is used for Integrated Load Balancer (ILB) in the Direct Server Return (DSR) mode. A back end server in an ILB set up needs to have the virtual IP (VIP) address of an ILB rule hosted by a virtual interface so that the server accepts packets from client destined to the VIP. For more information about ILB, see "Configuring ILB for High Availability By Using the DSR Topology" in *Configuring an Oracle Solaris 11.3 System as a Router or a Load Balancer*.

You can create a virtual network interface by using the `ipadm create-vni` command.

EXAMPLE 40 Creating a Virtual Network Interfaces for ILB in DSR mode

Assume that you have an ILB DSR set up with a virtual server IP address `192.0.2.200` and the VIP needs to be hosted in each of the back end servers. You can create the virtual network interface to host the VIP in the back end servers.

```
# ipadm create-vni vip0
# ipadm create-addr -T static -a 192.0.2.200/32 vip0/v4
```

In this example, a back end server accepts ILB forwarded packets from a client to the VIP `192.0.2.200`.

♦ ♦ ♦ CHAPTER 3

Configuring Virtual Networks by Using Virtual Extensible Local Area Networks

Traditional network isolation methods, such as virtual local area networks (VLANs) are not adequate to support virtualization in large data centers. As cloud environments are also tightly coupled with the underlying physical networks, virtual machines cannot be migrated between systems that belong to different physical Layer 2 networks. Oracle Solaris supports the virtual extensible local area network (VXLAN) technology that addresses such virtualization issues in a large virtualized data center or cloud environment.

This chapter provides an overview of deploying VXLANs and describes how to configure them. It also discusses how VXLANs can be used with other technologies, for example, zones.

This chapter contains the following topics:

Overview of VXLANs

In a cloud environment, systems might be located in different Layer 2 networks. For example, a cloud might span systems that are in different geographical locations. In such cases, creating virtual machines (VMs) or *tenants* over a Layer 2 network restricts the number of systems that you can use for provisioning these VMs. You can use systems in different Layer 2 networks for provisioning VMs. However, as the migration between different systems is restricted to the same Layer 2 network, the utilization of the physical resource is not optimized.

VXLAN is a Layer 2 technology that enables you to create a Layer 2 network on top of a Layer 3 network, thereby providing further network isolation. VXLAN provides a virtual Layer 2 network that stretches over multiple physical Layer 2 networks. Therefore, provisioning resources in a cloud environment is not restricted to a single physical Layer 2 network. Systems can be a part of a VXLAN network as long as they are connected by IPv4 or IPv6 networks.

You can use the VXLAN technology with the Elastic Virtual Switch (EVS) feature of Oracle Solaris to create a large number of virtual networks. For information about how to use VXLAN with the EVS feature to create a virtual network, see "Use Case: Configuring an Elastic Virtual Switch for a Tenant" on page 193. For more information, see Chapter 5, "About Elastic Virtual Switches" and Chapter 6, "Administering Elastic Virtual Switches".

VXLAN provides isolated Layer 2 segment that is identified by the VXLAN segment ID or VXLAN network identifier (VNI). All VMs in the same VXLAN segment belong to the same virtual Layer 2 broadcast domain.

Communication in VXLANs is similar to that in isolated VLANs. Hence, only VMs that are in the same VXLAN segment can talk to each other. VMs that are not in the same VXLAN segment cannot communicate with each other.

Advantages of Using VXLANs

VXLAN provides the following advantages:

- Increases scalability in virtualized cloud environments as the VXLAN ID is 24 bits, which enables you to create up to 16 million isolated networks. This overcomes the limitation of VLANs having the 12 bits VLAN ID, which enables you to create a maximum of 4094 isolated networks.
- Enables you to use the Layer 3 features of the underlying network.
- The virtual Layer 2 network is abstracted from the underlying physical network. As a result, the virtual network is not visible to the physical network and provides the following benefits:
  - Removes the need to have additional physical infrastructure. For example, the forwarding table of the external switch does not grow with the increase in the VMs behind the physical port on the server.
  - Reduces the scope of MAC address duplication to VMs that exists in the same VXLAN segment. The MAC address can overlap when the addresses are not a part of the same VXLAN segment.

In a VXLAN, only the MAC address of the datalink that belong to the same VXLAN segment or VNI must be unique. This is similar to a VLAN where the VLAN ID and the MAC address must have a unique combination.

VXLAN Naming Convention

In Oracle Solaris, a VXLAN endpoint is represented by a VXLAN datalink. This VXLAN datalink is associated with an IP address (IPv4 or IPv6) and a VXLAN network identifier (VNI). Even though multiple VXLAN datalinks can use the same IP address, the combination of the IP address and VNI must be unique. You can configure a VXLAN datalink with an optional multicast address, which is used for discovering the peer VXLAN endpoints on the same VNI and also to implement broadcast within a VXLAN segment. VXLAN datalinks in the same VNI must be configured with the same multicast address. For more information about the requirements of a VXLAN, see "Planning a VXLAN Configuration" on page 87.

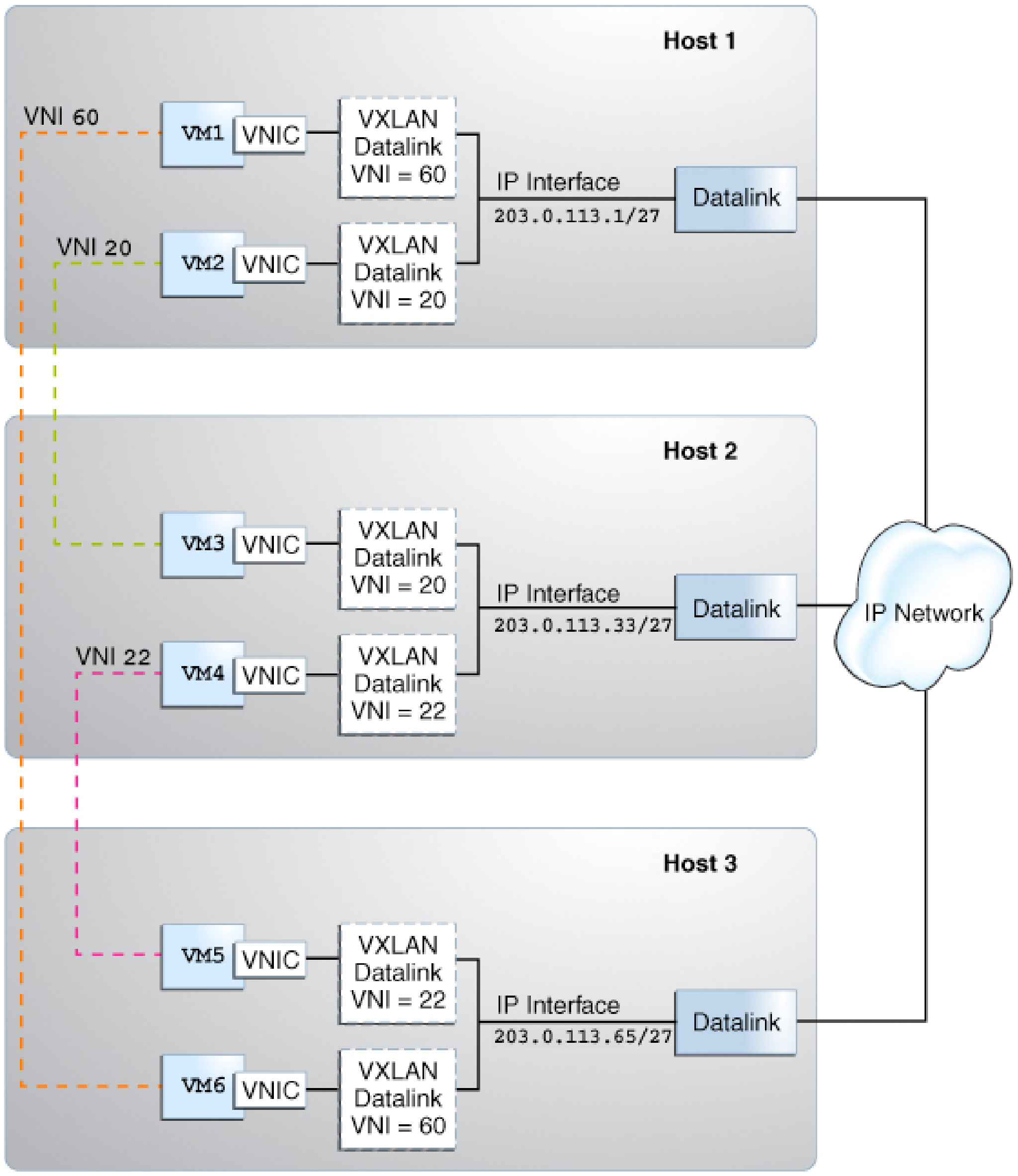
Every VXLAN datalink is associated with a VXLAN segment ID, or a VNI. The convention for naming VXLAN datalinks is same as the convention that is used for links or VLANs. For information about providing valid datalink names, see "Rules for Valid Link Names" in *Configuring and Managing Network Components in Oracle Solaris 11.3*.

VXLAN Topology

VXLAN enables you to organize systems on a Layer 3 network within their own VXLAN segments.

The following figure illustrates a VXLAN network that is configured over multiple physical servers.

FIGURE 8 VXLAN Topology



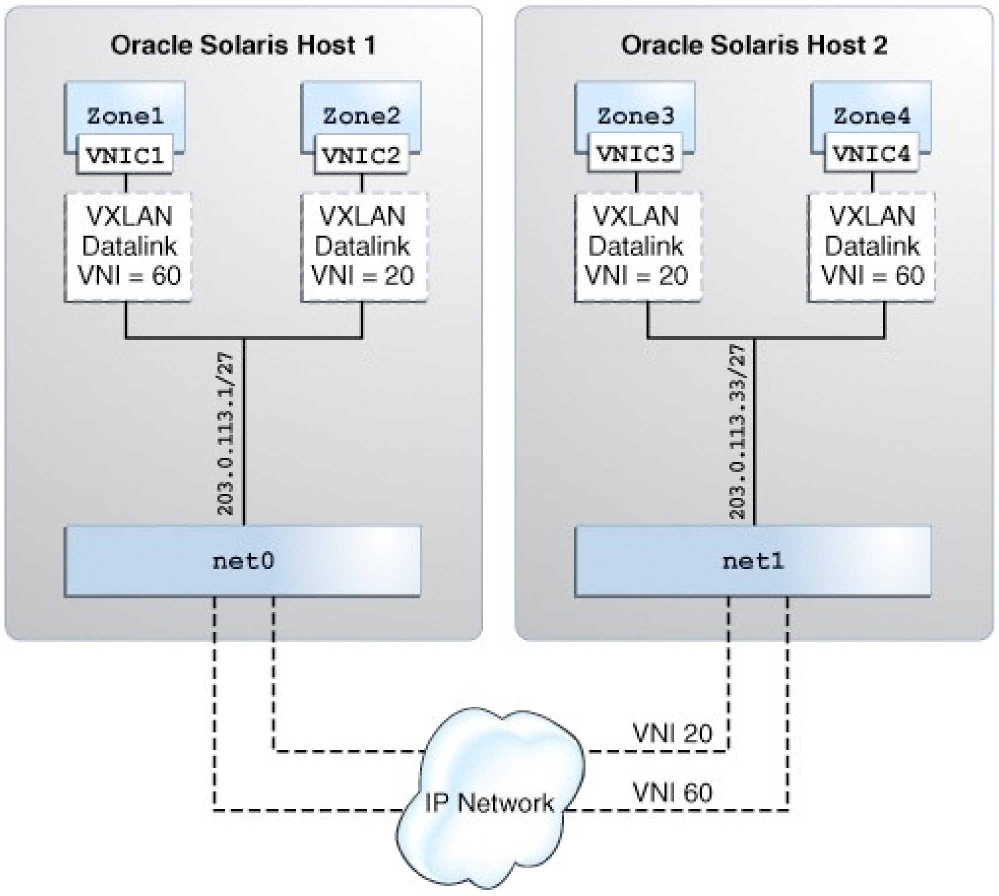
The figure shows three virtualized hosts attached to an IP network infrastructure. There are three VXLAN overlay networks identified by the VXLAN segment IDs or VNIs, `60`, `20`, and `22`. The VMs `VM1` and `VM6` are on the overlay network identified by the VNI `60`, the VMs `VM2` and `VM3` are on the overlay network identified by the VNI `20`, and the VMs `VM4` and `VM5` are on the overlay network identified by the VNI `22`.

Using VXLAN With Zones

You can assign VNICs that are created over VXLAN datalinks to zones. VXLAN datalinks are created by specifying a VNI and these VXLAN datalinks belong to the VXLAN segment that is identified by that VNI. For example, if you specify the VNI as `20` when you create the VXLAN datalink, then that datalink belongs to the VXLAN segment identified by the VNI `20`. VNICs that are created over VXLAN datalinks are a part of the VXLAN segment.

The following figure shows two virtualized Oracle Solaris hosts attached to an IP network infrastructure with two VXLAN overlay networks identified by the VNIs, `20` and `60`.

FIGURE 9 VXLAN With Zones



You can create zones that are a part of a VXLAN segment in the following ways:

- Create a VNIC over a VXLAN and assign the VNIC to the zone. For more information, see "Configuring a VXLAN" on page 88.
- Assign the VXLAN as the underlying link for the zone's `anet` (VNIC) resource. For more information, see "Assigning a VXLAN to a Zone" on page 93.

In any case, the VNIC that is created in a zone is a part of a VXLAN segment identified by the underlying VXLAN datalink. For more information about zones, see *Introduction to Oracle Solaris 11 Virtual Environments*.

Assigning VNICs to VXLAN links is similar to creating a VLAN link and assigning it to a zone. For more information about creating a VLAN and assigning it to a zone, see "How to Configure a VLAN" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Planning a VXLAN Configuration

Planning a VXLAN configuration, includes the following steps:

1. Determine the virtual network topology in a physical network. For example, if you are hosting a service that consists of several VMs on different servers, you can assign a VXLAN segment for these VMs. The VMs in this VXLAN segment can communicate with each other but not with the other VMs that are not in this VXLAN segment.
2. Verify that the physical servers are connected through an IP interface and that IP multicasting is enabled on the physical network.
3. Create a numbering scheme for the VXLAN segments. For example, you can assign the VXLAN segments (VNIs) based on the application hosted by the VMs.
4. Create a VXLAN datalink by specifying the IP address and the VXLAN segment ID.

   Optionally, you can assign the VXLAN segments with their own multicast address.
5. Create VNICs over VXLAN datalinks and assign the VNICs to zones.

   Alternatively, you can assign the VXLAN links as the underlying link for the zone's `anet` link.

Before using a VXLAN, check whether you have met the following requirements:

- Ensure that IP multicasting is supported on the network. If IP multicasting is not supported, VMs in the VXLAN cannot communicate with each other.
- If the VXLAN includes servers in different IP subnets, then multicast routing must be supported across the subnets. If multicasting routing is not supported, only the VMs over the VXLANs on the same IP subnet can communicate with each other and VMs over VXLANs on different IP subnets, for example, geographically dispersed data centers cannot communicate with each other.

  For more information about naming conventions of a VXLAN datalink, see "VXLAN Naming Convention" on page 83.

Note - The destination UDP port used for VXLAN is IANA port 4789, in accordance with RFC 7348 (`https://tools.ietf.org/html/rfc7348`).

Configuring a VXLAN

The following procedure assumes that the zones are already created on the system. For information about zone configuration, see Chapter 1, "How to Plan and Configure Non-Global Zones" in *Creating and Using Oracle Solaris Zones*.

▼ How to Configure a VXLAN

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Determine the IP addresses that are available on the system.**

   ```
   # ipadm show-addr
   ```

3. **Create the VXLAN datalink by specifying the IP address or IP interface.**

   - **To create the VXLAN by specifying the IP address:**

     ```
     # dladm create-vxlan -p prop=value  VXLAN-LINK
     ```

`-p` *prop=value*	Specifies a comma-separated list of VXLAN datalink properties that can be set to the specified values on the VXLAN datalink that you create. You set the following properties: ■ `addr` – Specifies the IPv4 or IPv6 address for the VXLAN network. This address can be a specific address or a combination of address/prefix length. ■ `vni` – Specifies the network identifier of the VXLAN segment. You can specify a number between 0 and 16777215. ■ `mgroup` – (Optional) Specifies the multicast group name. You can specify this option only if the VXLAN segment has its own multicast group.
VXLAN-LINK	Name of the VXLAN.

   - **To create the VXLAN by specifying the IP interface:**

     ```
     # dladm create-vxlan -p prop=value
     ```

`-p` *prop=value*	Specifies a comma-separated list of VXLAN datalink properties that can be set to the specified values on the VXLAN datalink that you create. You set the following properties: ■ `interface` – Specifies the IP interface for the VXLAN network. ■ `vni` – Specifies the network identifier of the VXLAN segment. You can specify a number between 0 and 16777215.
VXLAN	Name of the VXLAN.

When you specify the IP interface and the IP version, the VXLAN datalink is created over an available IP address of the version that is specified on that interface. For example, if you have an IP address `203.0.113.1` configured over `net0`, a VXLAN datalink is created over `203.0.113.1`. By default, an IP version is an IPv4 address. However, if you need an IPv6 address, you must specify the version by using the `ipvers` property.

Note - You can create VXLAN datalinks on IP addresses that are hosted on physical aggregated links (trunk or DLMP aggregation) or IPoIB links. However, you cannot create VXLAN datalinks on IP addresses hosted on IPMP, a virtual network interface, or loopback interfaces.

---

4. **Verify the VXLAN that you created.**

```
# dladm show-vxlan
```

5. **Create a VNIC over the VXLAN datalink.**

```
# dladm create-vnic -l VXLAN-LINK VNIC
```

You can create VLAN VNIC over a VXLAN datalink. To create a VLAN VNIC, you must specify the `-f` (force) option. For information, see "How to Configure VNICs as VLANs" on page 33.

6. **Configure an IP interface over the VNIC directly or by assigning the VNIC to a zone first.**

- **Configure an IP interface over the VNIC.**

```
# ipadm create-ip VNIC

# ipadm create-addr -a address VNIC
```

- **Assign the VNIC to a zone and configure an IP interface over the VNIC within the zone.**

a. **Assign the VNIC with the zone's interface.**

```
zonecfg:zone> add net
zonecfg:zone:net> set physical=VNIC
zonecfg:zone:net> end
```

b. **Verify and commit the changes that you have implemented and then exit the zone.**

```
zonecfg:zone> verify
zonecfg:zone> commit
zonecfg:zone> exit
```

c. **Reboot the zone.**

```
global# zoneadm -z zone reboot
```

d. **Log in to the zone.**

```
global# zlogin zone
```

e. **In the zone, create an IP interface over the VNIC that is now assigned to the zone.**

```
zone# ipadm create-ip interface
```

f. **Configure the VNIC with a valid IP address.**

If you are assigning a static address to the VNIC, you would type the following:

```
zone# ipadm create-addr -a address interface
```

-a *address*	Specifies the IP address, which can be in CIDR notation.

g. **Exit the zone.**

For information about the `dladm` and `ipadm` commands, see the `dladm`(1M) and `ipadm`(1M) man pages.

Example 41 Creating a VXLAN and Configuring an IP Interface for the VNIC Created Over the VXLAN

1. Check the available IP addresses on the system.

```
# ipadm show-addr net4
ADDROBJ   TYPE   STATE   ADDR
```

```
net4/v4   static ok      203.0.113.1/27
```

2. Create a VXLAN datalink in VXLAN segment `10`.

```
# dladm create-vxlan -p addr=203.0.113.1/27,vni=10 vxlan1
```

3. Verify the VXLAN link that you created.

```
# dladm show-vxlan
LINK   ADDR       VNI  MGROUP
vxlan1 203.0.113.1/27 10   224.0.0.1
```

   Because you have not specified a multicast address, this VXLAN segment uses the `All Host` multicast address, which addresses all the hosts on the same network segment.

4. Check the VXLAN link information.

```
# dladm show-link vxlan1
LINK   CLASS MTU  STATE OVER
vxlan1 vxlan 1440 up    --
```

   `vxlan1` is created and the link state is `up`.

5. Create a VNIC over `vxlan1`.

```
# dladm create-vnic -l vxlan1 vnic1
```

6. Verify the VNIC that you created.

```
# dladm show-vnic
LINK   OVER   SPEED  MACADDRESS      MACADDRTYPE  IDS
vnic1  vxlan1 10000  2:8:20:fe:58:d4 random       VID:0
```

7. Configure an IP interface over the VNIC.

```
# ipadm create-ip vnic1

# ipadm create-addr -T static -a local=203.0.113.34/27 vnic1/v4

# ipadm show-addr vnic1
ADDROBJ  TYPE   STATE  ADDR
vnic1/v4 static ok     203.0.113.34/27
```

You have successfully created a VXLAN by specifying the IP address. You have created a VNIC over the VXLAN and configured the IP interface.

Example 42 Assigning the VNIC Created Over a VXLAN to a Zone and Configuring an IP Interface

This example assumes that you have completed steps 1 to 6 in Example 41, "Creating a VXLAN and Configuring an IP Interface for the VNIC Created Over the VXLAN," on page 90.

After you create the VNIC, assign the VNIC to a zone and configure the IP interface.

```
global# zonecfg -z zone2
zonecfg:zone2> add net
zonecfg:zone2:net> set physical=vnic1
zonecfg:zone2:net> end
zonecfg:zone2> verify
zonecfg:zone2> commit
zonecfg:zone2> exit
global# zoneadm -z zone2 reboot

global# zlogin zone2
zone2# ipadm create-ip vnic1
zone2# ipadm create-addr -a 192.0.2.85/24 vnic1
ipadm: vnic1/v4

zone2# exit
```

You have assigned the VNIC to a zone and then configured the IP interface over the VNIC.

Displaying VXLAN Information

You can use the `dladm show-link` command to view generic link information about VXLAN links. To view information that is specific to a VXLAN, use the `dladm show-vxlan` command.

```
# dladm show-link
LINK                CLASS     MTU    STATE    OVER
net6                phys      1500   down     --
net0                phys      1500   up       --
net2                phys      1500   unknown  --
net3                phys      1500   unknown  --
net1                phys      1500   unknown  --
net5                phys      1500   unknown  --
net4                phys      1500   up       --
vxlan1              vxlan     1440   up       --
vnci1               vnic      1440   up       vxlan1

# dladm show-vxlan vxlan1
```

```
LINK           ADDR           VNI   MGROUP
vxlan1         203.0.113.1     10    224.0.0.1
```

Deleting a VXLAN

To delete a VXLAN link, use the `dladm delete-vxlan` command. Before deleting a VXLAN link, you must ensure that there are no VNICs configured on that VXLAN link by using the `dladm show-link` command.

Become an administrator and issue the following command:

```
# dladm delete-vxlan VXLAN
```

For example, if you want to delete `vxlan1`, type the following command:

```
# dladm delete-vxlan vxlan1
```

Assigning a VXLAN to a Zone

You can create zones that are a part of a VXLAN segment by assigning VXLAN as an underlying link to the zone's `anet` resource. For information about configuring a zone, see *Creating and Using Oracle Solaris Zones*.

▼ How to Assign a VXLAN to a Zone

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Determine the available IP addresses on the system.**

   ```
   # ipadm show-addr
   ```

3. **Create the VXLAN by specifying the IP address.**

   ```
   # dladm create-vxlan -p prop=value VXLAN-LINK
   ```

4. **Verify the VXLAN that you created.**

```
# dladm show-vxlan
```

5. **Configure the zone by assigning the VXLAN that you created as the underlying link for the zone's `anet`.**

```
global# zonecfg -z zone
zonecfg:zone2> add anet
zonecfg:zone2:anet> set linkname=datalink
zonecfg:zone2:anet> set lower-link=VXLAN-LINK
zonecfg:zone2:net> end
zonecfg:zone2> verify
zonecfg:zone2> commit
zonecfg:zone2> exit
global# zoneadm -z zone reboot
```

VXLAN is assigned as the underlying link for the zone's `anet`.

Example 43 Assigning a VXLAN to a Zone's `anet`

```
# ipadm show-addr net4
ADDROBJ   TYPE   STATE   ADDR
net4/v4   static ok      203.0.113.1/24 2

# dladm create-vxlan -p addr=203.0.113.1,vni=10 vxlan1

# dladm show-vxlan
LINK   ADDR        VNI  MGROUP
vxlan1 203.0.113.1 10   224.0.0.1
```

Because you have not specified a multicast address, this VXLAN segment uses the `All Host` multicast address, which addresses all the hosts on the same network segment.

```
# dladm show-link vxlan1
LINK   CLASS MTU  STATE OVER
vxlan1 vxlan 1440 up    --
```

`vxlan1` is created and the link state is `up`.

```
global# zonecfg -z zone2
zonecfg:zone2> add anet
zonecfg:zone2:anet> set linkname=net1
zonecfg:zone2:anet> set lower-link=vxlan1
zonecfg:zone2:anet> end
zonecfg:zone2> verify
zonecfg:zone2> commit
```

```
zonecfg:zone2> exit
global# zoneadm -z zone2 reboot
```

`vxlan1` is assigned as the underlying link for the zone's `anet`.

When the zone boots up, `net1` is created in `zone2` over `vxlan1`.

Use Case: Configuring a VXLAN Over a Link Aggregation

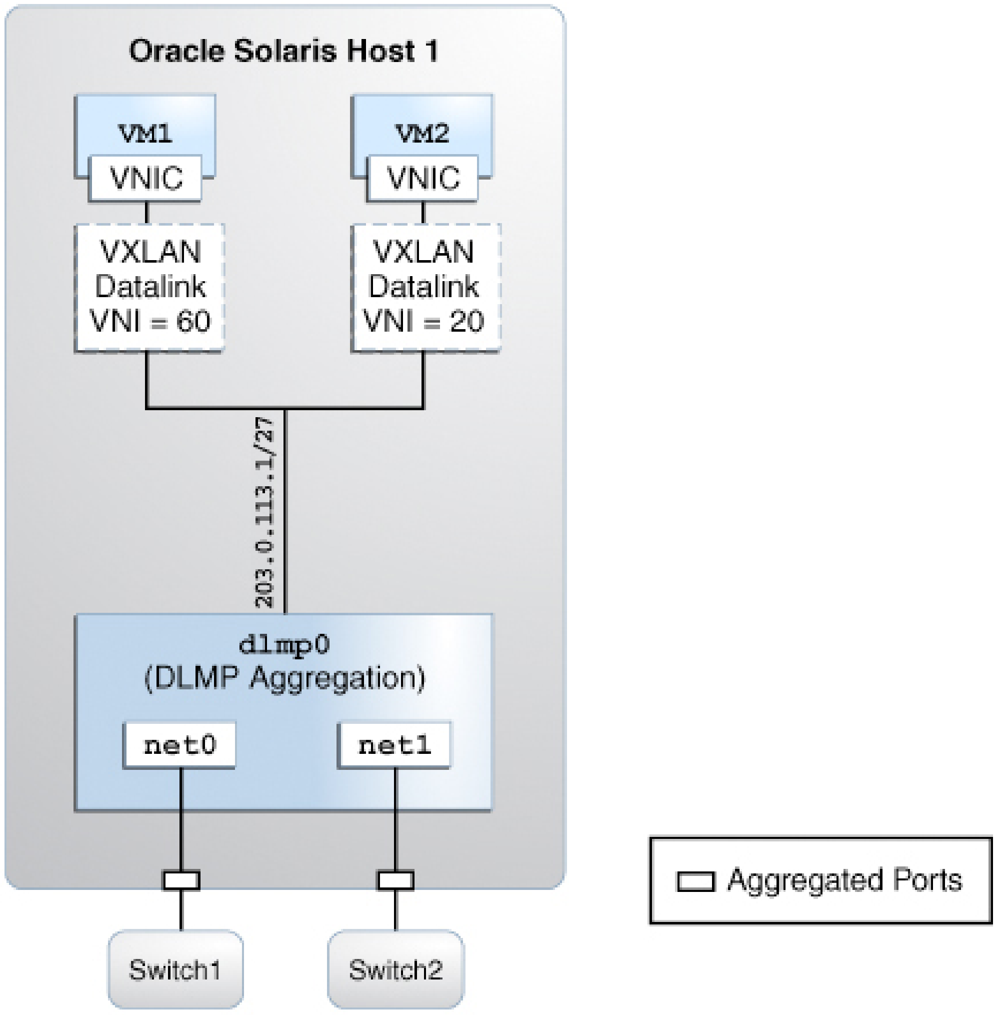
The following use case shows how to accomplish the following:

- Create a DLMP aggregation
- Configure an IP address over the aggregation
- Create two VXLANs over the aggregation
- Configure two zones with VXLAN datalinks as the lower links

For information about link aggregation, see Chapter 2, “Configuring High Availability by Using Link Aggregations” in *Managing Network Datalinks in Oracle Solaris 11.3*.

The following figure shows VXLAN configuration over a DLMP aggregation.

FIGURE 10 VXLAN Over a Link Aggregation



When an aggregated port or an external switch fails, VXLAN datalinks over the aggregation continue to exist as long as at least one port and a switch is functional, thereby providing network high availability during failover. For example, if `net0` fails, then DLMP aggregation shares the remaining port `net1`, between VXLAN datalinks. The distribution among the aggregated ports occurs transparently to the user and independently of the external switches connected to the aggregation.

1. Become an administrator.

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.
2. Display datalink information to identify the datalinks for aggregation.

```
# dladm show-link
LINK      CLASS     MTU     STATE   OVER
net0      phys      1500    up      --
net1      phys      1500    up      --
net2      phys      1500    up      --
```

3. Ensure that the datalinks that you want aggregate do not have IP interfaces configured over the link. Delete the interface if any interface is configured on any of the links.

```
# ipadm show-if
IFNAME       CLASS        STATE     ACTIVE     OVER
lo0          loopback     ok        yes        --
net0         ip           ok        no         --
# ipadm delete-ip net0
```

4. Create a DLMP aggregation with the links `net0` and `net1`.

```
# dladm create-aggr -m dlmp -l net0 -l net1 dlmp0
```

5. Configure an IP interface on top of the aggregation `dlmp0`.

```
# ipadm create-ip dlmp0
# ipadm create-addr -T static -a local=203.0.113.1 dlmp0/v4
```

6. Create two VXLANs by specifying the IP address that is configured over the aggregation and also specify the VNI, which is the network identifier of the VXLAN segment.

```
# dladm create-vxlan -p addr=203.0.113.1,vni=20 vxlan20
# dladm create-vxlan -p addr=203.0.113.1,vni=60 vxlan60
```

   Both VNIs are configured with the default multicast address.
7. Configure the zone `VM1` with the VXLAN datalink `vxlan20` as the lower-link.

```
global# zonecfg -z VM1
zonecfg:VM1> add anet
zonecfg:VM1:net> set linkname=net0
zonecfg:VM1:net> set lower-link=vxlan20
zonecfg:VM1:net> end
zonecfg:VM1> verify
zonecfg:VM1> commit
```

```
zonecfg:VM1> exit
global# zoneadm -z VM1 reboot
```

8. Configure the zone `VM2` with the VXLAN datalink `vxlan60` as the lower-link.

```
global# zonecfg -z VM2
zonecfg:VM2> add anet
zonecfg:VM2:net> set linkname=net0
zonecfg:VM2:net> set lower-link=vxlan60
zonecfg:VM2:net> end
zonecfg:VM2> verify
zonecfg:VM2> commit
zonecfg:VM2> exit
global# zoneadm -z VM2 reboot
```

The `net0` and `net1` datalinks are aggregated into DLMP aggregation, `dlmp0` and an IP address `203.0.113.1` is configured for the aggregation. The VXLANs, `vxlan20` and `vxlan60` are created over the specified IP address `203.0.113.1`, which is configured for the aggregation. The VXLAN, `vxlan20` is created in the VXLAN segment `20` and the VXLAN, `vxlan60` is created in the VXLAN segment `60`. The zone `VM1` is configured with the VXLAN datalink, `vxlan20` as the lower link and the zone `VM2` is configured with the VXLAN datalink, `vxlan60` as the lower link.

♦ ♦ ♦ CHAPTER 4

Administering Server-Network Edge Virtualization by Using Edge Virtual Bridging

A server-network edge exists at the connection between a server port and its first hop switch port. Network configurations such as virtual local area network (VLAN) and Link Aggregation Control Protocol (LACP) must be the same on the server port and the switch port at this edge. You can use Data Center Bridging Capability Exchange (DCBX) to automate the configuration on the server and the switch port. For more information, see Chapter 7, "Managing Converged Networks by Using Data Center Bridging" in *Managing Network Datalinks in Oracle Solaris 11.3*.

With server virtualization, multiple virtual ports are associated with the virtual machines (VMs) behind the server port instead of only one server port connected to a switch port. Server virtualization imposes the following additional requirements on the server-network edge:

- Switching between the virtual machines through the external switch so that inter-VM traffic is subjected to policies configured on the switch
- Extending the virtual port properties into the network

Oracle Solaris supports edge virtual bridging (EVB), which is an evolving IEEE standard that addresses these requirements.

This chapter contains the following topics:

EVB Support in Server-Network Edge Virtualization

A virtualized server might contain multiple virtual NICs over the same physical link. You can assign these VNICs to VMs. Traditionally, a switch does not transmit packets back on the same link on which it receive the packets. Packets between VMs are looped back by the virtual switch within the host itself. Therefore, any policies that are configured on the external switch are not applied to inter-VM packets. With the support for EVB, Oracle Solaris and the switch enable inter-VM packets to be switched by the external switch after enforcing any policies on the inter-VM packets. For more information about VNICs, see Chapter 2, "Creating and Managing Virtual Networks".

In addition, Oracle Solaris with the support of EVB can exchange information about VNICs with the switch. This exchange of information enables the switch to automatically configure the VNIC properties such as bandwidth limits, bandwidth shares, and MTU on the network. In the absence of this feature, the server administrator and the network administrator must coordinate with each other to make changes on the switch every time a VNIC is created, modified, or deleted on the server. Extending the VNIC properties into the network leads to an efficient use of networking resources based on VNIC properties. For example, enforcing a bandwidth limit on packets after they arrive at the host is not very helpful because the packets might have already used up the link bandwidth.

Reflective Relay

Reflective relay is a feature that enables VMs that are using the VNICs over the same physical NIC to communicate through the external switch. The switch must support this capability. In Oracle Solaris, LLDP is extended to include an EVB type-length value (TLV) unit, which is used to determine if the switch supports reflective relay capability and to enable or disable reflective relay capability on the switch. Therefore, you can automate the detection and configuration of this capability on the switch by using LLDP only if the switch supports LLDP and EVB TLV unit. Otherwise, reflective relay feature must be manually configured on the switch. For information about how to manually configure reflective relay, refer to the switch manufacturer's documentation.

For more information about the reflective relay support in Oracle Solaris, see "Controlling Switching Between VMs Over the Same Physical Port" on page 105. For more information about the LLDP TLV units, see "Information the LLDP Agent Advertises" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Automated VNIC Configuration in the Network

Oracle Solaris uses the Virtual Station Interface Discovery and Configuration Protocol (VDP) defined in IEEE 802.1Qbg to exchange VNIC information with the switch. If the switch supports VDP, then VNIC properties are automatically configured on the switch. This is similar to the host and switch exchanging physical link properties by using DCBX. When a VNIC is created, modified, or deleted, a VDP exchange is initiated between the host and the switch. This exchange enables the switch to allocate resources for the packets destined to the VNIC based on properties of the VNIC.

For more information about exchange of VNIC information between a system and an external switch in Oracle Solaris, see "Exchanging VNIC Information by Using VDP" on page 110 and "How VDP Exchanges VNIC Information" on page 111.

Improving Network and Server Efficiency by Using EVB

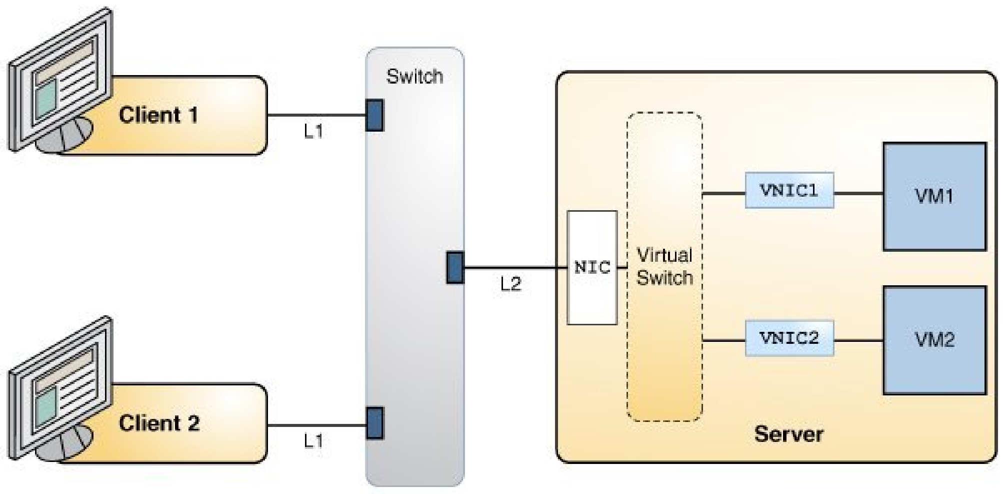
This section provides an example to show how you can increase server and network efficiency when you enable EVB on a server.

This example assumes that the server hosts two applications in a cloud environment on the same physical machine.

- Applications are hosted on a cloud as separate virtual machines (VM1 and VM2) on a physical machine. The VNICs `VNIC1` and `VNIC2` are configured for VM1 and VM2 respectively.
- Clients (Client 1 and Client 2) with an account can access the applications.
- The virtual machines (VM1 and VM2) share the resources of the physical system and the bandwidth on link L2.
- The clients are connected to the switch by using the link L1. The switch is connected to the NIC by using the link L2.
- Predetermined SLA determines the assignment of the resource for the virtual machines. The following (L2) bandwidth usage is included for SLAs of the virtual machines:
  - VM1 is running a high priority Transmission Control Protocol (TCP) service. So, SLA for VM1 has the maximum bandwidth limit of 8 Gbps.
  - VM2 is running a User Datagram Protocol (UDP) service that is not high priority. So, SLA for VM2 has the maximum bandwidth limit of 3 Gbps.

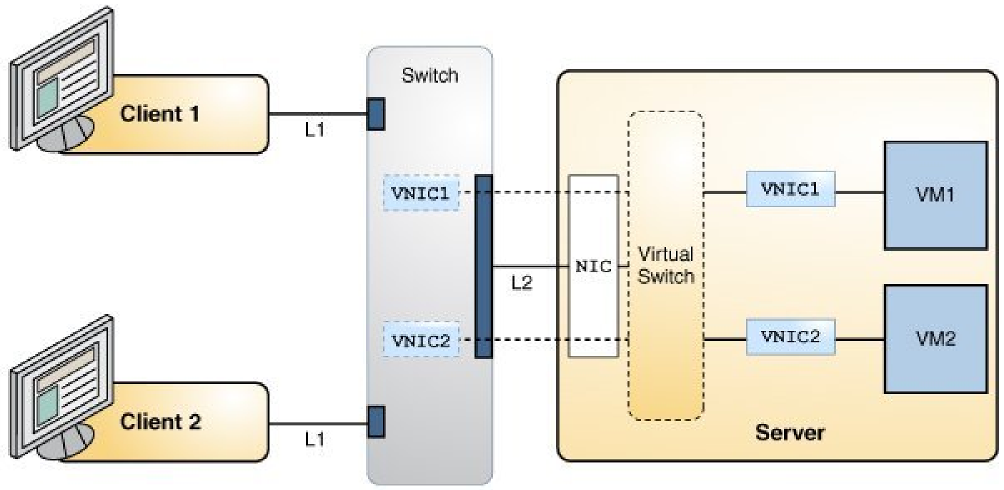
The following figure shows the applications hosted on a server.

FIGURE 11 Application Setup Without EVB



When you enable EVB on the server and the switch, the server exchanges the VNIC information with the switch through the same physical switch port as shown in the following figure.

FIGURE 12 Application Setup With EVB Enabled



The following table shows the efficiency of the server before and after enabling EVB on the server and switch.

TABLE 3 Efficiency of the Server Without EVB and With EVB

Server Efficiency Without EVB	Server Efficiency With EVB
The server regulates incoming traffic from the clients for bandwidth enforcement.	The switch regulates the traffic destined to the server.
System resources are used, thereby affecting the system and network performance.	System resources are not used to process the bandwidth, thereby improving the system efficiency.
In this example, when the clients (Client 1 and Client 2) need to utilize the services simultaneously, the clients use the bandwidth of link L2 and server resources. The server enforces the SLA on the VNICs for VM1 and VM2 to regulate the inbound and the outbound traffic of the clients. However, network performance and bandwidth usage are affected in the following ways: ■ Traffic from the clients (Client 1 and Client 2) use the bandwidth of link L2 without any restrictions. Also, if there is a bandwidth limit configured on the host, packets that use the bandwidth of L2 might be dropped	When EVB is enabled on the server and the switch, system efficiency increases in the following ways: ■ SLA configured on the VNICs of the server are reflected on the switch. ■ Switch regulates the traffic towards VM1 and VM2 based on the configured bandwidth and therefore helps to utilize the bandwidth of link L2 appropriately, thereby providing network efficiency. Because the switch regulates the bandwidth, the server does not have to process bandwidth on the receive side, thereby providing server efficiency.

Server Efficiency Without EVB	Server Efficiency With EVB
on the host, which results in inefficient use of the bandwidth. ■ VM1 provides a high priority TCP service and VM2 provides UDP service that is not high priority. Regulating VM1's bandwidth on the server causes TCP to respond, hence impacting VM1's use of bandwidth on the link L2. However, regulating VM2's service on the server does not impact its usage of the bandwidth of link L2. This affects other services using the link L2.	
In this example, the network traffic for UDP and TCP services inbound to the server uses the available bandwidth on the link L2 without any restrictions. After the server receives network traffic, it regulates the network traffic based on the configured bandwidth limit.	The configured bandwidth limits (3 Gbps and 8 Gbps) are regulated by the switch in addition to the server. Hence, the shared link L2's usage is based on the configured bandwidth limits.

Installing EVB

You must install the EVB package to use EVB on your system.

▼ How to Install EVB

1. **Become an administrator.**

   For more information, see “Using Your Assigned Administrative Rights” in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Verify whether the EVB package is installed.**

```
# pkg info evb
```

3. **If the EVB package is not installed, install the package.**

```
# pkg install evb
```

4. **Verify whether the service is enabled.**

```
# svcs vdp
```

5. **If the service is not enabled, enable the service.**

```
# svcadm enable vdp
```

The default EVB configuration is automatically enabled after EVB package installation. By accepting the default EVB configuration, the system can immediately exchange the information about any VNIC that you configure on the system with the external switch.

See Also

- To know more about exchanging VNIC information, the protocols that are used for exchanging the VNIC information, and EVB components, see "Exchanging VNIC Information by Using VDP" on page 110.
- To display information about the VSI discovery and configuration protocol (VDP) state for physical Ethernet links if EVB is enabled on the system and also check if VDP packets are being exchanged for VNICs, see "Displaying VDP and ECP State and Statistics" on page 112.
- To alter the default EVB configuration, see "Changing the Default EVB Configuration" on page 114.
- To display the default EVB configuration information, see Example 45, "Displaying EVB-Related Datalink Properties on a Physical Link," on page 117.

Controlling Switching Between VMs Over the Same Physical Port

You can use the `vswitchmode` datalink property to control switching between VMs over the same physical port. The three possible values are:

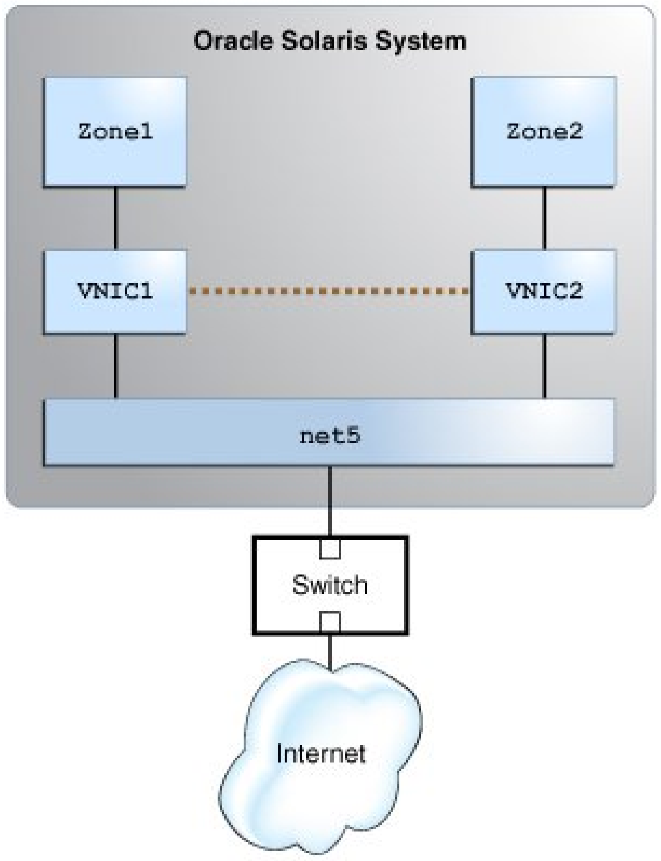
- `local` – Enables the network traffic between VMs over the same physical NIC to be exchanged internally. This is the default mode.
- `remote` – Enables the network traffic between VMs over the same physical NIC to be exchanged through the external switch.
- `auto` – Uses LLDP to determine whether reflective relay is supported on the external switch. If reflective relay is supported on the external switch, network traffic between VMs is exchanged through the external switch. Otherwise, network traffic between VMs is exchanged internally.

Enabling the VMs to Communicate Through an External Switch

When you have multiple VNICs configured over the same physical NIC, you can set the `vswitchmode` datalink property to `remote` to send the network traffic externally through the switch. However, the external switch must be configured in the reflective relay mode. The switch configuration that enables reflective relay is specific to the switch type. For more information, refer to the switch manufacturer's documentation.

The following figure shows a sample system with a 10G Ethernet link that is connected to an external switch and hosting two zones (VMs) that are running services for the same customer.

FIGURE 13 Internal Communication Between Zones



Because the two zones, `Zone1` and `Zone2`, are running services for the same customer, the communication between the two zones can occur internally without any restrictions. Hence, the traffic between `VNIC1` and `VNIC2` can be exchanged internally.

You would check the existing value of the `vswitchmode` property for the physical NIC `net5` as follows:

```
# dladm show-linkprop -p vswitchmode net5
LINK  PROPERTY     PERM  VALUE  EFFECTIVE  DEFAULT  POSSIBLE
net4  vswitchmode  rw    local  local      local    local,remote,auto
```

The output displays the value `local` for the `VALUE` and the `EFFECTIVE` fields. This value indicates that the communication between the zones is internal.

In this example, assume that the two zones, `Zone1` and `Zone2`, need to run services for different customers and the external switch has an access control list (ACL) configured that controls the network traffic for these services. Therefore, they must not communicate internally and the network traffic between `VNIC1` and `VNIC2` must be exchanged externally through a switch.

Hence, you must disable the internal communication between the zones by setting the `vswitchmode` property to `remote` as follows:

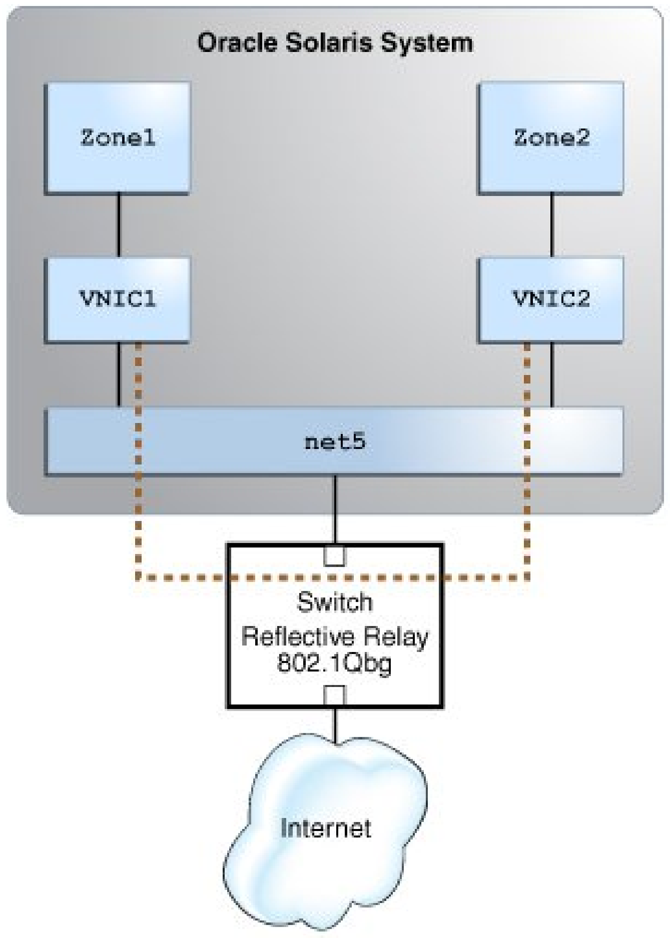
```
# dladm set-linkprop -p vswitchmode=remote net5

# dladm show-linkprop -p vswitchmode net5
LINK  PROPERTY     PERM  VALUE   EFFECTIVE  DEFAULT  POSSIBLE
net5  vswitchmode  rw    remote  remote     local    local,remote,auto
```

Note - The external switch must be configured for reflective relay before you set the `vswitchmode` to `remote`.

Because you set the `vswitchmode` property to `remote` to disable the internal communication of the VNICs, the network traffic between the VNICs is sent through the external switch as shown in the following figure.

FIGURE 14 Communication Between Zones by Using an External Switch



Using LLDP to Manage the Communication Between VMs

You can use LLDP for the automatic configuration of communication between VMs. LLDP configures the exchange of network traffic to be internal or external based on whether the external switch supports reflective relay. To use LLDP, set the `vswitchmode` datalink property to `auto`. First, you must ensure the following:

- The LLDP package is installed.

  To check whether the LLDP package is installed, use the following command:

  ```
  # pkg info lldp
  ```
- The LLDP service is online.

  To check whether the LLDP service is online, use the following command:

  ```
  # svcs lldp
  STATE          STIME    FMRI
  online         Jul_13   svc:/network/lldp:default
  ```
- EVB is enabled in the `dot1-tlv` TLV unit.
- LLDP mode is `both` for the NIC.

  In the example, to check whether EVB is enabled in the `dot1-tlv` TLV unit and the LLDP mode is `both`, you would use the following command:

```
# lldpadm show-agentprop -p mode,dot1-tlv net5
AGENT  PROPERTY  PERM  VALUE  DEFAULT  POSSIBLE
net5   mode      rw    both   disable  txonly,rxonly,both,disable
net5   dot1-tlv  rw    evb    none     none,vlanname,pvid,linkaggr,pfc,
                                       appln,evb,etscfg,etsreco,all
```

To set the `vswitchmode` datalink property to `auto`:

```
# dladm set-linkprop -p vswitchmode=auto net5
```

When you set the `vswitchmode` datalink property to `auto`, you can use the output of the `dladm show-linkprop` command to check whether the communication between the VMs is internal or through an external switch.

```
# dladm show-linkprop -p vswitchmode net5
LINK  PROPERTY     PERM  VALUE   EFFECTIVE  DEFAULT  POSSIBLE
net5  vswitchmode  rw    auto    remote     local    local,remote,auto
```

Since the value of the `EFFECTIVE` field of the output is `remote`, LLDP has enabled reflective relay on the external switch and the communication between the VMs is through the external switch.

For more information about LLDP, see Chapter 6, "Exchanging Network Connectivity Information With Link Layer Discovery Protocol" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Exchanging VNIC Information by Using VDP

VNIC (VSI) information is exchanged between the system (station) and the external switch (bridge) by using the VSI discovery and configuration protocol (VDP). The VDP type-length value (TLV) units are exchanged by using the Edge Control Protocol (ECP), which reliably transmits the VDP packets between the peers. The VDP TLV units are exchanged when you create or delete a VNIC.

Implementation of VDP

The following EVB components enable the system to advertise the VNIC (VSI) information to the external switch:

- A VSI profile consists of link properties that have been configured for the specific VNIC. Therefore, a system can have as many VSI profiles as there are configured VNICs.
- The VSI identifier uniquely identifies a VSI instance. In Oracle Solaris, this VSI instance is the MAC address of the VNIC (VSI). The VSI Type ID and VSI Version identify the profile within a given VSI Manager ID.
- The VSI Manager manages multiple VSI profiles on the system by mapping the VSI Type ID - VSI Version with a specific set of VNIC properties. Oracle Solaris has defined a default VSI Manager, `oracle_v1`, as a 3-byte encoding. This 3-byte encoding is used as the VSI Type ID by an Oracle Solaris host in the VDP packet.
- A VSI Manager ID identifies the VSI Manager that is relevant to a specific VSI Type ID - VSI Version pair. The VSI Manager ID is represented as an IPv6 address. Oracle Solaris has defined a default VSI Manager ID, `ORACLE_VSIMGR_V1`.

Note - Currently, there are no defined standards for defining a VSI profile and its specific properties. The definition of VSI types is vendor-specific and is closely linked to a VSI Manager ID.

This `oracle_v1` encoding supports the following properties:

- Bandwidth limit
- Bandwidth share
- Link speed of the underlying link
- Maximum transmission unit (MTU) of the VNIC

In Oracle Solaris, the system encodes the link information by using the `oracle_v1` encoding and then transmits the information to the external switch. After the information is received by the switch, it decodes the encoded information by using the same `oracle_v1` encoding.

By default, an Oracle Solaris host sends the following elements to the external switch:

- Oracle VSI Manager – `oracle_v1`
- VSI Type ID – VNIC properties encoded by using `oracle_v1` encoding
- VSI Version – Always `0`

In Oracle Solaris, the VNIC information exchange mechanism is as follows:

1. The external switch is configured to support the Oracle VSI Manager, `oracle_v1`.
2. The external switch uses `oracle_v1` to determine the properties encoded in the VSI Type ID.
3. The external switch applies the property configuration on packets for that VNIC.

An Oracle organization-specific OUI TLV unit follows the VSI Manager ID TLV to indicate that it is the Oracle-specific VSI Manager ID. The absence of the Oracle specific TLV unit in the response from the switch indicates to the Oracle Solaris host that the switch does not support Oracle VSI Manager (encodings). Oracle Switch ES1-24 supports the Oracle VSI Manager, `oracle_v1`. For more information about configuration of EVB on Oracle Switch ES1-24, see *Sun Ethernet Fabric Operating System, EVB Administration Guide*.

Note - In addition to supporting the VDP and ECP protocols, to interoperate with Oracle Solaris system, external switches must also support `ORACLE_VSIMGR_V1`, which is the default Oracle VSI Manager ID, and the Oracle organizationally unique identifier (OUI) TLV (subtype `VDP_ORACLEOUI_VSIMGR_SUBTYPE`, which is used to carry the encoding information).

How VDP Exchanges VNIC Information

A VNIC information exchange works as follows:

The system sends an association request (`ASSOC`) to the external switch by specifying the VNIC and its associated profile. The external switch responds to the association request with a success or failure response. The system can subsequently send a disassociation request (`DEASSOC`) to the external switch, which removes the association for a VNIC. For information about how to display and obtain the state of the request for a VNIC, see "Displaying VDP and ECP State and Statistics" on page 112.

When you create a VNIC, the VDP exchange occurs as follows:

1. A VDP association (`ASSOC`) request TLV unit containing the information about the VNIC is sent to the external switch by the system.
2. The external switch receives the VDP (`ASSOC`) TLV unit and obtains the VNIC information by using the VSI Type ID, VSI Version, and VSI Manager ID.
3. The external switch applies the property configuration for the VNIC.
4. The external switch sends a VDP association (`ASSOC`) response TLV unit to the system stating that the external switch has configured properties for the VNIC.

When you delete a VNIC, VDP exchange occurs as follows:

1. A VDP disassociation (`DEASSOC`) request TLV unit containing the VSI ID is sent to the external switch by the system.
2. The external switch receives the VDP (`DEASSOC`) TLV unit and obtains the VSI ID of the VSI that is deleted.
3. The external switch removes the configuration for the deleted VNIC.
4. The external switch sends a VDP disassociation (`DEASSOC`) response TLV unit to the system.

Note - In Oracle Solaris, the VDP supports *only* `ASSOC` and `DEASSOC` VDP requests.

Displaying VDP and ECP State and Statistics

You can display information about the VDP state for physical Ethernet links if EVB is enabled on the system and also if VDP packets are being exchanged for VNICs. To display information only for a single link, specify that link in the command. Otherwise, VDP information for all the Ethernet links is displayed.

Displaying the VDP State and Statistics

To display the VDP state, type the following command:

```
# dladm show-ether -P vdp
VSI      LINK       VSIID               VSI-TYPEID   VSI-STATE   CMD-PENDING
vnic1    net0       2:8:20:22:3c:6b     98/0         ASSOC       NONE
vnic2    net0       2:8:20:90:7f:ef     96/0         ASSOC       NONE
```

`VSI-STATE` shows the status of the VDP exchange with the peer. Possible values are:

- `TIMEDOUT` – The peer has not responded to the VDP requests.
- `ASSOC` – The peer processed the request successfully.
- `DEASSOC` – Either the host or the peer has rejected the request. The peer can reject the request if it is not able to determine the profile or the properties specified. The host can reject the exchange of VDP packets if it is using `oracle_v1` encoding and the peer does not include the Oracle OUI in its response.

The sample output shows that two VSIs (VNICs) are configured over the link `net0`. Their specific VSI IDs refer to their respective MAC addresses. The `VSI-TYPE ID` for VNICs, `vnic1` and `vnic2` are generated from their respective properties (bandwidth limit and MTU) and the encoding is defined by `oracle_v1`.

To obtain statistics about the outgoing or incoming VDP packets, type the following command:

```
# dlstat show-ether -P vdp net1
LINK    IPKTS    OPKTS   KeepAlives
net1    3        2       1
```

Displaying the Link Properties

You use the `-p` option of the `dladm show-linkprop` command to display link properties.

The following example shows how to display the link properties for `vnic1` and `vnic2`.

```
# dladm show-linkprop -p maxbw,mtu vnic1
LINK     PROPERTY        PERM   VALUE     EFFECTIVE    DEFAULT   POSSIBLE
vnic1    maxbw           rw     100       100          --        --
vnic1    mtu             rw     1500      1500         1500      1500

# dladm show-linkprop -p maxbw,mtu vnic2
LINK     PROPERTY        PERM  VALUE      EFFECTIVE    DEFAULT   POSSIBLE
vnic2    maxbw           rw    20         20           --        --
vnic2    mtu             rw    1500       1500         1500      1500
```

Displaying ECP State and Statistics

VDP uses ECP to exchange messages. The following example shows state of ECP that is specific to the physical link `net0`.

```
# dladm show-ether -P ecp net0
LINK       MAX-RETRIES     TIMEOUT
net0       3               164
```

`MAX-RETRIES`	Specifies the number of times ECP transmits a packet when it does not get an acknowledgement from the peer.
`TIMEOUT`	Specifies the interval (in milliseconds) before retransmitting a packet. The time interval that ECP waits for an acknowledgment before retransmitting a packet.

To obtain the statistics for a physical link, type the following command:

```
# dlstat show-ether -P ecp
LINK          IPKTS    OPKTS  IERRORS  OERRORS RETRANSMITS TIMEOUTS
net0          3        2      0        0       1            0
```

Changing the Default EVB Configuration

By default, you need not change the default EVB configuration. In most cases, you can install EVB and use the default EVB configuration to exchange the information about any VNIC that you configure on the system with the external switch. However, if you want to completely take control and manage EVB configuration on the host and the network, then you can change the default configuration.

When you use the default Oracle Solaris VSI Manager ID, `ORACLE_VSIMGR_V1` the system automatically generates the VSI Type ID for the VNICs that you create. Therefore, there is no need to set the datalink properties, such as `vsi-typeid` and `vsi-vers`. However, if you are not using the default VSI Manager ID, you must set the datalink properties that are related to EVB by using the `dladm set-linkprop` command. To set datalink properties that are related to EVB, the external switch must be able to communicate with the system and retrieve properties for a given set of VSI Type ID and VSI Version.

Use the default Oracle VSI Manager ID when using EVB so that the Oracle VSI Manager can automatically generate VSI Type IDs and VSI Version for the VSI profiles of the system.

You can configure the following datalink properties that are related to EVB:

- `vsi-mgrid` – Specifies the VSI Manager ID that is set for a physical link or a VNIC. If this property is not set for a VNIC, the default value, `ORACLE_VSIMGR_V1`, of the underlying physical link is used.

  If you explicitly set the `vsi-mgrid` property, then you also need to explicitly set the VSI Type ID and VSI Version. In addition, you also need to explicitly configure these properties on the datalinks.

  Note - In Oracle Solaris, when you manually configure the VSI Manager ID, VSI Type ID, and VSI Version, the corresponding VNIC properties are not automatically configured.

- `vsi-mgrid-enc` – Indicates the encoding that is associated with the VSI Manager ID. By default, this property is set to `oracle_v1`. If you do not want to associate `oracle_v1` with the VSI Manager ID, set this property value to `none`. When you set the value `none`, also make sure that you configure the VSI Manager ID, VSI Type ID, and VSI Version manually because they will not be automatically generated.
- `vsi-typeid` – Specifies a VSI Type ID. A VSI Type ID pairs with a VSI Version to be associated with a VSI profile. This 3-byte value is automatically generated if you use the default values for `vsi-mgrid` and `vsi-mgrid-enc`. Otherwise, you must explicitly specify a value for this property.
- `vsi-vers` – Specifies a VSI Version. The VSI Version pairs with a VSI Type ID to be associated with a VSI profile. This 1-byte value is automatically generated if you use the default values for `vsi-mgrid` and `vsi-mgrid-enc`. Otherwise, you must explicitly specify a value for this property.

You can display EVB-related properties by using the `dladm show-linkprop` command. You can obtain the effective values of the VNIC-related link properties from their respective `EFFECTIVE` field values of the properties. For more information, see Example 45, “Displaying EVB-Related Datalink Properties on a Physical Link,” on page 117.

For more information about the EVB components, see “Exchanging VNIC Information by Using VDP” on page 110. For more information about EVB, see the `evb`(7P) man page.

▼ How to Change the Default EVB Configuration

You must configure the `vsi-mgrid` and `vsi-mgrid-enc` properties only on the physical link. The other EVB-related properties, such as `vsi-typeid` and `vsi-vers`, must be configured on a VNIC.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create a VNIC by using the datalink properties mentioned in the profile database.**

   ```
   # dladm create-vnic -l datalink -p maxbw=maxbw-value,priority=priority-value VNIC
   ```

3. **Set the encoding that is associated with the VSI Manager ID to `none` on the physical link because you are not using the default Oracle VSI Manager ID.**

   ```
   # dladm set-linkprop -p vsi-mgrid-enc=none datalink
   ```

4. **Set the VSI Manager ID on the physical link with an IPv6 address.**

   ```
   # dladm set-linkprop -p vsi-mgrid=IPv6-address datalink
   ```

5. **Set the VSI Type ID and VSI Version for the VNIC that you have created.**

   ```
   # dladm set-linkprop -p vsi-typeid=VSI-Type-ID,vsi-vers=VSI-Version VNIC
   ```

6. **Verify the properties that are set for the VNIC.**

   ```
   # dladm show-linkprop VNIC
   ```

Example 44 Setting EVB-Related Datalink Properties

The following example shows how to set datalink properties that are related to EVB. This example uses a system with a profile that you can access by using an IPv6 address, `IP1`.

Assume that the VSI Manager ID, IP1 has the following profiles defined:

- VSI Type ID: `2`
- VSI Version: `1`
- Datalink properties: `maxbw=20`, `priority=5`

1. Create a VNIC by using the datalink properties mentioned in the profile.

   ```
   # dladm create-vnic -l net0 -p maxbw=20,priority=5 vnic1
   ```

2. Set the encoding that is associated with the VSI Manager ID to `none` on the physical link `net0` because you are not using the default Oracle VSI Manager ID.

   ```
   # dladm set-linkprop -p vsi-mgrid-enc=none net0
   ```

3. Set the VSI Manager ID on the physical link `net0` with the IPv6 address `IP1`.

```
# dladm set-linkprop -p vsi-mgrid=IP1 net0
```

4. Set the VSI Type ID and VSI Version for `vnic1`.

```
# dladm set-linkprop -p vsi-typeid=2,vsi-vers=1 vnic1
```

5. Verify the properties that are set for `vnic1`.

```
# dladm show-linkprop vnic1
LINK     PROPERTY            PERM VALUE      EFFECTIVE  DEFAULT    POSSIBLE
...
vnic1    vsi-typeid          rw   2          2           --         --
vnic1    vsi-vers            rw   1          1           --         --
vnic1    vsi-mgrid           rw   IP1        IP1         --         --
vnic1    vsi-mgrid-enc       rw   --         none        oracle_v1  none,oracle_v1
...
```

The VDP `ASSOC` TLV unit for `vnic1` contains the following information:

- VSI Manager ID = `IP1`
- VSI Type ID = `2`
- VSI Version = `1`

Example 45 Displaying EVB-Related Datalink Properties on a Physical Link

The following example displays EVB-related properties on the physical link.

```
# dladm show-linkprop -p vsi-mgrid,vsi-mgrid-enc net4
LINK     PROPERTY            PERM VALUE        EFFECTIVE    DEFAULT      POSSIBLE
net4     vsi-mgrid           rw   --           --           ::           --
net4     vsi-mgrid-enc       rw   --           --           oracle_v1    none,oracle_v1
```

The output displays the default configuration of EVB in Oracle Solaris. By using the `oracle_v1` encoding, the VSI Type ID and VSI version are automatically generated from the properties that are configured on the VNICs.

Example 46 Displaying EVB-Related Properties on a VNIC

The following example displays EVB-related properties on a VNIC.

```
# dladm show-linkprop vnic0
LINK     PROPERTY            PERM VALUE      EFFECTIVE  DEFAULT    POSSIBLE
...
vnic0    vsi-typeid          rw   --         94         --         --
vnic0    vsi-vers            rw   --         0          --         --
```

```
vnic0    vsi-mgrid              rw   --         ::         --         --
vnic0    vsi-mgrid-enc          rw   --         oracle_v1  oracle_v1  none,oracle_v1
...
```

The output displays the effective encoding for `vnic0` as `oracle_v1`. In turn, the `EFFECTIVE` value for `vsi-typeid 94` is automatically generated and effective for `vnic0`.

♦ ♦ ♦ CHAPTER 5

About Elastic Virtual Switches

Starting with the Oracle Solaris 11.2 release, you can use the Oracle Solaris Elastic Virtual Switch (EVS) feature to manage multiple virtual switches that are spread across several physical machines. This chapter provides an overview of the elastic virtual switch feature in Oracle Solaris and includes the following topics:

- "Overview of the Elastic Virtual Switch (EVS) Feature" on page 119
- "EVS Components" on page 127
- "EVS Administrative Commands" on page 132
- "Mandatory Packages for Using EVS" on page 137
- "How EVS Works With Zones" on page 137
- "Security Requirements for Using EVS" on page 138

Overview of the Elastic Virtual Switch (EVS) Feature

Today's data centers or multitenant cloud environments include multiple systems hosting several virtual machines (VMs) that are connected by a network fabric. Provisioning networking for VMs in a data center or multitenant cloud environment is a challenge for administrators, as it includes virtual networking between VMs, managing the MAC address and IP address, and administering VLANs and VXLANs. The additional challenge apart from ensuring internal and external network connectivity for VMs is to provision and enforce service-level agreements (SLAs) for the VMs and applications within VMs. These SLAs include bandwidth limits and priorities. Administrators also need to provide isolation between multiple tenants sharing a common network infrastructure.

To meet these requirements, Oracle Solaris network virtualization capabilities enable administrators to manage virtual switches across a data center or multitenant cloud environment. The virtual switches are exposed as first-class operating system abstractions. These virtual switches, also known as elastic virtual switches, span multiple systems and enable system administrators to manage them as a single virtual switch.

Virtual Switches in Oracle Solaris

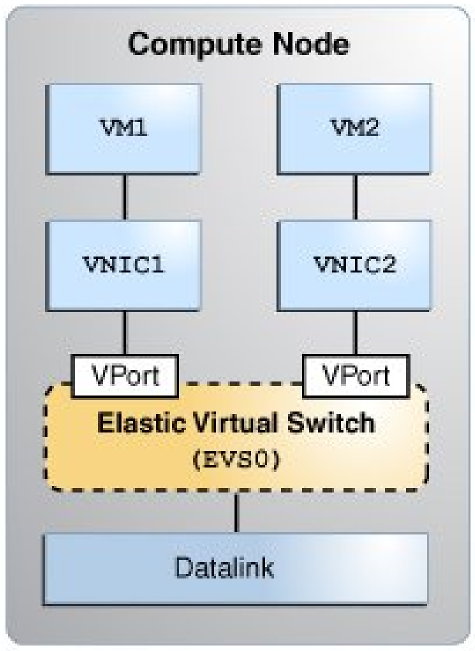
The virtual switch is an entity that facilitates communication between virtual machines. In Oracle Solaris, a virtual switch is automatically or implicitly created when you create a VNIC over a datalink, such as a link aggregation, a physical NIC, or an etherstub. The virtual switch loops traffic between VMs (inter-VM traffic) within the physical machine and does not send this traffic out on the wire. All VMs need to exist on the same Layer 2 segment to communicate with each other. For more information, see "Virtual Switch" on page 18.

In releases prior to Oracle Solaris 11.2, virtual switches were indirectly managed through the datalinks over which the VNICs were created. Starting with the Oracle Solaris 11.2 release, virtual switches can be managed by EVS. You can create a virtual switch explicitly and specify a name, assign virtual ports (VPort) to the virtual switch, and associate it with a block of IP addresses. You can set properties such as priority, maximum bandwidth, class of service (CoS), MAC address, and IP address for the virtual ports. You can also configure default SLAs on a per-virtual-switch basis.

Note - Virtual switches that are implicitly created as a part of the VNIC creation continue to exist and function the same in this release as in previous releases. EVS does not replace the existing implicit virtual switch.

The following figure shows the elastic virtual switch `EVS0` in a single compute node.

FIGURE 15 Elastic Virtual Switch in a Compute Node



What Is the Oracle Solaris Elastic Virtual Switch Feature?

The Oracle Solaris Elastic Virtual Switch (EVS) feature enables you to create and administer a virtual switch that spans one or more compute nodes. These compute nodes are the physical machines that hosts VMs. An elastic virtual switch is an entity that represents explicitly created virtual switches that belong to the same Layer 2 (L2) segment. An elastic virtual switch provides network connectivity between VMs connected to it from anywhere in the network.

Note - In EVS, all references to the term virtual machines (VMs) specifically refer to Oracle Solaris Zones and Oracle Solaris Kernel Zones.

An elastic virtual switch can span across multiple hosts. These virtual switches are described as "elastic" because they have the capability to span into the host and span out of the host. The elastic virtual switch spans into the host when you connect the VNICs of the hosts to the elastic virtual switch. When you delete these VNICs, the elastic virtual switch spans out of the hosts.

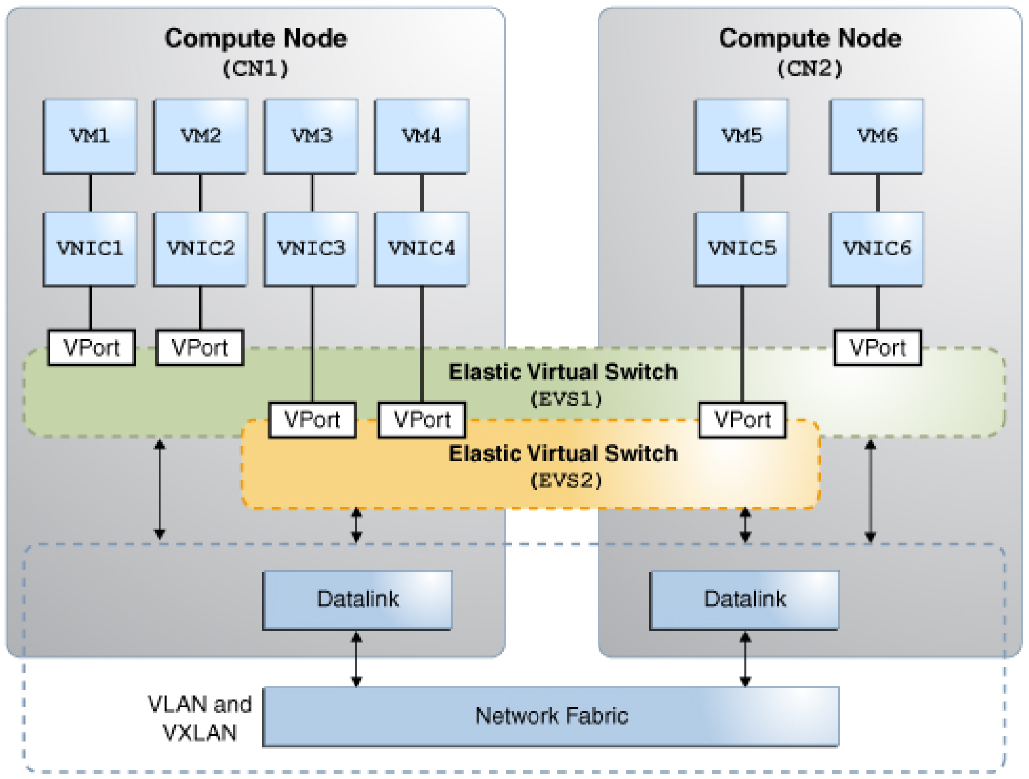
An elastic virtual switch represents an isolated L2 segment, and the isolation is implemented as a flat (untagged), a VLAN or a VXLAN. For information about how you can implement an elastic virtual switch with a VLAN, see "Use Case: Configuring an Elastic Virtual Switch" on page 187. For information about how you implement an elastic virtual switch with a VXLAN, see "Use Case: Configuring an Elastic Virtual Switch for a Tenant" on page 193. For information about how to implement an elastic virtual switch based on a flat network, see "How to Configure a Flat EVS Network" on page 164.

For information about administering VLANs, see Chapter 3, "Configuring Virtual Networks by Using Virtual Local Area Networks" in *Managing Network Datalinks in Oracle Solaris 11.3*. For information about administering VXLANs, see Chapter 3, "Configuring Virtual Networks by Using Virtual Extensible Local Area Networks".

Every elastic virtual switch is associated with a name, virtual ports, and a block of IP addresses. You can create, monitor, and control the virtual switch resources. For more information, see Chapter 6, "Administering Elastic Virtual Switches".

The following figure shows two elastic virtual switches (`EVS1` and `EVS2`) between two compute nodes. The VMs that are provisioned on these compute nodes are connected through the elastic virtual switches that span across the two compute nodes. Each compute node connects to the same network fabric through a datalink. The datalink is also known as an *uplink port*. The datalinks on these compute nodes connect the virtual switch to the external network. The VNIC is connected to the elastic virtual switch through a virtual port (VPort). The VNICs inherit properties that are associated with the virtual ports such as MAC address, IP address, and SLAs.

FIGURE 16 Elastic Virtual Switches Between Compute Nodes



In this figure, the VMs `VM1`, `VM2`, and `VM6` can communicate with each other through the elastic virtual switch `EVS1`. The VMs `VM3`, `VM4`, and `VM5` can communicate with each other through the elastic virtual switch `EVS2`. For more information, see "How to Configure an Elastic Virtual Switch" on page 162.

Benefits of Using EVS

In a data center or multitenant cloud environment that hosts several virtual machines, EVS makes some of the network administration tasks simpler by providing the following benefits:

- Creates a virtual network between VMs that are on systems thus providing network connectivity
- Supports addition of virtual ports with custom SLAs
- Provides network isolation by using VLANs or VXLANs
- Supports multitenant virtual networks that share the same underlying infrastructure
- Integrated with Oracle Solaris Zones and Oracle Solaris Kernel Zones
- Provides centralized management of:
  - MAC address and IP address for the virtual ports
  - SLAs on a per-virtual-switch or per-virtual-port basis
  - Monitoring runtime network traffic statistics of the virtual ports

Elastic Virtual Switch Resources

An elastic virtual switch is associated with the following main resources: an IP network and a virtual port. The resources and the elastic virtual switches are associated with Universal Unique Identifiers (UUIDs). An UUID is automatically generated by the EVS controller when you create an elastic virtual switch or its resources. See Example 59, "Displaying the UUID of an Elastic Virtual Switch," on page 172, Example 62, "Displaying the UUID of an IPnet," on page 175, and Example 67, "Displaying the UUID for a VPort," on page 180.

IP Network

An IP network, also known as an IPnet, represents a block of IPv4 or IPv6 addresses with a default router for the block. This block of IPv4 or IPv6 addresses is also known as the subnet. You can associate only one IPnet to an elastic virtual switch. All VMs that connect to the elastic virtual switch through a virtual port are assigned an IP address from the IPnet that is associated with the elastic virtual switch.

You can also manually assign an IP address to a VM by setting the IP address property, `ipaddr`, for the VPort. This IP address must be within the subnet range of the IPnet. For more information about how to add an IPnet to the elastic virtual switch, see "How to Configure an Elastic Virtual Switch" on page 162.

Virtual Port

A virtual port, also known as a VPort, represents the point of attachment between the VNIC and an elastic virtual switch. When a VNIC connects to a VPort, the VNIC inherits the network configuration parameters that the VPort encapsulates, such as the following:

- SLA parameters such as maximum bandwidth, class of service, and priority
- MAC address
- IP address

When you create a VPort, a randomly generated MAC address and the next available IP address from the associated IPnet are assigned to the VPort. The randomly generated MAC address has a default prefix consisting of a valid IEEE OUI with the local bit set. You can also specify the IP address and the MAC address when you add a VPort by using the `evsadm add-vport` command. For more information about how to add a VPort, see "How to Configure an Elastic Virtual Switch" on page 162.

Note - You do not always need to add a virtual port to an elastic virtual switch. When a VNIC is created, you can specify only the name of the elastic virtual switch to which the VNIC must connect. In such cases, the EVS controller generates a system virtual port. These virtual ports follow the naming convention `sys-`*vportname*, for example, `sys-vport0`. The system virtual port inherits the elastic virtual switch properties.

The following table shows the VPort properties.

TABLE 4 VPort Properties

VPort Property	Description	Possible Values	Default Value
`cos`	Specifies the 802.1p priority on outbound packets on the VPort.	`0 - 7`	`--`
`maxbw`	Specifies the full-duplex bandwidth for the VPort.	`--`	`--`
`priority`	Specifies the relative priority for the VPort.	`high`, `medium`, or `low`	`medium`
`ipaddr`	Specifies the IP address associated with the virtual port. You can assign the IP address only when you create the VPort.	`--`	If you do not specify the IP address for the VPort, the EVS controller automatically selects an IP address from the IPnet associated with the elastic virtual switch.
`macaddr`	Specifies the MAC address associated with the VPort.	`--`	If you do not specify the MAC address for the

VPort Property	Description	Possible Values	Default Value
	You can assign the MAC address only when you create the VPort.		VPort, the EVS controller generates a random MAC address for the VPort.
`evs`	A read-only property that represents the elastic virtual switch with which the VPort is associated.	`--`	`--`
`tenant`	A read-only property that represents the tenant with which the VPort is associated.	`--`	`--`
`protection`	Enables one or more types of link protection.	`mac-nospoof`, `ip-nospoof`, `dhcp-nospoof`, `restricted`, `none`	The default values are `mac-nospoof` and `ip-nospoof`. When you create a VNIC with a VPort, the `mac-nospoof` and `ip-nospoof` values are set by default for the VNIC. This prevents the VNIC from spoofing the other MAC and IP address.

You cannot modify the properties `evs` and `tenant` because they are read-only properties. For more information about the VPort properties, see the `evsadm`(1M) man page.

Namespace Management in EVS

The elastic virtual switches and their resources are logically grouped together. Each logical group is called a *tenant*. The defined resources for the elastic virtual switch within a tenant are not visible outside that tenant's namespace. The tenant acts as a container to hold all the tenant's resources together. For more information about how to create an elastic virtual switch with a tenant, see "How to Configure an Elastic Virtual Switch" on page 162.

You do not need to specify the tenant name for any EVS operation. The default tenant name is `sys-global` and all the EVS operations occur in this namespace.

Flat EVS Networks

In addition to implementing an elastic virtual switch by using a VLAN or VXLAN, Oracle Solaris also provides a flat L2-type network for implementing an elastic virtual switch. You can create a flat L2-type EVS and place all the VM instances on the same segment without a VLAN or VXLAN. This means that the VM instances share the same network, and therefore the same IP address space as a compute server. In a flat EVS network, there is no VLAN tagging or other types of network segregation. By default, the VNICs that you connect to the EVS with the flat L2-type are created with the VLAN ID set to `0`. You cannot use flat L2-type to create multi-tenant networks. However, you can use the flat L2-type EVS to map directly to the existing physical networks in the data center. The `evsadm` command is enhanced that enables you to create a flat L2-type network. For more information, see "How to Configure a Flat EVS Network" on page 164.

You use the flat networks to directly map OpenStack Neutron network to an existing physical network. For example, if the range of available floating IPs are a subset of the existing physical network, then you need to create a flat network with the subnet set to that range of floating IPs. So, the flat network contains a part of the existing physical network's IP. For more information about OpenStack, see *Installing and Configuring OpenStack (Havana) in Oracle Solaris*.

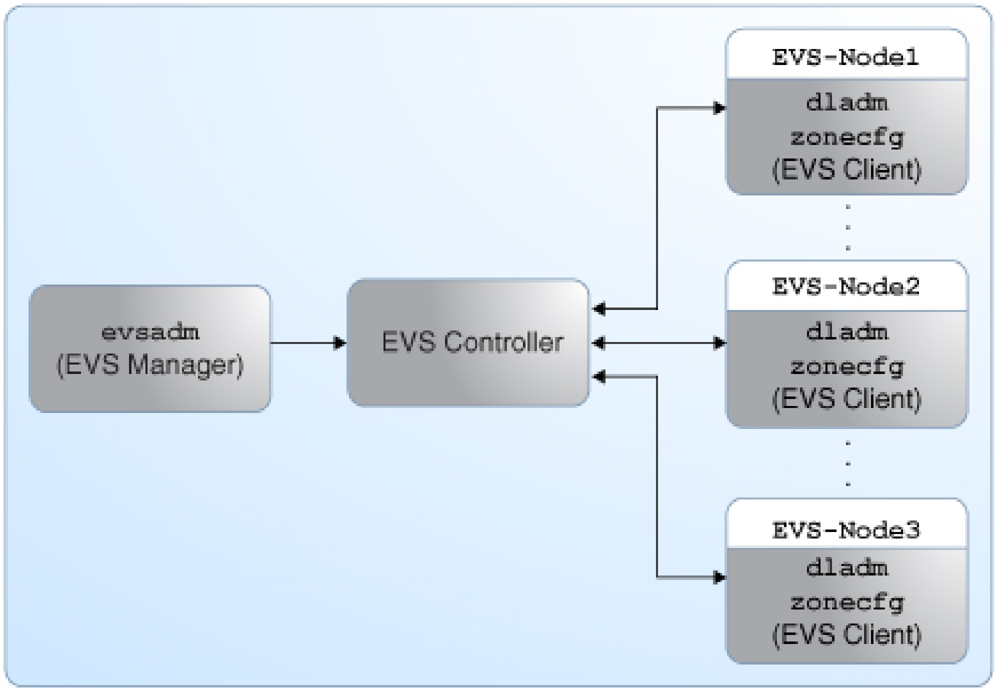
EVS Components

EVS has the following components:

- EVS manager
- EVS controller
- EVS clients
- EVS nodes

The following figure shows the components of EVS.

FIGURE 17 EVS Components



In this figure, the EVS manager and the EVS controller are two separate hosts. The EVS nodes `EVS-Node1`, `EVS-Node2`, and `EVS-Node3` are three hosts whose VNICs or zone's VNIC `anet` resources connect to an elastic virtual switch.

EVS Manager

The EVS manager is the entity that communicates with the EVS controller to define the L2 network topologies and the IP addresses that must be used on these L2 networks. The EVS manager communicates with the EVS controller by using the `evsadm` command. The EVS manager and the EVS controller can also be on the same compute node.

Note - The L2 network topologies are the network segments and each segment forms a single broadcast domain, which is implemented by using VLANs or VXLANs.

You can perform EVS operations on the EVS manager after you install the `service/network/evs` package and specify the EVS controller by using the `controller` property with the `evsadm set-prop` command. The `controller` property is specified in the `ssh://[`*user*`@]example-controller.com` format. For more information, see Chapter 6, "Administering Elastic Virtual Switches".

EVS Controller

The EVS controller provides functionality for the configuration and administration of an elastic virtual switch and all the resources associated with it. You must set up only one physical machine as the EVS controller in a data center or multitenant cloud environment.

You specify the EVS controller by using the `controller` property with the `evsadm set-prop` command. The `controller` property is saved in the `svc:/network/evs:default` SMF service and therefore is persistent across system boots.

The EVS controller is associated with properties that you can configure by using the `evsadm set-controlprop` command. To implement the L2 segments across physical machines, you need to configure the properties of an EVS controller with information such as available VLAN IDs, available VXLAN segment IDs, or an uplink port for each EVS node. For more information about how to configure the EVS controller and set properties for it, see "Creating and Administering an EVS Controller" on page 143.

Note - You can also push the EVS controller information to each of the EVS nodes in the data center or multitenant cloud environment by using SMF site profiles and the Auto Install (AI) service. For more information about SMF, see *Managing System Services in Oracle Solaris 11.3*. For more information about AI service, see "Working With Install Services" in *Installing Oracle Solaris 11.3 Systems*.

The following table shows the EVS controller properties.

TABLE 5 EVS Controller Properties

EVS Controller Property	Description	Possible Values	Default Value
`l2-type`	Defines how an elastic virtual switch is implemented across physical machines.	`flat`, `vlan`, or `vxlan`	`vlan`

EVS Controller Property	Description	Possible Values	Default Value
	Note - When you change the `l2-type` property, the elastic virtual switches that are created prior to change are not affected. Only the elastic virtual switches that are created after the change have the updated `l2-type` property. This behavior means that L2 segments based on Flat, VLAN, and VXLAN can coexist in an EVS controller.		
`vlan-range`	A comma-separated list of VLAN ID ranges that are used for creating an elastic virtual switch. One VLAN ID is associated with each elastic virtual switch.	`1 - 4094`	`--`
`vxlan-range`	A comma-separated list of VXLAN segment number ranges that are used for creating an elastic virtual switch. One VXLAN segment number is associated with each elastic virtual switch.	`0 - 16777215`	`--`
`vxlan-addr`	Specifies the IP address over which the VXLAN datalink must be created. You can also set the `vxlan-addr` property to a subnet.	`--`	`--`
`vxlan-mgroup`	Specifies the multicast address that you need to use while creating the VXLAN datalinks.	`--`	If you do not specify the multicast address, the VXLAN datalink uses the `All Host` address.
`vxlan-ipvers`	Specifies the IP version of the address that you need to use for the IP interface that hosts VXLAN datalinks.	`v4` or `v6`	`v4`
`uplink-port`	Specifies the datalink that you need to use for the network types: Flat, VLAN, or VXLAN.	`--`	`--`
`uuid`	Specifies an unique ID to identify an EVS controller in the data center or multitenant cloud environment. `uuid` is a read-only property whose value is automatically generated when you set up an EVS controller.	`--`	`--`
`uri-template`	Specifies the template from which the RAD URI scheme is	`ssh://[`*username*`@]`	`ssh://`

EVS Controller Property	Description	Possible Values	Default Value
	computed by the EVS controller. The computed RAD URI is used between EVS controller and EVS nodes.	or `unix://[`*username*`@]`	

The controller properties that you set for an EVS controller are applicable to the entire data center or multitenant cloud environment. However, you can override the values of the controller properties `uplink-port` and `vxlan-addr` on a per-host basis.

For example, suppose that when you set the controller properties, you set the `uplink-port` property to the datalink `net2`, which is used to create VNICs or VXLANs on every EVS node in the data center or multitenant cloud environment. However, if an EVS node in the data center or multitenant cloud environment has the datalink `net1` as the only interface, you would need to override the global value `net2` with a per-host value as follows:

```
# evsadm set-controlprop -h host1 -p uplink-port=net1
```

For more information, see "How to Configure an EVS Controller" on page 157.

If you do not specify a value for a controller property, the property is reset to the default value, as shown in Example 51, "Resetting Properties for an EVS Controller," on page 159. For more information about the EVS controller properties, see the `evsadm`(1M) man page.

EVS Clients

The `dladm` and `zonecfg` commands are the EVS clients. You can define the L2 network topologies through the `evsadm` command by using the elastic virtual switch, IPnet, and VPorts. You can use the `dladm` command to connect the VNICs to the L2 network topologies or the `zonecfg` command to connect the VNIC `anet` resource, thereby connecting the zones to the L2 network topologies.

Note - The `evsadm` command is the EVS manager that defines L2 network topologies.

When VNICs are created for the elastic virtual switch by using the `dladm` command or the `zonecfg` command, the configuration information for VNICs is retrieved from the EVS controller.

You can perform EVS operations on the EVS client after you install the `service/network/evs` package and specify the EVS controller by using the `controller` property with the `evsadm` `set-prop` command. The `controller` property is specified in the `ssh://[`*user*`@]example-controller.com` format. For more information, see Chapter 6, "Administering Elastic Virtual Switches".

EVS Nodes

EVS nodes are hosts whose VNICs or zone's VNIC `anet` resources connect to an elastic virtual switch. You can use commands such as `dladm` and `zonecfg` to specify VNICs that need to be connected to an elastic virtual switch. For more information, see "Creating a VNIC for an Elastic Virtual Switch" on page 165.

EVS Administrative Commands

You manage an elastic virtual switch by using the following administrative commands:

- `evsadm`
- `evsstat`
- `dladm`
- `zonecfg`

For information about how to configure an elastic virtual switch, see "How to Configure an Elastic Virtual Switch" on page 162.

`evsadm` Command

You use the `evsadm` command to communicate with the EVS controller and manage the elastic virtual switch, IPnet, and VPorts. This section describes the subcommands you use to perform activities with this command. For more information, see the `evsadm`(1M) man page.

`evsadm` Subcommands for Managing an Elastic Virtual Switch

The `evsadm` subcommands for managing a virtual switch are:

`create-evs`	Creates an elastic virtual switch
`delete-evs`	Deletes an elastic virtual switch
`show-evs`	Displays information about an elastic virtual switch
`set-evsprop`	Enables you to set the `maxbw` and `priority` properties for an elastic switch For more information about these properties, see "Setting Properties for an Elastic Virtual Switch" on page 170.
`show-evsprop`	Displays the properties of the elastic virtual switch

`evsadm` Subcommands for Managing an IPnet

The `evsadm` subcommands for managing an IPnet are:

`add-ipnet`	Adds an IPnet to the elastic virtual switch and enables you to set the `subnet`, `defrouter`, and `pool` properties For more information about these properties, see "Adding an IPnet to an Elastic Virtual Switch" on page 161.
`set-ipnetprop`	Sets properties for an IPnet
`show-ipnetprop`	Displays properties of an IPnet
`remove-ipnet`	Removes an IPnet
`show-ipnet`	Displays information about an IPnet

`evsadm` Subcommands for Managing a VPort

The `evsadm` subcommands for managing a virtual port are:

`add-vport`	Adds a VPort
`remove-vport`	Removes a VPort
`show-vport`	Displays information about a VPort

`set-evsprop`	Enables you to set the following properties for a VPort: ■ `cos` ■ `maxbw` ■ `priority` For more information about these properties, see Table 4, "VPort Properties," on page 125.
`show-vportprop`	Displays the properties of the VPort
`reset-vport`	Resets a VPort

`evsadm` Subcommands for Managing EVS Client Properties

The `evsadm` subcommands for managing EVS client properties are:

`set-prop`	Enables you to set the `controller` property
`show-prop`	Displays EVS client properties

`evsadm` Subcommands for Managing EVS Controller Properties

The `evsadm` subcommands for managing EVS controller properties are:

`set-controlprop`	Enables you to set the following properties for the controller: ■ `l2-type` ■ `vlan-range` ■ `vxlan-range` ■ `vxlan-mgroup` ■ `vxlan-addr` ■ `vxlan-ipvers` ■ `uplink-port` For more information about these properties, see Table 5, "EVS Controller Properties," on page 129.
`show-controlprop`	Displays the properties of the EVS controller

`evsstat` Command

The `evsstat` command displays the network traffic statistics for all the VPorts in a data center or multitenant cloud environment or for all the VPorts of the specified elastic virtual switch. It also reports the statistics of VNICs associated with the VPorts. For more information, see "Monitoring Elastic Virtual Switches" on page 184. For more information about the `evsstat` command, see the `evsstat`(1M) man page.

`dladm` Command

You can administer the VNICs connected to an elastic virtual switch by using the following `dladm` commands:

- `dladm create-vnic` command – Enables you to create a VNIC and specify the elastic virtual switch name to which you need to connect the VNIC. Optionally, you can specify the VPort of the elastic virtual switch.
- `dladm show-vnic` command – Enables you to display the elastic virtual switch information for a specific VNIC. The output of the `dladm show-vnic` command also displays the fields `TENANT`, `EVS`, and `VPORT`. However, these fields are not visible from within a zone.

For more information, see the `dladm`(1M) man page.

For more information about how to configure a VNIC for an elastic virtual switch, see "How to Create a VNIC for an Elastic Virtual Switch" on page 166.

`zonecfg` Command

You use the enhanced `zonecfg` command to configure a zone's VNIC `anet` resource for an elastic virtual switch. You can set the following properties for the VNIC `anet` resource:

- `tenant` – Specifies the name of the tenant. If you do not specify a value when configuring a zone, the system assigns the default value, `sys-global`.
- `vport` – Specifies the name of the VPort. If you do not specify a value when configuring a zone, the system generates a VPort for the elastic virtual switch and the VPort inherits the elastic virtual switch properties.
- `evs` – Specifies the name of an elastic virtual switch to which you must connect the VNIC `anet` resource.

For more information about the `anet` resource, see the `anet` description in "Resource Type Properties" in *Oracle Solaris Zones Configuration Resources*.

Note - Zone configuration must include the tenant name, elastic virtual switch name, and VPort name by which a VPort in a data center or multitenant cloud environment is uniquely identified. For more information about the zone configuration, see *Creating and Using Oracle Solaris Zones*.

For more information about how to configure the VNIC `anet` resource for an elastic virtual switch, see "Creating a VNIC `anet` Resource for an Elastic Virtual Switch" on page 167. For more information about the `zonecfg` command, see the `zonecfg`(1M) man page.

Restrictions for Administering VNICs Connected to an Elastic Virtual Switch

The following restrictions apply on the VNICs that you create and connect to an elastic virtual switch by using the `dladm create-vnic` command or the `zonecfg` command:

- You cannot rename the VNICs by using the `dladm rename-link` command.
- You cannot change the properties of such VNICs by using the `dladm set-linkprop` or `dladm reset-linkprop` commands.
- You cannot modify these VNICs by using the `dladm modify-vnic` command.

Automatically Generated VXLAN Datalinks

If you implement Layer 2 segments for elastic virtual switches by using VXLANs, EVS automatically creates VXLAN datalinks on the EVS nodes that hosts VNICs for the elastic virtual switch. These datalinks are known as automatically generated VXLAN datalinks and follow the naming convention `evs-vxlan`*segment-ID*, where `evs` is the entity that created the datalink. For example, the name `evs-vxlan200` indicates that `200` is the VXLAN ID and `evs` is the entity that has created this datalink. You can use the `dladm show-vxlan` command to display the automatically generated VXLAN datalinks. For more information, see "Displaying VXLAN Information" on page 92.

You cannot use the `dladm` subcommands on automatically generated VXLAN datalinks to delete or rename the datalink. However, you can temporarily set the datalink properties by using the `dladm set-linkprop` command and the `dladm reset-linkprop` command.

Mandatory Packages for Using EVS

You need to install the following packages before using EVS:

- `pkg:/service/network/evs`

  You need to install the core package `pkg:/service/network/evs` on the EVS manager, EVS controller, and EVS nodes. This package contains the following components:

  - `evsadm`
  - `evsstat`
  - SMF service (`svc:/network/evs:default`) – This SMF service has the `controller` property that holds the hostname or the IP address of the EVS controller. The EVS client uses the hostname or the IP address to communicate with the EVS controller. You use the `evsadm set-prop` command to manage the `controller` property.

  When you install the `pkg:/service/network/evs` package, a new user, `evsuser` is created. The `evsuser` is a specific user with the Elastic Virtual Switch Administration rights profile. This profile provides all the required authorizations and privileges to perform EVS operations.
- `pkg:/system/management/rad/module/rad-evs-controller`

  You need to install this package only on the system that acts as an EVS controller. You must use only one controller to manage all the elastic virtual switches in a data center or multitenant cloud environment. This package contains the SMF service, `svc:/network/evs-controller:default`. This SMF service has properties that capture information that is necessary for implementing L2 segments across physical machines. You use the `evsadm set-controlprop` command to manage the controller properties.

For more information, see "Mandatory Packages for an EVS Controller" on page 144.

How EVS Works With Zones

You can connect the VNIC `anet` resource to an elastic virtual switch by using the properties associated with the `zonecfg` command. Oracle Solaris Zones and Oracle Solaris Kernel Zones support the EVS feature.

Kernel zones support VNICs that you create for the elastic virtual switch. The VNIC that you create inside the kernel zone works only if the VNIC uses the factory MAC addresses that are associated with the `zvnet` driver. Because a VNIC that you create for the elastic virtual switch inherits the MAC address associated with the VPort of the elastic virtual switch, you must create the VPort for the elastic virtual switch by setting the `macaddr` property to the factory MAC address of the `zvnet` driver.

You use the following command syntax to explicitly specify the factory MAC address:

```
# evsadm add-vport -p macaddr=factory-MAC-addr-zvnet  EVS-name/VPort-name
```

In the kernel zone, you can connect the VNIC to the VPort that is created by using this command. For information about kernel zones, see *Creating and Using Oracle Solaris Kernel Zones*.

Using the Elastic Virtual Switch in OpenStack

Oracle Solaris provides a complete OpenStack distribution. OpenStack is the open source cloud computing software that provides comprehensive self-service environments for sharing and managing compute, network, and storage resources in the data center or multitenant cloud environment through a centralized web-based portal. OpenStack is integrated into all the core technology foundations of Oracle Solaris 11, so you can now set up an enterprise-ready private cloud infrastructure as a service (IaaS) environment in minutes.

OpenStack Neutron provides network virtualization. EVS in Oracle Solaris implements OpenStack Neutron APIs to provide network connectivity between VMs either through VLANs or VXLANs. For more information, see *Installing and Configuring OpenStack (Havana) in Oracle Solaris*.

Security Requirements for Using EVS

To perform EVS operations, you need to be superuser or a user with the Elastic Virtual Switch Administration rights profile. You can also create a user and assign the Elastic Virtual Switch Administration rights profile to the user. For more information, see *Securing Users and Processes in Oracle Solaris 11.3*.

Note - In a multitenant EVS setup, individual tenants cannot manage their own elastic virtual switches and their resources because per-tenant user authorizations for each user is not supported. The entire EVS domain must have a single administrator who manages resources of all the tenants.

The following example shows how to create `user1` with the Elastic Virtual Switch Administration rights profile.

```
# useradd -P “Elastic Virtual Switch Administration” user1
```

The following example shows how to add the Elastic Virtual Switch Administration rights profile to the existing user `user1`.

```
# usermod -P +”Elastic Virtual Switch Administration” user1
```

When you set the EVS controller, you must specify the user who has the Elastic Virtual Switch Administration rights profile. For example, you must specify `user1` when you set the EVS controller as follows:

```
# evsadm set-prop -p controller=ssh://user1@example-controller.com
```

For more information, see “Configuring an EVS Controller” on page 150.

Note - You can also use `evsuser` that is created when you install the `pkg:/service/network/evs` package. The user, `evsuser`, is assigned with the Elastic Virtual Switch Administration rights profile. This profile provides all the required authorizations and privileges to perform EVS operations. A new authorization solaris.network.evs.observability is required to observe EVS resources and statistics. A new authorization solaris.network.evs.observability is required to observe EVS resources and statistics.

Note - The Elastic Virtual Switch Administration rights profile with the authorization `solaris.network.evs.observability` is required to provide an ability to observe EVS resources and statistics.

♦ ♦ ♦ CHAPTER 6

Administering Elastic Virtual Switches

This chapter describes tasks for administering elastic virtual switches and their resources. For general information, see Chapter 5, "About Elastic Virtual Switches".

This chapter contains the following topics:

EVS Administration Tasks

This section provides the following information for accomplishing EVS administration tasks:

- "How to Configure an EVS Controller" on page 157
- "How to Configure an Elastic Virtual Switch" on page 162
- "Creating a VNIC for an Elastic Virtual Switch" on page 165
- "Displaying Elastic Virtual Switch Information" on page 168
- "Setting Properties for an Elastic Virtual Switch" on page 170
- "Displaying Properties of an Elastic Virtual Switch" on page 171
- "Setting Properties for an IPnet" on page 173
- "Displaying Properties of an IPnet" on page 173
- "Removing an IPnet" on page 175
- "Displaying IPnets" on page 176
- "Setting Properties for a VPort" on page 177

- "Displaying Properties of a VPort" on page 178
- "Displaying VPorts" on page 180
- "Removing a VPort" on page 182
- "How to Delete an Elastic Virtual Switch" on page 182
- "Monitoring Elastic Virtual Switches" on page 184

Planning an Elastic Virtual Switch Configuration

Planning an elastic virtual switch configuration includes the following actions:

1. Installing the mandatory packages on the EVS controller, EVS manager, and EVS nodes. You must install these packages for each of these components separately. For more information, see "Mandatory Packages for Using EVS" on page 137.
2. Setting up the SSH authentication with the preshared public key for `evsuser` between the following components in the EVS setup:
   - EVS manager and the EVS controller
   - Each EVS node and the EVS controller
   - EVS controller and each EVS node

   For more information, see "Setting Up SSH Authentication" on page 150.
3. Specify the EVS controller by setting the `controller` property. You must specify the host name or IP address of the EVS controller on the EVS nodes, EVS manager, and EVS controller. For more information, see "Configuring an EVS Controller" on page 150.
4. Configuring the EVS controller, which involves:

   a. Setting the properties for the EVS controller.
   b. Verifying the properties that are set for the EVS controller.

   For more information, see "How to Configure an EVS Controller" on page 157.
5. Configuring the elastic virtual switch by using the EVS manager, which involves:

   a. Creating the elastic virtual switch.
   b. Adding the IPnet to the elastic virtual switch.
   c. Adding the VPort to the elastic virtual switch.
   d. Verifying the configured elastic virtual switch.

   For more information, see "How to Configure an Elastic Virtual Switch" on page 162.
6. Creating VNICs on the EVS nodes and connecting the VNICs to the elastic virtual switch, which involves:

a. Creating VNICs by using the `dladm` command or creating VNIC `anet` resources by using the `zonecfg` command and connecting them to the elastic virtual switch.
b. Verifying the VNICs that are connected to the elastic virtual switch.

For more information, see "Creating a VNIC for an Elastic Virtual Switch" on page 165.

Creating and Administering an EVS Controller

An EVS controller provides functionality for the configuration and administration of an elastic virtual switch and all the resources associated with it. You must set properties for an EVS controller, which captures information necessary for implementing Layer 2 segments across physical machines. For more information, see "EVS Controller" on page 129.

Planning for an EVS controller includes the following considerations:

- Determine whether you are implementing the elastic virtual switch by using a VLAN, VXLAN, or both.
  - If you use a VLAN to implement the elastic virtual switch, you need to set the properties `uplink-port` and `vlan-range`.

    Note - If you use a VLAN to implement the elastic virtual switch on multiple nodes, you need to enable VLAN trunking on the appropriate physical switch ports. For more information, refer to the switch manufacturer's documentation.

  - If you use a VXLAN to implement the elastic virtual switch, you need to set the properties `vxlan-range` and `uplink-port` or `vxlan-addr`. Optionally, you can also set the properties `vxlan-mgroup` and `vxlan-ipvers`.

    Note - If you use a VXLAN to implement the elastic virtual switch, you cannot set the value of the `vxlan-addr` property to the IP address of an IPMP interface, while creating the VXLAN. The IPMP interfaces are not supported by VXLANs.

- If the compute nodes do not have the same datalink, then for every compute node, you need to specify the datalink for the `uplink-port` property.

  For example, consider two compute nodes, `host1` with the datalink `net2` and `host2` with the datalink `net3`. You need to specify the datalinks of both the hosts when you set the `uplink-port` property as follows:

```
# evsadm set-controlprop -h host1 -p uplink-port=net2
# evsadm set-controlprop -h host2 -p uplink-port=net3
```

Note - After you create an elastic virtual switch, you cannot modify the EVS controller properties for that elastic virtual switch. Any modifications to the EVS controller properties are reflected in the new elastic virtual switches that you create.

Mandatory Packages for an EVS Controller

You must use only one controller to manage all the elastic virtual switches in a data center or multitenant cloud environment. You must install the `pkg:/service/network/evs` package and the `pkg:/system/management/rad/module/rad-evs-controller` package on the system that acts as an EVS controller.

Use the following commands to install the packages:

```
# pkg install evs
# pkg install rad-evs-controller
```

After you install the `rad-evs-controller` package, you need to restart the `rad:local` service to load the EVS controller by using the following command:

```
# svcadm restart rad:local
```

Commands for Configuring an EVS Controller

This section describes how to perform the following tasks for an EVS controller:

- Setting the EVS controller
- Displaying the EVS controller
- Setting the properties for the EVS controller
- Displaying the properties of the EVS controller

Setting the EVS Controller

You use the `evsadm set-prop` command to set the EVS controller on a host. The command syntax is:

```
# evsadm set-prop -p controller=[value[...,]]
```

This command sets the values of a property for the host where the command is executed. The only supported property is `controller`, which can be of the format `ssh://[`*user*`@]evs-controller-`*host-name* or `ssh://[`*user*`@]evs-controller-`*IP-address*.

If you are configuring the EVS manager, EVS client, and EVS controller on the same system, you can use the UNIX connection instead of using SSH and set the `controller` property to UNIX RAD URI scheme as follows:

```
# evsadm set-prop -p controller=unix://
```

Displaying the EVS Controller

You use the `evsadm show-prop` command to display the EVS controller. The command syntax is:

```
# evsadm show-prop [[-c] -o field[,...]] [-p controller[,...]]
```

`-p controller`	Specifies the EVS controller to which the EVS clients must connect.
`-o` *field*[,...]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields
`PROPERTY`	Name of the property
`PERM`	Permission of the property, which is either `rw` or `r-`
`VALUE`	Value of the property
`DEFAULT`	Default value of the property

`-c`	Display using a stable machine-parseable format. You need to specify the `-o` option with the `-c` option.

For an example that shows how to display the EVS controller, see Example 50, "Configuring an EVS Controller," on page 157.

Setting Properties for an EVS Controller

You use the `evsadm set-controlprop` command to set the properties for the EVS controller. The command syntax is:

```
# evsadm set-controlprop [-h host] -p {prop=[value[...,]]}[,...]
```

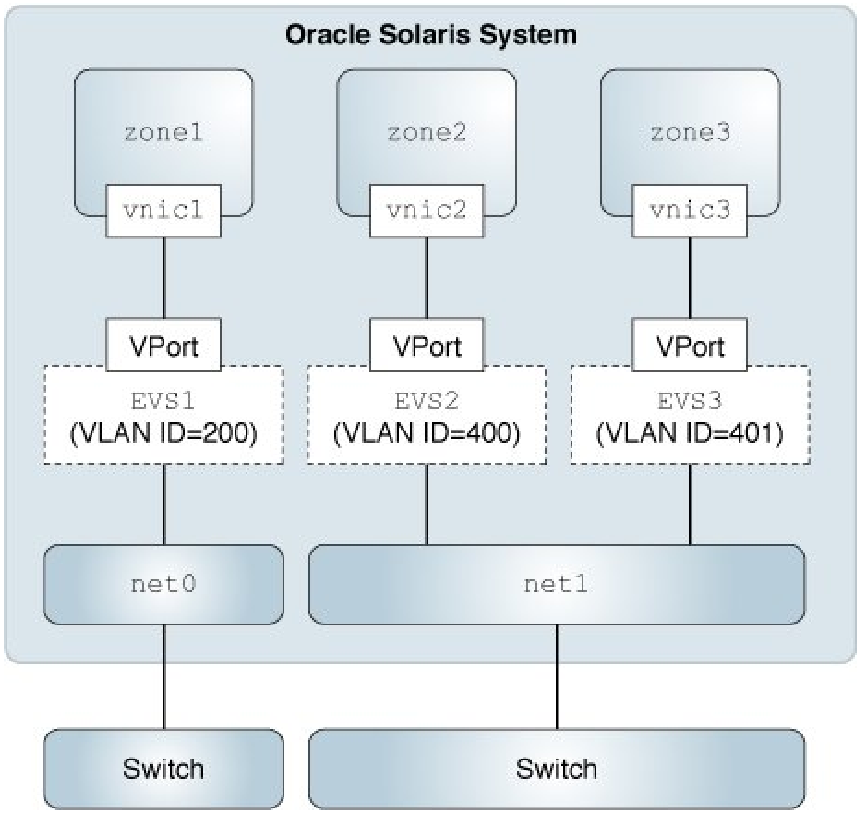
`-h` *host*	Specifies the host for which the property is set.
`-p` *prop*	Specifies the name of the controller property that is set for an EVS controller. If the property takes multiple values, you must specify the values with a comma as the delimiter. You must specify only one property at a time. If the value is not specified, the property is reset to the default value. For more information about the properties that you can set for an EVS controller, see Table 5, "EVS Controller Properties," on page 129.

When you set the `uplink-port` property for the EVS controller, you can optionally specify the `vlan-range` or `vxlan-range` properties. The command syntax is:

```
# evsadm set-controlprop [-h host] -p uplink-port=value\
[vlan-range=[value[,...]]][,vxlan-range=[value[,...]]] [,flat=yes|no]
```

You can use this command to specify multiple uplink ports per host. In this case, the uplink port supports the specified VLAN IDs, VXLAN IDs, or both. The `vlan-range` and `vxlan-range` properties specify which uplink port in a system must be selected for a given EVS from a set of multiple uplink ports. The following figure shows multiple uplink ports in a host.

FIGURE 18 Multiple Uplink Ports in a Host



In the figure there are two uplink-ports `net0` and `net1`. The uplink port `net0` supports vlan id `200-300` while `net1` supports vlan id `400-500`. So, if VM belonging to an EVS with VLAN set `200` is instantiated on the compute node, then `net0` will be selected for creating VM's VNIC. On the other had, if VM belonging to an EVS with VLAN `400` is instantiated on the compute node, then `net1` will be selected for creating VM's VNIC.

Note - You need to specify `flat=yes` for an uplink port if you are creating a flat network based on an elastic virtual switch. For more information, see "How to Configure a Flat EVS Network" on page 164.

For an uplink port, you can set the properties `vlan-range`, `vxlan-range`, and `flat` separately or set them together. You can also reset the value of a property by specifying only the name of the property followed by =. You do not need to specify any value for the property. See Example 51, “Resetting Properties for an EVS Controller,” on page 159.

EXAMPLE 47 Setting Uplink Port with VLAN and VXLAN Ranges for the EVS Controller

The following example shows how to set multiple uplink ports for `host1` and specify the VLAN range for each uplink port.

```
# evsadm set-controlprop -h solaris -p uplink-port=net0,\
vlan-range=200-300
evsadm: warning: provided value range is a subset of the complete range.
Ensure to provide the remaining value range on a different uplink-port or vxlan-addr
# evsadm set-controlprop -h solaris -p uplink-port=net1,\
vlan-range=400-500
# evsadm show-controlprop -p uplink-port
PROPERTY          PERM VALUE       DEFAULT    VLAN_RANGE  VXLAN_RANGE HOST
uplink-port       rw   net0        --         200-300     --          solaris
uplink-port       rw   net1        --         400-500     --          solaris
```

In this example, `solaris` has two uplink ports: `net0` and `net1`. The `net0` uplink port supports `200-300` VLAN range and the `net1` uplink port supports `400-500` VLAN range.

Similarly, you can set the `vxlan-range` property for multiple uplink ports in a host.

Both VLAN and VXLAN can exist together in the network fabric at the same time. The following example shows how to set the `vlan-range` and `vxlan-range` properties for multiple uplink ports in a host.

```
# evsadm set-controlprop -h solaris -p uplink-port=net0,\
vlan-range=200-300,vxlan-range=7000-8000
# evsadm set-controlprop -h solaris -p uplink-port=net1,\
vlan-range=400-500,vxlan-range=5000-6000
# evsadm set-controlprop -p uplink-port=net0
# evsadm show-controlprop -p uplink-port
PROPERTY          PERM VALUE       DEFAULT    VLAN_RANGE  VXLAN_RANGE HOST
uplink-port       rw   net0        --         200-300     7000-8000   solaris
uplink-port       rw   net0        --         200-500     5000-8000   --
uplink-port       rw   net1        --         400-500     5000-6000   solaris
```

Displaying Properties of an EVS Controller

You use the `evsadm show-controlprop` command to display the properties of an EVS controller. The command syntax is:

```
# evsadm show-controlprop [[-c] -o field[,...]] [-p prop[,...]]
```

This command displays the current values of one or more properties for the EVS controller. If properties are not specified for the EVS controller, then all the existing properties for the controller are displayed. For more information about the controller properties, see Table 5, "EVS Controller Properties," on page 129.

`-o` *field*[,...] Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`PROPERTY`	Name of the property.
`PERM`	Permission of the property, which is either `rw` or `r-`.
`VALUE`	Value of the property.
`DEFAULT`	Default value of the property.
`HOST`	If the value is `--`, then the property is global and applicable to all the hosts. Otherwise, the property is applicable to the particular host.
`VLAN-RANGE`	Represents a comma-separated range of VLAN IDs that are associated with the corresponding uplink port. This field has a value only for the `uplink-port` property. For the remaining properties, `--` is shown.
`VXLAN-RANGE`	Represents a comma-separated range of VXLAN IDs that are served by the corresponding uplink port. This field has a value only for the `uplink-port` or `vxlan-addr` properties. For the remaining properties, `--` is shown.

For an example that shows how to display the properties for the EVS controller, see Example 50, "Configuring an EVS Controller," on page 157.

EXAMPLE 48 Displaying the Universal Unique Identifier for the EVS Controller

This example shows how to display the Universal Unique Identifier (UUID) for the EVS controller.

```
# evsadm show-controlprop -p uuid
PROPERTY     PERM VALUE                                DEFAULT   HOST
uuid         r-   9468f042-5e4f-11e4-ae7e-173d3676ad1b --
```

Configuring an EVS Controller

You must configure only one compute node as an EVS controller in your network and then set the EVS controller on each EVS node so that the EVS nodes can communicate with the EVS controller. However, you need to set the properties for the EVS controller only once from any node that can communicate with the EVS controller. You use the `evsadm set-controlprop` command to set the properties for the EVS controller. For more information, see "How to Configure an EVS Controller" on page 157.

You can also reset the properties for an EVS controller. Example 51, "Resetting Properties for an EVS Controller," on page 159 shows how to reset a property for an EVS controller. For information about the EVS controller and its properties, see "EVS Controller" on page 129.

To simplify the configuration of an elastic virtual switch, you need to connect as `evsuser`. When you install the mandatory EVS package (`service/network/evs`), a special user, `evsuser`, is created and assigned with the Elastic Virtual Switch Administration rights profile. This profile contains all the authorizations and privileges to perform the EVS operations. To use `evsuser`, you need to set the `controller` property as follows:

```
# evsadm set-prop -p controller=ssh://evsuser@evs-controller-hostname-or-IP-address
```

In addition, you must set up the SSH authentication by using the preshared public key between the host where you run the `evsadm` command and the EVS controller.

Note - To perform the EVS operations, you need to be superuser or a user that has the Elastic Virtual Switch Administration rights profile. For more information, see "Security Requirements for Using EVS" on page 138.

Setting Up SSH Authentication

You need SSH authentication with the preshared public key for the `evsadm` command to communicate with the EVS controller non-interactively and securely. You need to set up the SSH authentication with the preshared public key for `evsuser` between the following components in the EVS setup:

- **EVS manager and EVS controller** – Append the public key of the administrator or the user running the `evsadm` command on the EVS manager in the `/var/user/evsuser/.ssh/authorized_keys` file on the EVS controller.
- **EVS nodes and EVS controller** – Append the public key of the `root` user on each EVS node in the `/var/user/evsuser/.ssh/authorized_keys` file on the EVS controller. You need to append these public keys because the `zoneadmd` daemon runs as root. This daemon connects to the EVS controller and retrieves configuration information for the VNIC `anet` resource. For more information, see the `zoneadmd`(1M) man page.
- **EVS controller and EVS nodes** – Append the public key of `evsuser` on the EVS controller in the `/var/user/evsuser/.ssh/authorized_keys` file on each EVS node as the EVS controller communicates with each of the EVS node for setting VPort properties.

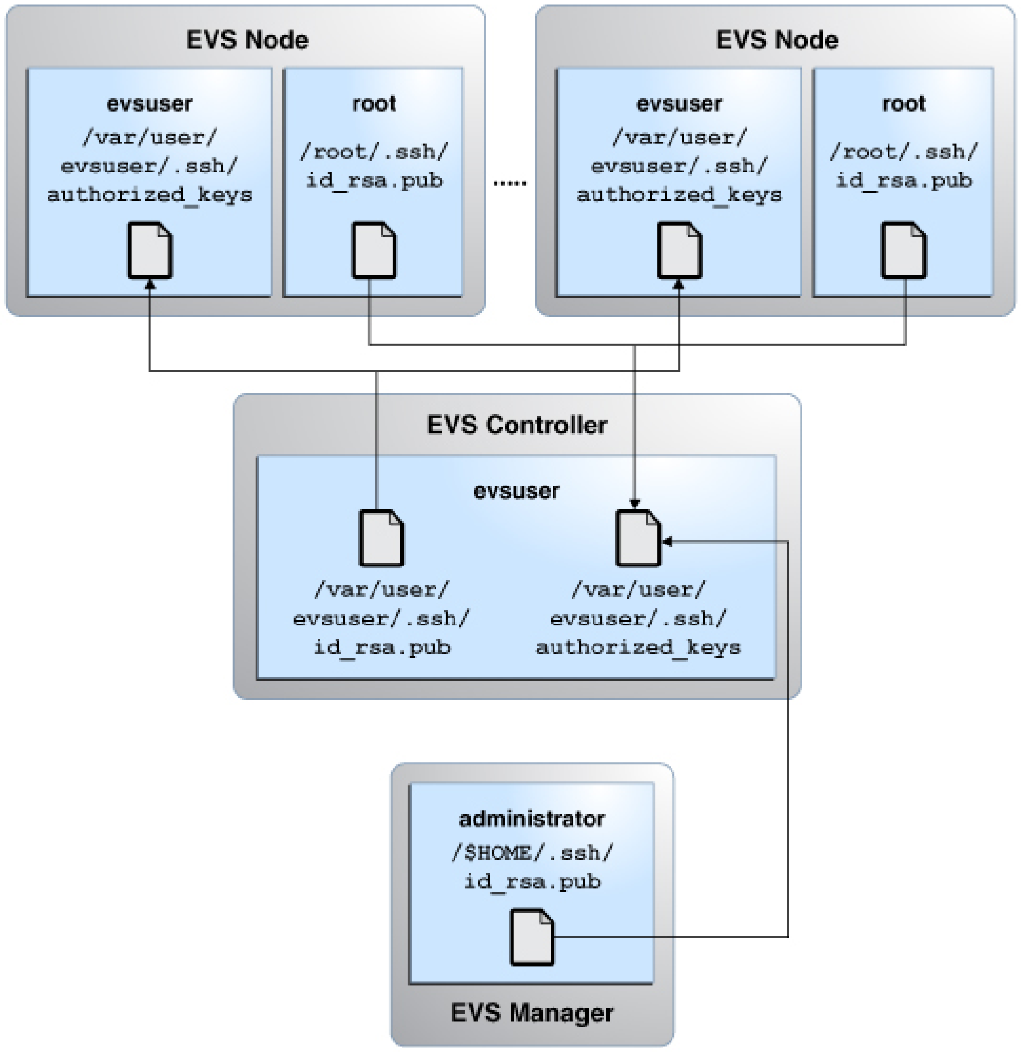
If the EVS components are in a single host, you can use the unix RAD connection to set up authentication. The command syntax is:

```
# evsadm set-prop -p controller=unix://
```

For more information, see "Per-EVS Node Connection" on page 155.

The following figure shows the setting up of SSH authentication between the EVS components.

FIGURE 19 SSH Authentication in the EVS Setup



After you set up the SSH authentication, you need to specify the EVS controller. The assumption is that the `controller` property is set to `ssh://evsuser@evs-controller.example.com` on the EVS nodes, EVS manager, and EVS controller.

The following procedures show how to set up the SSH authentication.

▼ How to Set Up SSH Authentication Between an EVS Node and the EVS Controller

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Generate a RSA key pair in the EVS node.**

```
evs-node# ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
a0:64:de:3d:c8:26:59:cb:4a:46:b9:1d:17:04:7d:bf root@evs-node
```

3. **Copy the public key from the `/root/.ssh/id_rsa.pub` file in the EVS node to the `/var/user/evsuser/.ssh/authorized_keys` file in the EVS controller.**

4. **Log in to the EVS controller as `evsuser` from the EVS node to verify whether the SSH authentication is set up.**

```
evs-node# ssh evsuser@evs-controller
The authenticity of host 'evs-controller (192.0.2.10)' can't be established.
RSA key fingerprint is 73:66:81:15:0d:49:46:e0:1d:73:32:77:4f:7c:24:a5.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'evs-controller' (RSA) to the list of known hosts.
Last login: Wed Jun 11 14:36:28 2014 from evs-controller
Oracle Corporation      SunOS 5.11      11.2    April 2014
evsuser@evs-controller$
```

   The output shows that you can log in to the EVS controller as `evsuser` without a password from the EVS node.

▼ How to Set Up SSH Authentication Between the EVS Manager and the EVS Controller

1. **Become an administrator.**

For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Generate a RSA key pair in the EVS manager.**

```
evs-manager# ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
a0:64:de:3d:c8:26:59:cb:4a:46:b9:1d:17:04:7e:bf root@evs-manager
```

3. **Copy the public key from the `/root/.ssh/id_rsa.pub` file in the EVS manager to the `/var/user/evsuser/.ssh/authorized_keys` file in the EVS controller.**

4. **Log in to the EVS controller as `evsuser` from the EVS manager to verify whether the SSH authentication is set up.**

```
evs-manager# ssh evsuser@evs-controller
The authenticity of host 'evs-controller (192.0.2.10)' can't be established.
RSA key fingerprint is 73:66:81:15:0d:49:46:e0:1d:73:32:77:4f:7c:24:a5.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'evs-controller' (RSA) to the list of known hosts.
Last login: Wed Jun 11 14:38:28 2014 from evs-controller
Oracle Corporation      SunOS 5.11      11.2    April 2014
evsuser@evs-controller$
```

The output shows that you can log in to the EVS controller as `evsuser` without a password from the EVS manager.

▼ How to Set Up SSH Authentication Between the EVS Controller and an EVS Node

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Become the user, `evsuser`, in the EVS controller.**

```
evs-controller# su - evsuser
```

For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

3. **Generate a RSA key pair in the EVS controller for `evsuser`.**

```
evsuser@evs-controller$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/var/user/evsuser/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /var/user/evsuser/.ssh/id_rsa.
Your public key has been saved in /var/user/evsuser/.ssh/id_rsa.pub.
The key fingerprint is:
a0:64:de:3d:c8:26:59:cb:4a:46:b9:1e:17:04:7d:bf evsuser@evs-controller
```

4. **Copy the public key from the `/var/user/evsuser/.ssh/id_rsa.pub` file in the EVS controller to the `/var/user/evsuser/.ssh/authorized_keys` file in the EVS node.**

5. **Log in to the EVS node as `evsuser` from the EVS controller to verify whether the SSH authentication is set up.**

```
evsuser@evs-controller$ ssh evsuser@evs-node
The authenticity of host 'evs-node (192.0.2.20)' can't be established.
RSA key fingerprint is 73:66:89:15:0d:49:46:e0:1d:73:32:77:4f:7c:24:a5.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'evs-node' (RSA) to the list of known hosts.
Last login: Wed Jun 11 14:40:28 2014 from evs-node
Oracle Corporation      SunOS 5.11      11.2    April 2014
evsuser@evs-node$
```

The output shows that you can log in to the EVS node as `evsuser` without a password from the EVS controller.

Caution - If you do not set up the SSH authentication in the EVS setup, the `evsadm` command cannot communicate with the EVS controller non-interactively and securely.

Per-EVS Node Connection

You can configure node RAD connection by using the `uri-template` controller property. You can specify either `ssh://[`*username*`@]` or `unix://[`*username*`@]` values for the `uri-template` property. The default value of this property is `ssh://`. The RAD URI that is used to connect to an EVS node is derived from the `uri-template` property by the EVS controller.

EXAMPLE 49 Connecting to an EVS Node

The following example displays the value for the `uri-template` property.

```
# evsadm show-controlprop -p uri-template
PROPERTY          PERM VALUE       DEFAULT   HOST
uri-template      rw   ssh://      ssh://    --
```

The output shows that all the EVS controller uses the RAD SSH to connect to all of the EVS nodes. The SSH user is the user connected to the EVS controller.

The following example shows how to connect to an EVS node as `evsuser` by using the `uri-template` property.

```
# evsadm set-controlprop -p uri-template=ssh://evsuser@
# evsadm show-controlprop -p uri
PROPERTY          PERM VALUE           DEFAULT   HOST
uri-template      rw   ssh://evsuser@  ssh://    --
```

The output shows that all the per-EVS node RAD connections must use SSH. However, the SSH user must use `evsuser` instead of the SSH user connected to the EVS controller. For example, consider that an EVS client connects to the EVS controller as `ssh://user1@controller.example.com`. If `uri-template` is set to `ssh://evsuser@`, then instead of using `user1` as the SSH user the EVS controller uses `evsuser` as the SSH user.

The following example shows how to set up authentication on a single system that contains all the EVS components by using the `uri-template` property.

```
# evsadm set-controlprop -p uri-template=unix://
# evsadm show-controlprop -p uri-template
PROPERTY          PERM VALUE       DEFAULT   HOST
uri-template      rw   unix://     unix://   --
```

If the EVS Controller is set up on one of the EVS nodes, then you can use `AF_UNIX` for the EVS node instead of `SSH` as shown in the following example.

```
# evsadm set-controlprop -h evs-controller.example.com -p uri-template=unix://
# evsadm show-controlprop -p uri-template
PROPERTY          PERM VALUE       DEFAULT   HOST
uri-template      rw   ssh://      ssh://    --
uri-template      rw   unix://     unix://   evs-controller.example.com
```

The output shows that all the per-EVS node RAD connection must use the default SSH except for the host `evs-controller.example.com` where you need to use `AF_UNIX`.

▼ How to Configure an EVS Controller

Before You Begin Set up the SSH authentication with the preshared keys between the host where you run the `evsadm` command and the EVS controller.

1. **Become an administrator or user with the Elastic Virtual Switch Administration rights profile.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Set the EVS controller.**

   ```
   # evsadm set-prop -p controller=[value[...,]]
   ```

   This command sets the values of a property for the host where the command is executed. The only supported property is `controller`, which can be of the format `ssh://[`*user*`@]evs-controller-`*host-name*, `ssh://[`*user*`@]evs-controller-`*IP-address*, or `unix://`.

3. **(Optional) Display the configured EVS controller.**

   ```
   # evsadm show-prop [[-c] -o field[,...]] [-p controller[,...]]
   ```

   For more information, see "Displaying the EVS Controller" on page 145.

4. **Set the properties for the EVS controller.**

   ```
   # evsadm set-controlprop [-h host] -p prop=[value[...,]]
   ```

   For more information, see "Setting Properties for an EVS Controller" on page 146.

5. **(Optional) Display the properties of an EVS controller.**

   ```
   # evsadm show-controlprop [[-c] -o field[,...]] [-p prop[,...]]
   ```

   For more information, see "Displaying Properties of an EVS Controller" on page 148.

Example 50 Configuring an EVS Controller

The following example shows how to configure the host `s11-server` as the EVS controller, whose L2 segments are created by using a VXLAN.

```
# evsadm set-prop -p controller=ssh://evsuser@s11-server
# evsadm show-prop
PROPERTY            PERM   VALUE                      DEFAULT
controller          rw     ssh://evsuser@s11-server   --
# evsadm set-controlprop -p l2-type=vxlan
```

```
# evsadm set-controlprop -p vxlan-range=10000-20000
# evsadm set-controlprop -p vxlan-addr=192.0.2.0/24
# evsadm set-controlprop -h s11-server -p uplink-port=net3
# evsadm set-controlprop -h s11-client -p uplink-port=net4
# evsadm show-controlprop
PROPERTY            PERM VALUE                    DEFAULT     HOST
l2-type             rw   vxlan                    vlan          --
uplink-port         rw   --                       --            --
uplink-port         rw   net3                     --          s11-server
uplink-port         rw   net4                     --          s11-client
uri-template        rw   ssh://                   ssh://        --
uuid                r-   b3fda654-c14c-11e4-ae16-5f67bed8a8e9 -- --
vlan-range          rw   --                        --            --
vlan-range-avail    r-   --                        --            --
vxlan-addr          rw   192.0.2.0/24 0.0.0.0  --
vxlan-ipvers        rw   v4                        v4            --
vxlan-mgroup        rw   0.0.0.0                   0.0.0.0       --
vxlan-range         rw   10000-20000               --            --
vxlan-range-avail   r-   10000-20000               --            --
# evsadm show-controlprop -o property,value,vlan_range,vxlan_range, \
flat,host -p uplink-port
PROPERTY          VALUE       VLAN_RANGE  VXLAN_RANGE FLAT HOST
uplink-port       --          --          --          no   --
uplink-port       net3        --          10000-20000 yes  s11-server
uplink-port       net4        --          10000-20000 yes  s11-client
```

In this example, the `vxlan-range-avail` property displays the VXLAN IDs (`10000-20000`) that are available for implementing elastic virtual switches. An IP interface that is part of the subnet `192.0.2.0/27` is used to create the VXLAN links on the EVS nodes.

The following example shows how to configure a host with the IP address `192.0.2.1` as the EVS controller, whose L2 segments are created by using a VLAN.

```
# evsadm set-prop -p controller=ssh://evsuser@192.0.2.1
# evsadm set-controlprop -p l2-type=vlan
# evsadm set-controlprop -p vlan-range=200-300,400-500
# evsadm set-controlprop -p uplink-port=net2
# evsadm set-controlprop -h host2.example.com -p uplink-port=net3
# evsadm set-controlprop -h host3.example.com -p uplink-port=net4
```

The output shows that the VLAN IDs `200-300` and `400-500` are set aside for elastic virtual switches. The datalink `net2` is `uplink-port` on all the hosts except for `host2.example.com` and `host3.example.com`. On `host2`, the datalink `net3` is used as `uplink-port` and on `host3`, the datalink `net4` is used as `uplink-port`.

You can optionally specify the `vlan-range` or `vxlan-range` properties with the `uplink-port` property. See Example 47, "Setting Uplink Port with VLAN and VXLAN Ranges for the EVS Controller," on page 148.

Example 51 Resetting Properties for an EVS Controller

The following example shows how to reset the controller property `uplink-port`.

```
# evsadm show-controlprop -p uplink-port
PROPERTY            PERM     VALUE      DEFAULT             HOST
uplink-port         rw       net2       --                  --
# evsadm set-controlprop -p uplink-port=
# evsadm show-controlprop -p uplink-port
PROPERTY            PERM     VALUE      DEFAULT             HOST
uplink-port         rw       --         --                  --
```

Configuring Elastic Virtual Switches

An elastic virtual switch is a virtual switch that spans one or more physical machines and represents an isolated L2 segment. The isolation is implemented either through VLANs or VXLANs. You can connect the VNICs or `anet` resources of the EVS nodes to the elastic virtual switch, thus providing network connectivity between the EVS nodes. For more information, see "What Is the Oracle Solaris Elastic Virtual Switch Feature?" on page 121.

When you plan to configure an elastic virtual switch, you need to understand your virtual topology. Determine how many L2 segments you need and the IPnet information for each network including the subnet and the default router. In addition, you might need to determine the number of virtual ports that you need to configure for the elastic virtual switch and properties that you need to specify for virtual ports.

Mandatory Package for an Elastic Virtual Switch

You must install the `pkg:/service/network/evs` package on the system that acts as EVS clients and EVS nodes.

Use the following command to install the package:

```
# pkg install evs
```

Commands for Configuring an Elastic Virtual Switch

This section describes how to perform the following tasks to configure an elastic virtual switch:

- Creating an elastic virtual switch
- Adding an IPnet to an elastic virtual switch
- Adding a VPort to an elastic virtual switch

Creating an Elastic Virtual Switch

You use the `evsadm create-evs` command to create an elastic virtual switch. The command syntax is:

```
# evsadm create-evs [-T tenant-name] [-p {prop=value[,...]}[,..]] EVS-switch-name
```

`-T` *tenant-name*	Specifies the tenant. If you specify a tenant, then the elastic virtual switch is created within the namespace of that tenant. Otherwise, the elastic virtual switch is created in the default tenant `sys-global`. A tenant is a read-only property that represents the tenant with which an elastic virtual switch is associated.
`-p` *prop*	Specifies a comma-separated list of properties that you can set to the specified values on the elastic virtual switch. You can set the following properties: ■ `maxbw` - Sets the full-duplex bandwidth for the ports of the elastic virtual switch. The bandwidth is specified as an integer with a scale suffix (`K`, `M`, or `G` for Kbps, Mbps, and Gbps). If units are not specified, the input value is read as Mbps. There is no default bandwidth limit. ■ `priority` - Sets the relative priority for the ports of the elastic virtual switch. The possible values are `high`, `medium`, or `low`. The default value is `medium`. The priority is not reflected in any protocol priority fields on the wire but is used for packet processing scheduling within the system. A VPort with a high priority offers more latency depending on the availability of system resources.
EVS-switch-name	Specifies the name of the elastic virtual switch.

For an example that shows how to create an elastic virtual switch, see Example 52, "Configuring an Elastic Virtual Switch," on page 163.

Adding an IPnet to an Elastic Virtual Switch

You use the `evsadm add-ipnet` command to add an IPnet to an elastic virtual switch. The command syntax is:

```
# evsadm add-ipnet [-T tenant-name] -p subnet=value[{,prop=value[,...]}
[,...]]\
EVS-switch-name/IPnet-name
```

`-T` *tenant-name*	Specifies the name of the tenant. If you specify the tenant name, the IPnet is associated with the EVS in the tenant namespace.
`-p` *prop*	A comma-separated list of IPnet properties that you must set for the specific elastic virtual switch. The supported properties for an IPnet are: ■ `subnet` - Mandatory. Represents the block of either IPv4 or IPv6 addresses. You must specify the `subnet` property when you add an IPnet. Otherwise, adding an IPnet fails. ■ `defrouter` - Optional. Specifies the gateway's IP address for the given subnet. When `defrouter` is not specified, the first address in the range is selected as the default router IP address. ■ `pool` - Represents the sub-ranges of IP addresses within a subnet. An IP address that is allocated to a virtual port is selected from the pool instead of the entire subnet. You can specify multiple ranges with the comma as the delimiter. The specified IP addresses must not overlap with each other. Each range is of the form `start_ip_address-end_ip_address` and the specified IP addresses must be within the subnet.
EVS-switch-name/IPnet-name	Specifies the name of the elastic virtual switch with the associated IPnet.

For more information about IPnet properties, see the `evsadm`(1M) man page. For an example that shows how to add an IPnet to an elastic virtual switch, see Example 52, "Configuring an Elastic Virtual Switch," on page 163.

The following example shows how to add the IPnet `ora_ipnet` to `ORA`. In this example, you restrict the block from which the IP address is automatically allocated to a VPort. The IP address is allocated from the specified pool of IP addresses instead of the entire subnet.

```
# evsadm add-ipnet -T ABC -p subnet=192.0.2.0/27,\
pool=192.0.2.10-192.0.2.15,192.0.2.20-192.0.2.25 ORA/ora_ipnet
# evsadm show-ipnetprop -p pool ORA/ora_ipnet
NAME          TENANT  PROPERTY  PERM VALUE                      DEFAULT   POSSIBLE
ORA/ora_ipnet ABC     pool      rw   192.0.2.10-192.0.2.15, --        --
                                     192.0.2.20-192.0.2.25
```

In this example, the IP addresses that are allocated to the VPorts are within the pools `192.0.2.10-192.0.2.15` and `192.0.2.20-192.0.2.25`. You can add 42 VPorts to `ORA`, since there are 42 IP addresses in the pool that can be allocated to VPorts. Note that the addition of the 43rd VPort fails, since there are no IP addresses in the pool that can be allocated to the 43rd VPort.

Adding a VPort to an Elastic Virtual Switch

You use the `evsadm add-vport` command to add a VPort to an elastic virtual switch. The command syntax is:

`# evsadm add-vport [-T` *tenant-name*`] [-p {`*prop*=*value*`[,...]}[,...]]` *EVS-switch-name/VPort-name*

`-p` *prop*	Specifies a comma-separated list of VPort properties that you can set for the VPort. For more information about the supported VPort properties, see Table 4, "VPort Properties," on page 125.
EVS-switch-name/VPort-name	Specifies the name of the elastic virtual switch with the associated VPort.

For an example that shows how to add a VPort to an elastic virtual switch, see Example 52, "Configuring an Elastic Virtual Switch," on page 163.

▼ How to Configure an Elastic Virtual Switch

Before You Begin You need to set the EVS controller on the compute node on which you want to configure the elastic virtual switch. For information, see the step 2 in "How to Configure an EVS Controller" on page 157.

1. **Become an administrator or user with the Elastic Virtual Switch Administration rights profile.**

For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Create an elastic virtual switch.**

```
# evsadm create-evs [-T tenant-name] [-p {prop=value[,...]}[,..]] EVS-switch-name
```

For more information, see "Creating an Elastic Virtual Switch" on page 160.

Note - If you set a property explicitly for a virtual port, that property value overrides the corresponding elastic virtual switch property value.

3. **Add an IPnet to an elastic virtual switch.**

```
# evsadm add-ipnet [-T tenant-name] -p subnet=value[{,prop=value[,...]}[,...]]
 \
EVS-switch-name/IPnet-name
```

For more information, see "Adding an IPnet to an Elastic Virtual Switch" on page 161.

4. **(Optional) Add a VPort to an elastic virtual switch.**

```
# evsadm add-vport [-T tenant-name] [-p {prop=value[,...]}[,...]] EVS-switch-name/VPort-
name
```

When a VPort is added to the elastic virtual switch, it is assigned a random MAC address and an IP address from the IPnet address range. Therefore, you must first add an IPnet to the elastic virtual switch and then add the VPort. For more information about the `evsadm add-vport` command, see "Adding a VPort to an Elastic Virtual Switch" on page 162.

Note - You do not need to always add a virtual port to an elastic virtual switch. When a VNIC is created, you can specify only the name of the elastic virtual switch to which the VNIC must connect. In such cases, the EVS controller generates a system virtual port. These virtual ports follow the naming convention `sys-`*vportname*, for example, `sys-vport0`. The system virtual port inherits the elastic virtual switch properties.

5. **(Optional) Display the configured elastic virtual switch.**

```
# evsadm
```

Example 52 Configuring an Elastic Virtual Switch

The following example shows how to create the elastic virtual switch `ORA`, add the IPnet `ora_ipnet`, and add the VPort `vport0` to the elastic virtual switch.

```
# evsadm create-evs ORA
# evsadm add-ipnet -p subnet=192.0.2.2/27 ORA/ora_ipnet
# evsadm add-vport ORA/vport0
# evsadm
NAME          TENANT        STATUS  VNIC         IP                HOST
ORA           sys-global    idle    --           ora_ipnet         --
   vport0     --            free    --           192.0.2.2/27   --
```

The following example shows how to create the elastic virtual switch `ORA` with the tenant `tenantA`, add the IPnet `ora_ipnet`, and add the VPort `vport0` to the elastic virtual switch.

```
# evsadm create-evs -T tenantA ORA
# evsadm add-ipnet -T tenantA -p subnet=192.0.2.0/27 ORA/ora_ipnet
# evsadm add-vport -T tenantA ORA/vport0
# evsadm
NAME          TENANT        STATUS  VNIC         IP                HOST
ORA           tenantA       idle    --           ora_ipnet         --
   vport0     --            free    --           192.0.2.2/27   --
```

▼ How to Configure a Flat EVS Network

You can implement an elastic virtual switch by using the flat L2-type network instead of using a VLAN or VXLAN. For more information, see "Flat EVS Networks" on page 126. This procedure shows how to configure a flat EVS network in a single system.

1. **Become an administrator or user with the Elastic Virtual Switch Administration rights profile.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Configure the EVS controller.**

   a. **Set the EVS controller.**

   ```
   # evsadm set-prop -p controller=unix://
   ```

   b. **Set the `uplink-port` property for the EVS controller.**

   ```
   # evsadm set-controlprop [-h host] -p uplink-port=value [,flat=yes|no]
   ```

   c. **(Optional) Display the `uplink-port` property that is configured for the EVS controller.**

```
# evsadm show-controlprop -o property,value,flat,vlan_range,vxlan_range,host -p
 uplink-port
```

3. **Create an elastic virtual switch with the `l2-type` property set to `flat`.**

   ```
   # evsadm create-evs [-T tenant-name] -p l2-type=flat EVS-switch-name
   ```

   Note - You cannot change the L2 type network after you create an EVS by specifying the `l2-type` property to `vlan`, `vxlan`, or `flat`.

4. **(Optional) Display the `l2-type` property for the EVS created in the previous step.**

   ```
   # evsadm show-evsprop -p l2-type
   ```

5. **(Optional) Display the configured EVS.**

   ```
   # evsadm show-evs -L
   ```

   After you configure the EVS, you can add an IPnet and VPorts. For more information, see the steps 3 and 4 in "How to Configure an Elastic Virtual Switch" on page 162.

Example 53 Configuring a Flat EVS Network

This example shows how to configure a flat EVS network.

```
# evsadm set-prop -p controller=unix://
# evsadm set-controlprop -p uplink-port=net4,flat=yes
# evsadm show-controlprop -o property,value,flat,vlan_range,\
vxlan_range,host -p uplink-port
PROPERTY          VALUE       FLAT VLAN_RANGE  VXLAN_RANGE  HOST
uplink-port       net4        yes   --         --           --
# evsadm create-evs -p l2-type=flat evs0
# evsadm show-evsprop -p l2-type
EVS     TENANT        PROPERTY   PERM VALUE     DEFAULT      POSSIBLE
evs0    sys-global    l2-type    r-   flat      --           --
# evsadm show-evs -L
EVS           TENANT        L2TYPE VID  VNI
evs0          sys-global    flat   --   --
```

Creating a VNIC for an Elastic Virtual Switch

The `dladm` and `zonecfg` commands now enable you to create VNICs for an elastic virtual switch.

▼ How to Create a VNIC for an Elastic Virtual Switch

Before You Begin You must set the `controller` property on the EVS node by using the `evsadm set-prop` command. For more information, see "How to Configure an EVS Controller" on page 157.

1. **Become an administrator or user with the Elastic Virtual Switch Administration rights profile.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Configure a VNIC for an elastic virtual switch.**

   ```
   # dladm create-vnic -t -c EVS-switch-name[/VPort-name] [-T tenant-name] VNIC-name
   ```

`-t`	Specifies that the VNIC is temporary.
`-c` *EVS-switch-name*[/*VPort-name*]	Specifies the name of the elastic virtual switch to which you must connect the VNIC. If you specify the name of the VPort, the VNIC is connected to the specified VPort. If you do not specify the VPort name, the system automatically generates a VPort and assigns the VPort to the VNIC. After the VNIC is connected to an elastic virtual switch, the VNIC either inherits the properties from the specified elastic virtual switch or VPort.
`-T` *tenant-name*	Specifies the name of the tenant that owns the elastic virtual switch. If the tenant is not specified, then the system assumes default `sys-global` tenant.
VNIC-name	The name of the VNIC.

3. **(Optional) Display information about the VNICs connected to an elastic virtual switch.**

   ```
   # dladm show-vnic -c
   ```

   The `-c` option displays the information about VNICs connected to an elastic virtual switch.

Example 54 Creating a VNIC for an Elastic Virtual Switch

This example shows how to create a temporary VNIC `vnic1` and connect the VNIC to the elastic virtual switch `ORA` and VPort `vport0`.

```
# dladm create-vnic -t -c ORA/vport0 vnic1
# dladm show-vnic -c
```

```
LINK     TENANT        EVS      VPORT       OVER             MACADDRESS        IDS
vnic1    sys-global    ORA      vport0      evs-vxlan10000   2:8:20:b0:6e:63   VID:0
```

Creating a VNIC `anet` Resource for an Elastic Virtual Switch

You can use the enhanced `zonecfg` command to configure a zone's VNIC `anet` resource for an elastic virtual switch.

You can set the following properties for the `anet` resource when you are configuring a zone:

- `tenant` – Specifies the name of the tenant. If a value is not specified when configuring a zone, the system assigns the default value, `sys-global` tenant.
- `vport` – Specifies the name of the VPort. If a value is not specified when configuring a zone, a system VPort is automatically generated for the elastic virtual switch and the VPort inherits the elastic virtual switch properties.
- `evs` – Specifies the name of an elastic virtual switch to which you must connect the `anet` resource.

A VPort in a data center or multitenant cloud environment is uniquely identified by the tenant name, elastic virtual switch name, and VPort name. For more information, see *Creating and Using Oracle Solaris Zones*.

EXAMPLE 55 Creating a VNIC `anet` Resource for an Elastic Virtual Switch

This example shows how to create a zone that has a VNIC `anet` resource `evszone/net1`, which is connected to `ORA` and `vport0` of the tenant `tenantA`.

```
# zonecfg -z evszone
Use 'create' to begin configuring a new zone
zonecfg:evszone> create
create: Using system default template 'SYSdefault'
zonecfg:evszone> set zonepath=/export/zones/evszone
zonecfg:evszone> set tenant=tenantA
zonecfg:evszone> add anet
zonecfg:evszone:net> set evs=ORA
zonecfg:evszone:net> set vport=vport0
zonecfg:evszone:net> end
zonecfg:evszone> exit
# zoneadm -z evszone install
# zoneadm -z evszone boot
# zlogin -C evszone
# dladm show-vnic -c
LINK          TENANT   EVS  VPORT   OVER  MACADDRESS       IDS
```

```
evszone/net1  tenantA  ORA  vport0  net2  2:8:20:89:a1:97  VID:200
```

When `evszone` boots, the VNIC `anet evszone/net1` is associated with the MAC address, IP address, and SLA properties of the VPort `ORA/vport0`. For more information about configuring a zone's VNIC `anet` resources for an elastic virtual switch, see "Use Case: Configuring an Elastic Virtual Switch" on page 187.

Administering Elastic Virtual Switches, IPnets, and VPorts

This section describes how to administer an elastic virtual switch, an IPnet, and a VPort. For more information about how to configure an elastic virtual switch, IPnet, and VPort, see "Configuring Elastic Virtual Switches" on page 159.

Administering an Elastic Virtual Switch

This section describes how to perform the following tasks for an elastic virtual switch:

- Displaying information about an elastic virtual switch
- Setting properties for an elastic virtual switch
- Displaying elastic virtual switch properties

Displaying Elastic Virtual Switch Information

You use the `evsadm show-evs` command to display elastic virtual switch information. The command syntax is:

```
# evsadm show-evs [-f {fname=value[,...]}[,...]] [-L] [[-c] -o field[,...]] [EVS-switch-name]
```

`-f` {*fname*=*value*[,...]}[,...]
: A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are:

  - `tenant`
  - `evs`

- `host`
- `ipnet`
- `vport`

`-L`	Displays the L2 segment associated with an elastic virtual switch. Additionally, the VLAN IDs or VXLAN segment IDs associated with an elastic virtual switch is displayed.
`-o` *field*[,...]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`EVS`	Name of the elastic virtual switch.
`TENANT`	Name of the tenant that owns the elastic virtual switch.
`STATUS`	Status of the elastic virtual switch, whether it is idle or busy. The elastic virtual switch is busy if it has at the least one VPort that has a VNIC connected to it.
`NVPORTS`	Number of virtual ports associated with the elastic virtual switch.
`IPNETS`	The list of IP networks associated with the EVS. Currently only one IP network can be associated with an elastic virtual switch.
`HOST`	The list of hosts that the elastic virtual switch spans across multiple systems.

EXAMPLE 56 Displaying Elastic Virtual Switch Information

The following example displays information for the elastic virtual switch `ORA`.

```
# evsadm show-evs ORA
EVS           TENANT        STATUS NVPORTS IPNETS      HOST
ORA           sys-global    busy   1       ora_ipnet   s11-client
```

The following example displays the VLAN ID associated with the elastic virtual switch `ORA`.

```
# evsadm show-evs -L
EVS           TENANT      L2TYPE  VID  VNI
ORA           tenantA     VLAN    200  --
```

The output shows the following information:

`EVS`	Name of the elastic virtual switch
`TENANT`	Name of the tenant that owns the elastic virtual switch
`L2TYPE`	Type of the L2 network
`VID`	VLAN ID used to implement the elastic virtual switch
`VNI`	VXLAN segment ID used to implement the elastic virtual switch

Setting Properties for an Elastic Virtual Switch

You use the `evsadm set-evsprop` command to set properties for an elastic virtual switch. The command syntax is:

`# evsadm set-evsprop [-T` *tenant-name*`] -p` *prop*=*value*`[,...]` *EVS-switch-name*

`-p` *prop*

Sets the values of a property on the specified elastic virtual switch.

EVS supports the following properties:

- `maxbw` – Sets the full-duplex bandwidth for all the virtual ports that connect to the specified elastic virtual switch. The bandwidth is specified as an integer with a scale suffix (`K`, `M`, or `G` for Kbps, Mbps, and Gbps). If no units are specified, the input value is read as Mbps. The default is no bandwidth limit.
- `priority` – Sets the default priority for all the virtual ports that connect to the specified elastic virtual switch. The possible values are `high`, `medium`, or `low`. The default value is `medium`. The priority is not reflected in any protocol priority fields on the wire but is used for packet processing scheduling within the system. A VPort with a high priority offers a better latency depending on the availability of system resources.

EXAMPLE 57 Setting Properties for an Elastic Virtual Switch

This example shows how to set properties for the elastic virtual switch `ORA`.

```
# evsadm set-evsprop -p maxbw=200 ORA
# evsadm set-evsprop -p priority=high ORA
```

Displaying Properties of an Elastic Virtual Switch

You use the `evsadm show-evsprop` command to display the properties of an elastic virtual switch. The command syntax is:

```
# evsadm show-evsprop [-f {fname=value[,...]}[,...] [[-c] -o field[,...]] \
[-p prop[,...]] [EVS-switch-name]
```

`-f` {*fname*=*value*[,...]} [,...]	A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are: ■ `tenant` – Filter the elastic virtual switch properties by the tenant name ■ `evs` – Filter the elastic virtual switch properties by the elastic virtual switch name ■ `host` – Filter the elastic virtual switch properties by the host name. Example 58, "Displaying Elastic Virtual Switch Properties," on page 172 shows output based on the filter value.

Note - You can filter elastic virtual switches by using their property values. See Example 66, "Displaying VPort Properties," on page 179.

`-o` *field*[,...]

Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`EVS`	Name of the elastic virtual switch.
`TENANT`	Name of the tenant that owns the elastic virtual switch.
`PROPERTY`	Name of the elastic virtual switch property.

`PERM`	The read or write permissions of the property. The value shown is either `r-` or `rw`.
`VALUE`	The current property value. If the value is not set, it is shown as `--`. If the value is unknown, it is shown as `?`.
`DEFAULT`	The default value of the property. If the property has no default value, `--` is shown.
`POSSIBLE`	A comma-separated list of possible values for the property. If the possible values are unknown or unbounded, `--` is shown.

EXAMPLE 58 Displaying Elastic Virtual Switch Properties

The following example displays the properties configured for the elastic virtual switch `ORA`.

```
# evsadm show-evsprop ORA
EVS      TENANT        PROPERTY  PERM VALUE     DEFAULT   POSSIBLE
ORA      sys-global    maxbw     rw   200       --        --
ORA      sys-global    priority  rw   high      medium    low,medium,high
ORA      sys-global    tenant    r-   --        --        --
```

The following example displays the output for the elastic virtual switches `HR` and `ORA`. In this example, the `evs` filter is specified to obtain the output for elastic virtual switches `HR` and `ORA`.

```
# evsadm show-evsprop -f evs=HR,ORA
EVS         TENANT        PROPERTY  PERM VALUE     DEFAULT   POSSIBLE
HR          tenantA       maxbw     rw   300       --        --
HR          tenantA       priority  rw   --        medium    low,medium,high
HR          tenantA       tenant    r-   --        --        --
ORA         sys-global    maxbw     rw   --        --        --
ORA         sys-global    priority  rw   --        medium    low,medium,high
ORA         sys-global    tenant    r-   --        --        --
```

EXAMPLE 59 Displaying the UUID of an Elastic Virtual Switch

This example shows how to display the UUID of the elastic virtual switch `evs1`.

```
# evsadm show-evsprop -p uuid -o evs,tenant,property,perm,value evs1
EVS       TENANT        PROPERTY   PERM VALUE
evs1      sys-global    uuid       r-   5c5b7120-95cc-11e4-ab91-171c32874415
```

Administering an IPnet Configuration

This section describes how to perform the following tasks for an IPnet after you add an IPnet for an elastic virtual switch:

- Setting properties for an IPnet
- Displaying properties associated with an IPnet
- Removing an IPnet configured for an elastic virtual switch
- Displaying information about IPnets

Setting Properties for an IPnet

You use the `evsadm-setipnetprop` command to set properties for an IPnet. The command syntax is:

```
# evsadm set-ipnetprop [-T tenant-name] -p
 prop=[value[,...]]\
EVS-switch-name/IPnet-name
```

The property associated with an IPnet is reset to the default value, if you do not specify any value for the property. For more information about the properties that can be set for an IPnet, see “Adding an IPnet to an Elastic Virtual Switch” on page 161.

EXAMPLE 60 Setting Properties for an IPnet

This example shows how to set the `pool` property for the IPnet `ora_ipnet`.

```
# evsadm set-ipnetprop -T ABC -p pool=192.0.2.10-192.0.2.15 ORA/ora_ipnet
```

In this example, `ABC` is the name of the tenant and `ORA` is the name of the EVS.

Displaying Properties of an IPnet

You use the `evsadm-showipnetprop` command to display the properties associated with an IPnet. The command syntax is:

```
# evsadm show-ipnetprop [-f {fname=value[,...]}[,...]] [[-c] -o field[,...]] \
[-p prop[,...]] [IPnet-name]
```

`-f` {*fname*=*value*[,...]}[,...]	A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are: ■ `tenant` – Filter the IPnet list by the tenant name ■ `evs` – Filter the IPnet list by the elastic virtual switch name ■ `ipnet` – Filter the IPnet list by the IPnet name ■ `host` – Filter the IPnet list by the host name

Note - You can filter IPnets by using their property values. See Example 66, "Displaying VPort Properties," on page 179.

`-p` *prop*	Specifies the properties that are associated with an IPnet. For information, see "Adding an IPnet to an Elastic Virtual Switch" on page 161.
`-o` *field*[,...]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`NAME`	Name of the IPnet with the name of the elastic virtual switch with which it is associated in the format *EVS-switch-name*/*IPnet-name*.
`IPnet`	Name of the IPnet.
`EVS`	Name of the elastic virtual switch.
`TENANT`	Name of the tenant that owns the elastic virtual switch.
`PROPERTY`	Name of the IPnet property.
`PERM`	Permission of the property, which is either `rw` or `r-`.
`VALUE`	The current value of the property. If you have not set a value, it is shown as `--`. If the value is unknown, it is shown as `?`.

`DEFAULT`	The default value of the property. If the property does not a have default value, it is shown as `--`.
`POSSIBLE`	A comma-separated list of possible values for the property. If the possible values are unknown or unbounded, `--` is shown.

EXAMPLE 61 Displaying Properties of an IPnet

This example shows how to display properties for the IPnet `ora_ipnet`.

```
# evsadm show-ipnetprop ora_ipnet
NAME             TENANT   PROPERTY  PERM VALUE                      DEFAULT   POSSIBLE
ORA/ora_ipnet    ABC      evs       r-   ORA                        --        --
ORA/ora_ipnet    ABC      subnet    r-   192.0.2.0/27             --        --
ORA/ora_ipnet    ABC      defrouter r-   192.0.2.1                --        --
ORA/ora_ipnet    ABC      pool      rw   192.0.2.10-192.0.2.15, --        --
                                         192.0.2.20-192.0.2.25
ORA/ora_ipnet    ABC      tenant    r-   ABC                        --        --
```

EXAMPLE 62 Displaying the UUID of an IPnet

This example shows how to display the UUID for the IPnet `evs1/ipnet1`.

```
# evsadm show-ipnetprop -p uuid -o name,tenant,property,perm,value evs1/ipnet1
NAME         TENANT      PROPERTY  PERM VALUE
evs1/ipnet1  sys-global  uuid      r-   d2698f0c-96ba-11e4-ab94-171c32874415
```

Removing an IPnet

You use the `evsadm remove-ipnet` command to remove an IPnet configured for the elastic virtual switch. The command syntax is:

`# evsadm remove-ipnet [-T` *tenant-name*`]` *EVS-switch-name*/*IPnet-name*

This command removes the specified IPnet from the specified elastic virtual switch. You cannot remove an IPnet if any one of the VPorts is in use. A VPort is in use if it has a VNIC connected to it.

EXAMPLE 63 Removing an IPnet Configured for an Elastic Virtual Switch

This example shows how to remove the IPnet `ora_ipnet` from the elastic virtual switch `ORA`.

```
# evsadm remove-ipnet ORA/ora_ipnet
```

Displaying IPnets

You use the `evsadm show-ipnet` command to display information about IPnets managed by the EVS controller or for the specified IPnet. The command syntax is:

```
# evsadm show-ipnet [-f {fname=value[,...]}[,...]] [[-c] -o field[,...]] [IPnet-name]
```

`-f` {*fname*=*value*[,...]} [,...]	A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are `tenant`, `evs`, `ipnet`, and `host`.
`-o` *field*[,...]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`NAME`	Name of the IPnet along with the name of the elastic virtual switch with which it is associated.
`IPNET`	Name of the IPnet.
`EVS`	Name of the elastic virtual switch.
`TENANT`	The name of the tenant that owns the elastic virtual switch.
`SUBNET`	Represents the subnet (either IPv4 or IPv6) for this IPnet.
`START`	Start address of the IP address range.
`END`	End address of the IP address range.
`DEFROUTER`	The IP address of the default router for the given IPnet.

`AVAILRANGE`	A comma-separated list of available IP addresses that can be assigned to VPort.

EXAMPLE 64 Displaying IPnet for an Elastic Virtual Switch

This example displays the IPnet configured for the elastic virtual switch `ORA`.

```
# evsadm show-ipnet
NAME         TENANT     SUBNET         DEFROUTER    AVAILRANGE
ORA/ora_ipnet sys-global 192.0.2.0/27 192.0.2.1 192.0.2.3-192.0.2.30
```

Administering VPort Configuration

This section describes how to perform the following tasks for a VPort:

- Setting properties for a VPort
- Displaying properties associated with a VPort
- Displaying information about VPorts
- Resetting a VPort
- Removing a VPort

Setting Properties for a VPort

You use the `evsadm set-vportprop` command to set properties for a VPort. The command syntax is:

```
# evsadm set-vportprop [-T tenant-name] -p prop=value[,...] EVS-switch-name/VPort-name
```

`-T` *tenant-name*	Specifies the name of the tenant.
`-p` *prop*=*value*[...,]	Specifies the values of a property for the specified VPort. If the VPort has a VNIC connected to it, then setting the property on that VPort results in change of VNIC's property. For information about VPort properties, see Table 4, “VPort Properties,” on page 125.

Note - You cannot change the property of the system VPort. For more information about the system VPort, see “How to Configure an Elastic Virtual Switch” on page 162.

EVS-switch-name/*VPort-name*	Specifies the name of the elastic virtual switch or the VPort for which the properties are set.

Note - You cannot modify the `ipaddr`, `macaddr`, `evs`, and `tenant` properties after you have created the VPort.

EXAMPLE 65 Setting a Property for a VPort

This example shows how to set the maximum bandwidth property to `1G` for `HR/vport0`.

```
# evsadm set-vportprop -p maxbw=1G HR/vport0
```

Displaying Properties of a VPort

You use the `evsadm show-vportprop` command to display properties of a VPort. The command syntax is:

```
# evsadm show-vportprop [-f {fname=value[,...]}[,...] [[-c] -o field[,...]] \
[-p prop[,...]] [[EVS-switch-name]/[VPort-name]]
```

This command shows the current values of one or more properties for either all VPorts or the specified VPort. If VPort properties are not specified, then all available VPort properties are displayed. For information about the VPort properties, see Table 4, "VPort Properties," on page 125.

`[-f` {*fname*=*value*[,...]} [,...]

A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are:

- `tenant` – Filter the VPort properties by the tenant name
- `EVS` – Filter the VPort properties by the elastic virtual switch name
- `vport` – Filter the VPort properties by the VPort name
- `host` – Filter the VPort properties by the host name

Note - You can filter VPorts by using their property values. See Example 66, "Displaying VPort Properties," on page 179.

`-o` *field*[,...]

Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`NAME`	Name of the VPort with the name of the elastic virtual switch with which the VPort is associated in the format *EVS-switch-name*/*VPort-name*.
`TENANT`	Name of the tenant that owns the elastic virtual switch.
`PROPERTY`	Name of the VPort property.
`PERM`	The read or write permissions of the property. The value shown is either `r-` or `rw`.
`VALUE`	The current property value. If the value is not set, it is shown as `--`. If it is unknown, the value is shown as `?`.
`DEFAULT`	The default value of the property. If the property has no default value, `--` is shown.
`POSSIBLE`	A comma-separated list of possible values for the property. If the values span a numeric range, min - max might be shown as shorthand. If the possible values are unknown or unbounded, -- is shown.

EXAMPLE 66 Displaying VPort Properties

The following example displays the VPort properties for the VPort `vport0`.

```
# evsadm show-vportprop ORA/vport0
NAME          TENANT      PROPERTY  PERM VALUE          DEFAULT    POSSIBLE
ORA/vport0    sys-global  cos       rw   --              0         0-7
ORA/vport0    sys-global  maxbw     rw   --              --        --
ORA/vport0    sys-global  priority  rw   --              medium    low,medium,high
ORA/vport0    sys-global  ipaddr    r-   192.0.2.2/24 --         --
ORA/vport0    sys-global  macaddr   r-   2:8:20:b0:6e:63 --        --
ORA/vport0    sys-global  evs       r-   ORA             --        --
ORA/vport0    sys-global  tenant    r-   sys-global      --        --
```

The following example shows how to filter the virtual ports by using the values of their property.

```
# evsadm show-vportprop -p priority
```

```
NAME              TENANT      PROPERTY  PERM VALUE         EFFECTIVE POSSIBLE
evs1/vport0       sys-global  priority  rw   --            medium    low,
                                                                     medium,
                                                                     high
evs1/vport1       sys-global  priority  rw   high          high      low,
                                                                     medium,
                                                                     high
evs1/vport2       sys-global  priority  rw   --            medium    low,
                                                                     medium,
                                                                     high
# evsadm show-vport -f priority=high
NAME                TENANT        STATUS VNIC          HOST
evs1/vport1         sys-global    free   --            --
```

The output shows only the VPort `evs1/vport1` whose `priority` property is set to `high`.

EXAMPLE 67 Displaying the UUID for a VPort

This example shows how to display the UUID for the VPort `evs1/vport1`.

```
# evsadm show-vportprop -p uuid -o name,tenant,property,perm,value evs1/vport1
NAME          TENANT      PROPERTY  PERM VALUE
evs1/vport1   sys-global  uuid      r-   7d4c90e0-96bb-11e4-ab96-171c32874415
```

Displaying VPorts

You use the `evsadm show-vport` command to display VPorts. The command syntax is:

```
# evsadm show-vport [-f {fname=value[,...]}[,...]] [[-c] -o field[,...]] \
[[EVS-switch-name/][VPort-name]]
```

`-f` {*fname*=*value*[,...]} [,...]

A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are:

- `tenant` – Filter the VPort list by the tenant name
- `EVS` – Filter the VPort list by the elastic virtual switch name
- `vport` – Filter the VPort list by the VPort name
- `host` – Filter the VPort list by the host name

`-o` *field*[,...]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output:

`all`	Displays all the output fields.
`NAME`	Name of the VPort with the name of the elastic virtual switch with which it is associated in the format *EVS-switch-name*/*VPort-name*.
`TENANT`	Name of the tenant that owns the elastic virtual switch.
`STATUS`	Displays whether the VPort is in use or free. A VPort is in use if the VPort is associated with a VNIC. Otherwise, the VPort is free.
`VNIC`	Name of the VNIC associated with the VPort.
`HOST`	Name of the host that has the VNIC associated with the VPort.

EXAMPLE 68 Displaying VPort Information

This example displays information about the VPort `vport0`.

```
# evsadm show-vport
NAME            TENANT        STATUS VNIC      HOST
ORA/vport0      sys-global    used   vnic1     s11-client
```

Resetting a VPort

When you delete a VNIC associated with a VPort, the state of the VPort is `free`. The VPort can be in the `used` state even if you delete the VNIC that is associated with the VPort in the following situations:

- The EVS node is unable to reach the EVS controller when you delete the VNIC in the EVS node.
- The VNIC associated with the VPort is not deleted before you reboot the EVS node.

To reset the state of a VPort to `free`, use the `evsadm reset-vport` command. The command syntax is:

```
# evsadm reset-vport [-T tenant-name] EVS-switch-name/VPort-name
```

Removing a VPort

If a VNIC is associated with the VPort, then the removal of the VPort fails. Therefore, you must first check whether a VNIC is associated with the VPort that you want to remove by using the `evsadm show-vport` command. You use the `evsadm remove-vport` command to remove a VPort from an elastic virtual switch. The command syntax is:

```
# evsadm remove-vport [-T tenant-name] EVS-switch-name/VPort-name
```

This command removes the specified VPort. When a VPort is removed, the IP address and the MAC address associated with the VPort are released.

EXAMPLE 69 Removing a VPort

This example shows how to remove the VPort `vport0` configured for the elastic virtual switch `ORA`.

```
# evsadm remove-vport -T tenantA ORA/vport0
```

Deleting an Elastic Virtual Switch

This section describes how to delete an elastic virtual switch. You can delete an elastic virtual switch only when all the VPorts of an elastic virtual switch are free. Therefore, VPorts must not be associated with VNICs.

▼ How to Delete an Elastic Virtual Switch

1. **Become an administrator or user with the Elastic Virtual Switch Administration rights profile.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Check whether VPorts are used by the elastic virtual switch.**

   ```
   # evsadm show-evs
   ```

You cannot delete an elastic virtual switch if a VPort is in use. A VPort is in use if a VNIC is connected to the VPort. The `STATUS` field in the `evsadm show-evs` command output displays whether an elastic virtual switch is busy or idle.

If a VPort is in use, you need to delete the VNIC associated with the VPort as follows:

```
# dladm delete-vnic VNIC
```

3. **Delete the elastic virtual switch.**

```
# evsadm delete-evs [-T tenant-name] EVS-switch-name
```

This command deletes the specified elastic virtual switch and all the VPorts and the IPnet associated with the elastic virtual switch.

Example 70 Deleting an Elastic Virtual Switch

The following example shows how to delete the elastic virtual switch `ORA`.

```
# evsadm show-evs
EVS           TENANT        STATUS NVPORTS IPNETS      HOST
ORA           sys-global    idle   0       ora_ipnet   --
# evsadm delete-evs ORA
# evsadm show-evs ORA
evsadm: failed to show EVS(s): evs not found
```

The following example shows how to delete the elastic virtual switch `EVS1`, which is busy.

```
# evsadm show-evs EVS1
EVS           TENANT        STATUS NVPORTS IPNETS      HOST
EVS1          sys-global    busy   1       evs1_ipnet  s11-server
# evsadm show-vport EVS1/vport1
NAME               TENANT        STATUS VNIC         HOST
EVS1/vport1        sys-global    used   vnic1        s11-server
# dladm delete-vnic vnic1
# evsadm show-evs EVS1
EVS           TENANT        STATUS NVPORTS IPNETS      HOST
EVS1          sys-global    idle   1       evs1_ipnet  --
# evsadm delete-evs EVS1
# evsadm show-evs EVS1
evsadm: failed to show EVS(s): evs not found
```

Monitoring Elastic Virtual Switches

You can monitor network traffic statistics for the virtual ports of an elastic virtual switch to obtain the following information:

- The amount of network traffic that is sent and received by a VM, which provides information about the workload on the VM.
- The number of packets that are dropped inbound (`idrops`) and outbound (`odrops`). These values provide information about faulty networks.
- The amount of network traffic that is sent and received by all the VMs on a compute node, which helps you to perform capacity planning.

You use the `evsstat` command to monitor elastic virtual switches. The `evsstat` command reports runtime statistics for each VPort of the elastic virtual switch. It also reports the statistics of VNICs associated with the VPorts. For more information about EVS and virtual ports, see the `evsadm`(1M) man page.

The `evsstat` command is a Remote Administration Daemon (RAD) client, and it communicates with a remote EVS controller to execute all the `evsstat` subcommands. Before using the `evsstat` command, you must specify a resolvable hostname or the IP address of the EVS controller by using the `evsadm set-prop` command. The command syntax is:

```
# evsadm set-prop -p controller=ssh://[username@]hostname-or-IP-address
```

In addition, you must set up SSH authentication by using the preshared public key between the host where you run the `evsstat` command and the EVS controller. You need SSH authentication with the preshared public key for the `evsstat` command to communicate with the EVS controller non-interactively and securely. For more information, see "Setting Up SSH Authentication" on page 150.

The command syntax for `evsstat` is:

```
# evsstat [-f {fname=value[,...]}[,...] [[-c] -o field[,...]] [-u R|K|M|G|T|P] \
[EVS-switch-name[/VPort-name]] [interval] [count]
```

EVS-switch-name Specifies the name of the elastic virtual switch whose statistics you want to monitor. If the name of the elastic virtual switch is not specified, statistics for all elastic virtual switches are displayed.

VPort-name Specifies the name of the VPort whose statistics you want to monitor. The statistics are displayed only for the VNIC connected to the specified

	VPort. You must specify the name of the elastic virtual switch and then specify the name of the VPort.
`-f` {*fname*=*val*[,...]}[,...]	A comma-separated name-value pair used to filter the output (row selection). If multiple filters are specified, then the displayed output is a result of an AND operation among the filters. If the filter value is multivalued, then the displayed output is a result of an OR operation among the filter values. The supported filters are `tenant`, `evs`, and `host`.
`-o` *field*[,...]]	Specifies a case-insensitive, comma-separated list of output fields to display. You can specify the following fields, which appear as columns in the output: ■ `vport` ■ `evs` ■ `tenant` ■ `vnic` ■ `host` ■ `ipkts` ■ `rbytes` ■ `opkts` ■ `idrops` ■ `odrops`
`-u R|K|M|G|T|P`	Specifies the unit in which the statistics are displayed. If not specified, then different units, as appropriate, are used to display the statistics, using the format `xy.zU`, where `x`, `y`, and `z` are numbers and `U` is the appropriate unit. The supported units are: ■ `R` – Raw count ■ `K` – Kilobits ■ `M` – Megabits ■ `G` – Gigabits ■ `T` – Terabits ■ `P` – Petabits
interval	Specifies the time in seconds at which you want to refresh the network statistics.
count	Specifies the number of times to refresh the statistics. You must specify the interval and then specify the count.

EXAMPLE 71 Monitoring Elastic Virtual Switches

The following example displays statistics for all elastic virtual switches.

```
# evsstat
VPORT        EVS      TENANT       IPKTS     RBYTES      OPKTS   OBYTES
sys-vport0   ORA      sys-global   101.88K   32.86M      40.16K  4.37M
sys-vport2   ORA      sys-global   4.50M     6.78G       1.38M   90.90M
sys-vport0   HR       sys-global   132.89K   12.25M      236     15.82K
sys-vport1   HR       sys-global   144.47K   13.32M      247     16.29K
```

The following example displays statistics for the specified elastic virtual switch, `evs0`.

```
# evsstat ORA
VPORT         EVS      TENANT       IPKTS     RBYTES    OPKTS    OBYTES
sys-vport0    ORA      sys-global   101.88K   32.86M    40.16K   4.37M
sys-vport2    ORA      sys-global   4.50M     6.78G     1.38M    90.90M
```

The following example displays statistics for the specified VPort, `evs0/sys-vport2`.

```
# evsstat ORA/sys-vport2
VPORT        EVS     TENANT       IPKTS   RBYTES   OPKTS  OBYTES
sys-vport2   ORA     sys-global   4.50M   6.78G    1.38M  90.90M
```

The following example shows the statistics of a VPort with an interval value of `1` second and count value of `3`. The statistics are refreshed three times with an interval of one second.

```
# evsstat ORA/sys-vport2 1 3
VPORT         EVS      TENANT       IPKTS   RBYTES   OPKTS  OBYTES
sys-vport2    ORA      sys-global   4.50M   6.78G    1.38M  90.90M
sys-vport2    ORA      sys-global   4.50M   6.78G    1.38M  90.90M
sys-vport2    ORA      sys-global   4.50M   6.78G    1.38M  90.90M
```

The following example shows the statistics for the specified output fields.

```
# evsstat -o vport,evs,vnic,host,ipkts,opkts
VPORT          EVS      VNIC      HOST    IPKTS     OPKTS
sys-vport0     ORA      vnic0     host1   101.88K   40.16K
sys-vport2     ORA      vnic0  host2   4.50M     1.38M
sys-vport0     HR       vnic1     host1   132.89K   236
sys-vport1     HR       vnic1     host2   144.47K   247
```

Example Use Cases for Elastic Virtual Switches

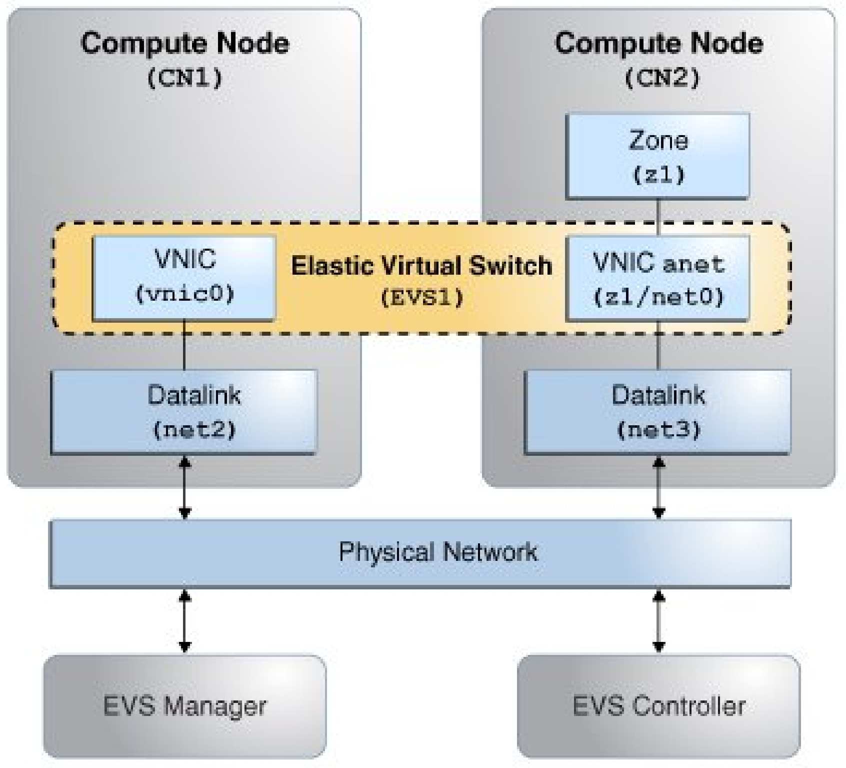
This section provides example use cases that describes how to configure an elastic virtual switch.

Use Case: Configuring an Elastic Virtual Switch

Objective – This use case shows how to set up an elastic virtual switch (`EVS1`) across two compute nodes.

In this use case, you connect the VNIC `vnic0` on `CN1` and the VNIC `anet` of the zone `z1` to the elastic virtual switch `EVS1` so that they are a part of the same L2 segment and they can communicate with each other on a VLAN. The following figure shows the elastic virtual switch (`EVS1`) across two compute nodes.

FIGURE 20 Elastic Virtual Switch Configuration



The figure shows a network with four nodes that contains the following components:

- Two compute nodes (`CN1` and `CN2`)
- Zone `z1` on `CN2` with the VNIC `anet` resource (`z1/net0`)
- VNIC `vnic0` on `CN1`
- A node that acts as an EVS controller (`evs-controller.example.com`)
- A node that acts as an EVS manager on which you need to run the `evsadm` command (`MANAGER`)
- A VLAN to implement the elastic virtual switch `EVS1`
- `uplink-port`, which specifies the datalink that is used for the VLAN

Note - All the four nodes can be on a single system. The EVS controller and EVS manager can be on the same system.

Planning for the Elastic Virtual Switch Setup

1. Install the mandatory EVS packages.

   For information about the required packages, see "Mandatory Packages for Using EVS" on page 137.

   Note - The `evsuser` is a specific user that is created when you install the `pkg:/service/network/evs` package. The user, `evsuser`, is assigned with the Elastic Virtual Switch Administration rights profile. This profile provides all the required authorizations and privileges to perform EVS operations.

   ---

2. Set up SSH authentication with the preshared public key for `evsuser` between the following components in the EVS setup:
   - The EVS manager and the EVS controller
   - Each EVS node and the EVS controller
   - The EVS controller and each EVS node

   For more information, see "Setting Up SSH Authentication" on page 150.

   Note - This use case assumes that the `controller` property is set to `ssh://evsuser@evs-controller.example.com` on the EVS node, EVS manager, and EVS controller.

   ---

3. Configure the EVS controller.

   a. Specify a compute node as an EVS controller in your network and then set the EVS controller on each compute node so that the compute nodes can communicate with the

EVS controller. Note that you can set the controller properties from any compute node that can communicate with the EVS controller. For more information, see "Configuring Elastic Virtual Switches" on page 159.

   b. Specify the properties `l2-type`, `vlan-range`, and `uplink-port`. Otherwise, you cannot create the elastic virtual switch.

4. Create an elastic virtual switch. You must associate an IPnet and add a VPort to the elastic virtual switch.
5. Create a temporary VNIC on `CN1` and connect the VNIC to the VPort of the elastic virtual switch.
6. Create a VNIC `anet` resource on the zone `z1` and connect it to the elastic virtual switch.

EVS Manager Operations

1. Set the EVS controller.

```
MANAGER# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
```

2. Set the EVS controller properties.

   a. Set the type of L2 topology that must be used for the elastic virtual switch.

   ```
   MANAGER# evsadm set-controlprop -p l2-type=vlan
   ```

   b. Set the VLAN range.

   ```
   MANAGER# evsadm set-controlprop -p vlan-range=200-300
   ```

   c. Specify the datalinks (`uplink-port`) that are used for the VLAN.

   ```
   MANAGER# evsadm set-controlprop -p uplink-port=net2

   MANAGER# evsadm set-controlprop -h CN2 -p uplink-port=net3
   ```

Note - You can configure the EVS controller from any node in the data center or multitenant cloud environment as long as you can connect to the EVS controller and have the required authorizations. For more information, see "Security Requirements for Using EVS" on page 138.

3. Verify the controller properties.

```
MANAGER# evsadm show-controlprop -p l2-type,vlan-range,uplink-port
NAME            VALUE           DEFAULT         HOST
l2-type         vlan            vlan            --
vlan-range      200-300         --              --
uplink-port     net2            --              --
```

```
uplink-port         net3                --                  CN2
```

4. Create an elastic virtual switch named `EVS1`.

   ```
   MANAGER# evsadm create-evs EVS1
   ```

5. Add the IPnet `EVS1_ipnet` to `EVS1`.

   ```
   MANAGER# evsadm add-ipnet -p subnet=192.0.2.0/27 EVS1/EVS1_ipnet
   ```

6. Add the VPort `vport0` to `EVS1`.

   ```
   MANAGER# evsadm add-vport EVS1/vport0
   ```

   You do not need to always add a virtual port to an elastic virtual switch. When a VNIC is created, you can specify only the name of the elastic virtual switch to which the VNIC must connect. In such cases, the EVS controller generates a system virtual port. These virtual ports follow the naming convention `sys-`*vportname*, for example, `sys-vport0`. The system virtual port inherits the elastic virtual switch properties.

7. Verify the elastic virtual switch that is created.

   ```
   MANAGER# evsadm
   NAME           TENANT           STATUS    VNIC      IP                      HOST
   EVS1           sys-global       --        --        EVS1_ipnet              --
      vport0      --               free      --        192.0.2.2/27        --
   ```

   Note - Because the tenant name is not specified, the default tenant name, `sys-global` is used by the elastic virtual switch `EVS1`. You can specify the tenant name by using the `-T` option when you create an elastic virtual switch. For more information, see "How to Configure an Elastic Virtual Switch" on page 162.

8. Check the MAC address and the IP address associated with `EVS1/vport0`.

   ```
   MANAGER# evsadm show-vportprop -p macaddr,ipaddr EVS1/vport0
   NAME           TENANT        PROPERTY  PERM   VALUE              DEFAULT   POSSIBLE
   EVS1/vport0    sys-global    ipaddr    r-     192.0.2.2/27    --        --
   EVS1/vport0    sys-global    macaddr   r-     2:8:20:3c:78:bd    --        --
   ```

   The VNIC that connects to `vport0` will inherit the IP address and MAC address. The IP address that is assigned for `vport0` is the next available IP address from the IPnet `EVS1_ipnet` and the MAC address is randomly generated for `vport0`.

9. Check the VLAN ID associated with the elastic virtual switch `EVS1`.

   ```
   MANAGER# evsadm show-evs -L
   EVS          TENANT          VID   VNI
   EVS1         sys-global      200   --
   ```

Compute Node `CN1` Operations

1. Specify the EVS controller.

   ```
   CN1# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
   ```
2. Create a temporary VNIC `vnic0` and connect it to `EVS1/vport0`.

   ```
   CN1# dladm create-vnic -t -c EVS1/vport0 vnic0
   ```
3. Verify the VNIC that is created.

   ```
   CN1# dladm show-vnic -c
   LINK     TENANT         EVS     VPORT       OVER     MACADDRESS        IDS
   vnic0    sys-global     EVS1    vport0      net2     2:8:20:3c:78:bd   VID:200
   ```

   The MAC address of `vnic0` maps to the MAC address of the VPort.
4. Check the allowed IP addresses for `vnic0`.

   ```
   CN1# dladm show-linkprop -p allowed-ips vnic0
   LINK     PROPERTY     VALUE            EFFECTIVE       DEFAULT   POSSIBLE
   vnic0    allowed-ips  192.0.2.2    192.0.2.2   --        --
   ```

   The `allowed-ips` property is set to the IP address associated with the VPort. With this setting, you cannot create any other IP address on `vnic0` other than `192.0.2.2`.
5. Create an IP interface for `vnic0` and assign `192.0.2.2` as the IP address.

   ```
   # ipadm create-ip -t vnic0
   # ipadm create-addr -t -a 192.0.2.2 vnic0
   ```

Compute Node `CN2` Operations

1. Specify the EVS controller.

   ```
   CN2# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
   ```
2. Configure the VNIC `anet` resource for the zone `z1` and connect it to the elastic virtual switch.

   ```
   CN2# zonecfg -z z1
   zonecfg:z1> create
   create: Using system default template 'SYSdefault'
   zonecfg:z1> set zonepath=/export/zones/z1
   zonecfg:z1> select anet linkname=net0
   zonecfg:z1:anet> set evs=EVS1
   zonecfg:z1:anet> end
   ```

```
zonecfg:z1> commit
zonecfg:z1> exit
```

3. Install and boot the zone `z1`.

   ```
   CN2# zoneadm -z z1 install
   CN2# zoneadm -z z1 boot
   ```

4. Log in to the zone `z1` and complete the zone configuration.

   ```
   CN2# zlogin -C z1
   ```

   For more information about zone configuration, see *Creating and Using Oracle Solaris Zones*.

5. Verify the VNIC `anet` that is created.

   ```
   CN2# dladm show-vnic -c
   LINK       TENANT       EVS    VPORT        OVER   MACADDRESS        IDS
   z1/net0    sys-global   EVS1   sys-vport0   net2   2:8:20:1a:c1:e4   VID:200
   ```

   Because the VPort was not specified when you created the VNIC `anet` resource, the EVS controller creates a system VPort, `sys-vport0`, for the VNIC `anet` resource.

6. Display the information that is related to the VPort.

   ```
   CN2# evsadm show-vport -o all
   NAME            TENANT     STATUS VNIC    HOST MACADDR         IPADDR
   EVS1/sys-vport0 sys-global used   z1/net0 CN2  2:8:20:1a:c1:e4 192.0.2.3/24
   ```

   The VNIC `anet` resource is plumbed and assigned the VPort's IP address.

7. Verify the IP address of the VNIC `anet` resource, `z1/net0`.

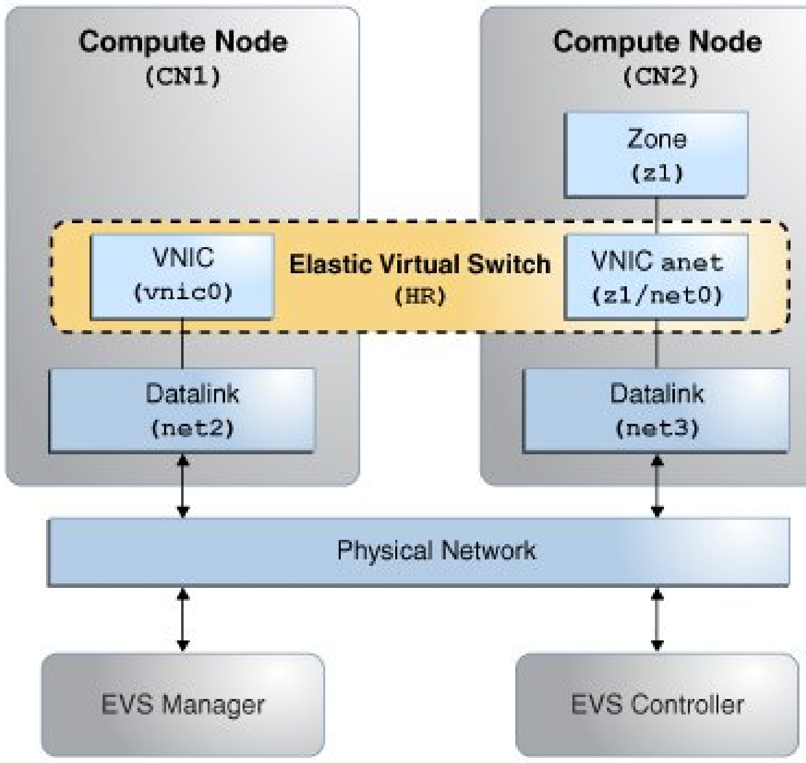
   ```
   CN2# zlogin z1 ipadm
   NAME              CLASS/TYPE    STATE        UNDER      ADDR
   lo0               loopback      ok           --         --
      lo0/v4         static        ok           --         127.0.0.1/8
      lo0/v6         static        ok           --         ::1/128
   net0              ip            ok           --         --
      net0/v4        inherited     ok           --         192.0.2.3/27
   ```

Use Case: Configuring an Elastic Virtual Switch for a Tenant

Objective – This use case shows how to set up an elastic virtual switch (`HR`) across two compute nodes for a tenant.

In this use case, you connect the VNIC `vnic0` on `CN1` and the VNIC `anet` of the zone `z1` to the elastic virtual switch `HR`, so that they are a part of the same L2 segment and they can communicate with each other on a VXLAN. The VNICs are part of the tenant `tenantA`. The following figure shows the EVS setup.

FIGURE 21 Elastic Virtual Switch Configuration for a Tenant



The figure shows a network with four nodes that contains the following components:

- Two compute nodes (`CN1` and `CN2`)
- Zone `z1` on `CN2` with a VNIC `anet` resource
- VNIC `vnic0` on `CN1`
- A node that acts as an EVS controller, `CONTROLLER`
- A node that acts as an EVS manager on which you need to run the `evsadm` command, `MANAGER`
- A VXLAN to implement the elastic virtual switch `HR`
- `uplink-port` that specifies the datalink that is used for the VXLANs

Planning for the Elastic Virtual Switch Setup

1. Install the mandatory EVS packages. For information about the required packages, see "Mandatory Packages for Using EVS" on page 137.

   Note - The `evsuser` is a specific user that is created when you install the `pkg:/service/network/evs` package. The user, `evsuser`, is assigned with the Elastic Virtual Switch Administration rights profile. This profile provides all the required authorizations and privileges to perform EVS operations.

   ---

2. Set up SSH authentication with the preshared public key for `evsuser` between the following components in the EVS setup:

   - The EVS manager and the EVS controller
   - Each EVS node and the EVS controller
   - The EVS controller and each EVS node

   For more information, see "Setting Up SSH Authentication" on page 150.

   Note - This use case assumes that the `controller` property is set to `ssh://evsuser@evs-controller.example.com` on each of the EVS node, EVS manager, and EVS Controller.

   ---

3. Configure the EVS controller and set the controller properties.

   a. Set the EVS controller on all the compute nodes and then set the controller properties that specify how to implement the elastic virtual switch across the compute nodes.

   b. Specify the properties `l2-type`, `vxlan-range`, and `uplink-port`. Otherwise, you cannot create the elastic virtual switch.

4. Create an elastic virtual switch. You must associate an IPnet and add a VPort to the elastic virtual switch.
5. Create a temporary VNIC on `CN1` and connect the VNIC to the VPort of the elastic virtual switch.
6. Create a VNIC `anet` on the zone `z1` and connect the VNIC `anet` resource to the elastic virtual switch.

EVS Manager Operations

1. Set the EVS controller.

```
MANAGER# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
```

2. Set the EVS controller properties.

   a. Set the type of L2 topology that must be used for the elastic virtual switch. This example uses a VXLAN.

   ```
   MANAGER# evsadm set-controlprop -p l2-type=vxlan
   ```

   b. Set the VXLAN range.

   ```
   MANAGER# evsadm set-controlprop -p vxlan-range=200-300
   ```

   c. Specify the datalinks (`uplink-port`) that are used for the VXLAN.

   ```
   MANAGER# evsadm set-controlprop -p uplink-port=net2

   MANAGER# evsadm set-controlprop -h CN2 -p uplink-port=net3
   ```

Note - You can configure the controller from any node in the data center or multitenant cloud environment as long as you can connect to the EVS controller and have the required authorizations. For more information, see “Security Requirements for Using EVS” on page 138.

3. Verify the EVS controller properties.

```
MANAGER# evsadm show-controlprop -p l2-type,vxlan-range,uplink-port
NAME                VALUE               DEFAULT             HOST
l2-type             vxlan               vlan                --
vxlan-range         200-300             --                  --
uplink-port         net2                --                  --
uplink-port         net3                --                  CN2
```

4. Create the elastic virtual switch `HR` for the tenant `tenantA`.

```
MANAGER# evsadm create-evs -T tenantA HR
```

5. Add the IPnet `hr_ipnet` to the elastic virtual switch `HR`.

```
MANAGER# evsadm add-ipnet -T tenantA -p subnet=192.0.2.0/27 HR/hr_ipnet
```

6. Add the VPort `vport0` to the elastic virtual switch `HR`.

```
MANAGER# evsadm add-vport -T tenantA HR/vport0
```

7. Verify the elastic virtual switch that was created for the tenant `tenantA`.

```
MANAGER# evsadm
NAME          TENANT        STATUS VNIC         IP                HOST
HR            tenantA       --     --           hr_ipnet          --
   vport0     --            free   --           192.0.2.2/27  --
```

8. Check the MAC address and the IP address associated with `HR/vport0`.

```
MANAGER# evsadm show-vportprop -p macaddr,ipaddr HR/vport0
NAME          TENANT    PROPERTY  PERM VALUE            DEFAULT   POSSIBLE
HR/vport0     tenantA   ipaddr    r-   192.0.2.2/27  --        --
HR/vport0     tenantA   macaddr   r-   2:8:20:d8:da:10   --        --
```

9. Check the VXLAN segment ID associated with the elastic virtual switch `HR`.

```
MANAGER# evsadm show-evs -L
EVS           TENANT        VID VNI
HR            tenantA       --  200
```

Compute Node `CN1` Operations

1. Specify the EVS controller.

```
CN1# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
```

2. Create a temporary VNIC `vnic0` and connect it to the elastic virtual switch `HR/vport0`.

```
CN1# dladm create-vnic -t -T tenantA -c HR/vport0 vnic0
```

3. Verify the VNIC that was created.

```
CN1# dladm show-vnic -c
LINK   TENANT    EVS   VPORT     OVER           MACADDRESS        IDS
vnic0  tenantA   HR    vport0    evs-vxlan200   2:8:20:d8:da:10   VID:0
```

The MAC address of `vnic0` maps to the MAC address of the VPort.

4. Check the allowed IP addresses for `vnic0`.

```
CN1# dladm show-linkprop -p allowed-ips vnic0
LINK     PROPERTY     VALUE         EFFECTIVE      DEFAULT   POSSIBLE
vnic0    allowed-ips  192.0.2.2 192.0.2.2  --        --
```

The `allowed-ips` property is set to the IP address associated with the VPort. This output means that you cannot create any IP address on `vnic0` other than `192.0.2.2`.

5. Create an IP interface for `vnic0` and assign `192.0.2.2` as the IP address.

```
# ipadm create-ip -t vnic0
# ipadm create-addr -t -a 192.0.2.2 vnic0
```

6. Check the automatically generated VXLAN datalink.

```
CN1# dladm show-vxlan
LINK               ADDR                     VNI   MGROUP
evs-vxlan200       0.0.0.0                  200   224.0.0.1
```

Compute Node `CN2` Operations

1. Specify the EVS controller.

```
CN2# evsadm set-prop -p controller=ssh://evsuser@evs-controller.example.com
```

2. Configure the VNIC `anet` for the zone `z1` and connect it to the elastic virtual switch.

```
CN2# zonecfg -z z1
zonecfg:z1> create
create: Using system default template 'SYSdefault'
zonecfg:z1> set zonepath=/export/zones/z1
zonecfg:z1> set tenant=tenantA
zonecfg:z1> select anet linkname=net0
zonecfg:z1:anet> set evs=HR
zonecfg:z1:anet> end
zonecfg:z1> commit
zonecfg:z1> exit
```

3. Install and boot the zone `z1`.

```
CN2# zoneadm -z z1 install
CN2# zoneadm -z z1 boot
```

4. Log in to the zone `z1` and complete the zone configuration.

```
CN2# zlogin -C z1
```

For more information about zone configuration, see *Creating and Using Oracle Solaris Zones*.

5. Verify the VNIC `anet` resource that was created.

```
CN2# dladm show-vnic -c
LINK      TENANT   EVS    VPORT       OVER          MACADDRESS        IDS
z1/net0   tenantA  HR     sys-vport0  evs-vxlan200  2:8:20:1a:c1:e4   VID:0
```

   Because the VPort is not specified, the EVS controller creates a system VPort `sys-vport0` for the VNIC `anet` resource.

6. Display the information that is related to the VPort.

```
CN2# evsadm show-vport -o all
NAME            TENANT  STATUS VNIC     HOST MACADDR         IPADDR
HR/sys-vport0   tenantA used   z1/net0  CN2  2:8:20:1a:c1:e4 192.0.2.3/27
```

   The VNIC `anet` resource is plumbed and assigned the VPort's IP address.

7. Verify the IP address of the VNIC `anet` `z1/net0`.

```
CN2# zlogin z1 ipadm
NAME              CLASS/TYPE STATE        UNDER      ADDR
lo0               loopback   ok           --         --
   lo0/v4         static     ok           --         127.0.0.1/8
   lo0/v6         static     ok           --         ::1/128
net0              ip         ok           --         --
   net0/v4        inherited  ok           --         192.0.2.3/27
```

♦ ♦ ♦ CHAPTER 7

Managing Network Resources

This chapter explains how to manage and allocate network resources by using datalink properties and flows. By managing network resources, you can implement IP quality of service (QoS) that enhances the performance of the virtual network and physical network. For an introduction to network resource management, see "Overview of Network Resource Management" on page 23.

This chapter contains the following topics:

Managing Network Resources by Using Datalink Properties

You can allocate network resources to datalinks to increase the system's efficiency to process packets. You can allocate network resources by setting datalink properties when you create a datalink. Alternatively, you can set datalink properties to an existing datalink. You can set the following datalink properties to allocate network resources to a datalink by using the `dladm` command:

- `maxbw` – Specifies the maximum amount of bandwidth that you can allocate to a datalink. For more information, see "Use Case: Managing Network Resources by Setting Datalink and Flow Properties" on page 225.
- `rxrings` and `txrings` – Specifies the number of receive rings and transmit rings of a NIC that you can assign to a specific datalink. For more information, see "Managing NIC Rings" on page 200.

- `pool` – Specifies the name of the CPU pool containing sets of CPU that you can assign to a datalink to manage network processes efficiently. For more information, see "Managing Pools and CPUs" on page 210.
- `cpus` – Specifies the name of the CPUs that you can assign to a datalink. For more information, see "Managing Pools and CPUs" on page 210.
- `lro` – Specifies the status of the large receive offload (LRO) feature for a datalink. For more information, see "Using the Large Receive Offload Feature in Oracle Solaris" on page 215.

For a demonstration of managing network resources in Oracle Solaris, see Managing Network Resources Using Oracle Solaris (`https://www.oracle.com/webfolder/technetwork/tutorials/tutorial/solaris/11/ManagingNetworkResources/ManagingNetworkResources.htm`).

You can allocate resources to existing datalinks or while creating new datalinks.

The following commands are used for allocating network resources in datalinks:

- To simultaneously create a virtual link and allocate resources to it, use the following command syntax:

  ```
  # dladm create-vnic -l link -p prop=value[,...] VNIC
  ```

link	Refers to the name of the link which can be either a physical link or a virtual link.
prop	Refers to the datalink property. For information about the different types of datalink properties that can be set for resource allocation, see "Managing Network Resources by Using Datalink Properties" on page 199.

- To set the property for an existing link, use the following command syntax:

  ```
  # dladm set-linkprop -p prop=value[,...] link
  ```

For more information, see the `dladm`(1M) man page.

Managing NIC Rings

On NICs, receive (Rx) rings and transmit (Tx) rings are hardware resources through which the system receives and sends network packets, respectively. By managing and allocating rings according to the network traffic, you increase the system's efficiency for processing packets. For example, you can allocate more number of receive (Rx) rings for a link that is receiving more packets.

Allocating Rings in MAC Clients

MAC clients such as physical datalinks and VNICs are configured over a NIC to enable communication between a system and other network nodes. A MAC client can be either a hardware-based client or a software-based client.

Hardware-based Clients

Clients that have exclusive use of one or more NIC rings are called hardware-based clients. You can assign rings for exclusive use by hardware-based clients depending on the ring allocation supported by the NICs.

Software-based Clients

Clients that do not have exclusive use of NIC rings are called software-based clients. They share rings with other existing software-based clients or with the primary client. The rings that the software-based clients use depend on the number of hardware-based clients that have priority in ring allocation.

Allocating Rings in VLANs

Ring allocation in VLANs differs based on how the VLAN is created.

You can create a VLAN in the following ways:

- By using the `dladm create-vlan` command:

  ```
  # dladm create-vlan -l link -v vid VLAN
  ```

  If you create a VLAN by using the `dladm create-vlan` command, it shares the same MAC address as the underlying datalink. Therefore, the VLAN also shares the Rx and Tx rings of the underlying datalink. For more information about configuring VLANs, see "Configuring a VLAN" in *Managing Network Datalinks in Oracle Solaris 11.3*.
- By using the `dladm create-vnic` command:

```
# dladm create-vnic -l link -v vid VNIC
```

If you create a VLAN as a VNIC by using the `dladm create-vnic` command, it has a different MAC address from its underlying datalink. The allocation of rings for this type of VLAN is independent of the allocation of the underlying datalink. Hence, the VLAN can be assigned its own dedicated rings, assuming that the NIC supports hardware-based clients. For more information about how to assign rings to clients, see "Configuring Clients and Allocating Rings" on page 204.

Commands for Configuring Rings

To configure the rings of a datalink, use the following `dladm` subcommands:

- `# dladm show-linkprop` *link*

  Displays the current values of the datalink properties, including Rx and Tx rings. For an example, see Example 72, "Ring Use and Ring Assignments on a Datalink," on page 204.

  The following table describes the ring properties that are displayed by using the `dladm show-linkprop` command.

Ring Property	Permission	Description
`rxringsavail`	Read only	Indicates the number of Rx rings that you can allocate to hardware-based clients on the physical datalink.
`rxhwclntavail`	Read only	Indicates the number of hardware-based Rx clients that you can create on the physical datalink.
`rxrings`	Read and write	Indicates the number of Rx rings exclusively used by the datalink. You can set this property to one of the three possible values: ■ `hw` indicates that you are configuring a hardware-based client. You can set this value, if the hardware-based Rx clients (`rxhwclntavail`) on the underlying physical link is greater than zero. ■ *number* indicates the number of rings that you can assign to a datalink. You can set this value, if the Rx rings (`rxringsavail`) on the underlying physical link is greater than zero.

Ring Property	Permission	Description
		■ `sw` indicates that the datalink is a software-based client.
`txringsavail`	Read only	Indicates the number of Tx rings that you can allocate to hardware-based clients on the physical datalink.
`txhwclntavail`	Read only	Indicates the number of hardware-based Tx clients that you can create on the physical datalink.
`txrings`	Read and write	Indicates the number of Tx rings exclusively used by the datalink. You can set this property to one of the three possible values: ■ `hw` indicates that you are configuring a hardware-based client. You can set this value, if the hardware-based Tx clients (`txhwclntavail`) on the underlying physical link is greater than zero. ■ *number* indicates the number of rings that you can assign to a datalink. You can set this value, if the Tx rings (`txringsavail`) on the underlying physical link is greater than zero. ■ `sw` indicates that the datalink is a software-based client.

- `# dladm show-phys -H` *link*

  Displays how the rings of a physical datalink are currently being used by existing clients.
- `# dladm create-vnic -p` *ring-properties* `-l` *link VNIC*

  `-p` *ring-properties* Refers to the ring-properties whose values can be set.

  Creates a client with a specific number of Rx or Tx rings.
- `# dladm set-linkprop -p` *ring-properties VNIC*

  Allocates rings to a specific client, provided that the rings are available and ring allocation is supported.

Displaying Ring Use and Ring Assignments on a Datalink

To display the possible values, configured values, and effective values of Rx rings and Tx rings of a datalink, you use the following command syntax:

```
# dladm show-linkprop -p rxrings,txrings link
```

To display how the rings of a physical datalink are currently being used by clients, you use the following command syntax:

```
# dladm show-phys -H link
```

EXAMPLE 72 Ring Use and Ring Assignments on a Datalink

The following example shows the ring assignments on the datalink `net4`.

```
# dladm show-linkprop net4
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
...
net4     rxrings         rw   1            --           --        sw,hw,<1-7>
net4     txrings         rw   1            --           --        sw,hw,<1-11>
net4     txringsavail    r-   10           10           --        --
net4     rxringsavail    r-   7            7            --        --
net4     rxhwclntavail   r-   3            3            --        --
net4     txhwclntavail   r-   3            3            --        --
...
```

The output shows that the datalink `net4` has exclusive use of one Rx ring and one Tx ring. The datalink `net4` has seven Rx rings and ten Tx rings that are available for allocation to the clients. You can create three hardware-based Rx clients and three hardware-based Tx clients over the datalink `net4`.

The following example shows the ring use for the datalink `net0`.

```
# dladm show-phys -H net0
LINK   RINGTYPE   RINGS   CLIENTS
net0   RX         0-1     <default,mcast>
net0   TX         0-7     <default>net0
net0   RX         2-3     net0
net0   RX         4-5     --
net0   RX         6-7     --
```

Based on the output, the two Rx rings allocated to `net0` are rings `2` and `3`. For Tx rings, `net0` uses rings `0` through `7`.

Configuring Clients and Allocating Rings

This section describes how to configure clients on a datalink based on the type of support for ring allocation.

▼ How to Configure Clients and Allocate Rings

Make sure that you can interpret the output of the `dladm` commands that display datalink ring properties, as explained in "Commands for Configuring Rings" on page 202. This information helps you to configure clients and allocate rings.

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Display the underlying physical datalink's properties.**

   ```
   # dladm show-linkprop -p rxringsavail,txringsavail,rxhwclntavail,txhwclntavail link
   ```

   Determine the following information from the output of the command:

   - Whether the NIC supports hardware-based clients
   - The availability of rings to allocate to hardware-based clients
   - The availability of hardware-based clients that you can configure on the link

3. **Depending on the information from the previous step, perform one of the following:**

   - **Create the hardware-based client with the following syntax:**

     ```
     # dladm create-vnic -p rxrings=value[,txrings=value] -l link VNIC
     ```

     where *value* can be one of the following:

     - `hw` - Indicates that you are configuring a hardware-based client.
     - *number* - Indicates that you are configuring a hardware-based client only. The number refers to the quantity of rings that you can allocate to the client for its exclusive use.

   - **Create the software-based client with the following syntax:**

     ```
     # dladm create-vnic -p rxrings=sw[,txrings=sw] -l link VNIC
     ```

   Alternatively, if the client was previously created, you can use the `dladm set-linkprop` command to set the ring properties.

4. **(Optional) Verify the ring information of the client that you created.**

   ```
   # dladm show-linkprop -p rxrings,txrings VNIC
   ```

5. **(Optional) Verify the link's rings that are distributed among different clients.**

```
# dladm show-phys -H link
```

Example 73 Configuring Clients and Allocating Rings on the `nxge` Device

This example is based on the `nxge` device and shows how to configure clients and allocate rings on the datalink `net5`. This example shows how to create the following clients:

- The VNIC `vnic2`, which is a hardware-based client with exclusive use of Rx and Tx rings.
- The VNIC `vnic3`, which is a hardware-based client with a fixed number of rings that are set according to the NIC driver's initial configuration.
- The VNIC `vnic4`, which is a software-based client.

1. Check whether the physical datalink `net5` supports ring allocation for clients.

   ```
   # dladm show-linkprop -p rxringsavail,txringsavail net5
   LINK     PROPERTY        PERM  VALUE     EFFECTIVE   DEFAULT   POSSIBLE
   net5     rxringsavail    r-    7         7           --        --
   net5     txringsavail    r-    11        11          --        --
   ```

   The output shows that the physical datalink `net5` has `7` Rx rings and `11` Tx rings that you can assign to the clients over the physical datalink `net5`.
2. Check the availability of hardware-based clients that you can create over the physical datalink `net5`.

   ```
   # dladm show-linkprop -p rxhwclntavail,txhwclntavail net5
   LINK     PROPERTY        PERM  VALUE    EFFECTIVE   DEFAULT   POSSIBLE
   net5     rxhwclntavail   r-    3        3           --        --
   net5     txhwclntavail   r-    4        4           --        --
   ```

   The output shows that you can create `3` hardware-based Rx clients and `4` hardware-based Tx clients over the datalink `net5`.
3. Check the existing ring usage over the physical datalink `net5`.

   ```
   # dladm show-phys -H net5
   LINK     RINGTYPE    RINGS     CLIENTS
   nxge1    RX          0-7       <default,mcast>
   nxge1    TX          0-11      <default>
   ```

   The output shows that the `nxge1` device has eight Rx rings (`0-7`) and twelve Tx rings (`0-11`). Because no datalinks are on the `nxge1` device, the Rx rings and Tx rings are not assigned to any datalinks. The value `<default>` in the `CLIENTS` column means that the Tx rings will be used by the software-based clients. The value `<default,mcast>` under the

`CLIENTS` column means that the Rx rings will be used by the software-based clients and non-unicast packets.

4. Create the VNIC `vnic2` over the datalink `net5` with two Rx rings and two Tx rings.

```
# dladm create-vnic -l net5 -p rxrings=2,txrings=2 vnic2
```

5. Verify the rings that are assigned to the VNIC `vnic2`.

```
# dladm show-linkprop -p rxrings,txrings vnic2
LINK     PROPERTY     PERM   VALUE    EFFECTIVE    DEFAULT   POSSIBLE
vnic2    rxrings      rw     2        2            --        sw,hw,<1-7>
vnic2    txrings      rw     2        2            --        sw,hw,<1-11>
```

6. Verify the ring usage on the physical datalink `net5`.

```
# dladm show-phys -H net5
LINK     RINGTYPE     RINGS      CLIENTS
nxge1    RX           0,3-7      <default,mcast>
nxge1    TX           0,3-11     <default>
nxge1    RX           1-2        vnic2
nxge1    TX           1-2        vnic2
```

The output shows that the Rx rings allocated to `vnic2` are `1` and `2`. For Tx rings, `vnic2` uses the rings `1` and `2`.

7. Check whether you can create additional hardware-based clients over the physical datalink `net5`.

```
# dladm show-linkprop -p rxhwclntavail,txhwclntavail net5
LINK     PROPERTY        PERM  VALUE     EFFECTIVE   DEFAULT   POSSIBLE
net5     rxhwclntavail   r-    2         2           --        --
net5     txhwclntavail   r-    3         3           --        --
```

The output shows that you can create two hardware-based Rx clients and three hardware-based Tx clients over the physical datalink `net5`.

8. Create the VNIC `vnic3`, which is a hardware-based client.

```
# dladm create-vnic -l net5 -p rxrings=hw,txrings=hw vnic3
```

9. Verify the rings that are assigned to the VNIC `vnic3`.

```
# dladm show-linkprop -p rxrings,txrings vnic3
LINK     PROPERTY     PERM    VALUE   EFFECTIVE    DEFAULT   POSSIBLE
vnic3    rxrings      rw      --      1            --        sw,hw,<1-7>
vnic3    txrings      rw      hw      hw           --        sw,hw,<-11>
```

Note - The number of rings that are assigned to a client depends on the network device. One ring is assigned to a client on the device that enables you to explicitly specify the number of rings, for example, the `nxge` device. For other devices, the number of rings assigned to a client depends on how the device is configured. See Example 74, "Configuring Clients and Allocating Rings on the `ixgbe` Device," on page 209.

---

10. Check whether you can create additional hardware-based clients over the physical datalink `net5`.

```
# dladm show-linkprop -p rxhwclntavail,txhwclntavail net5
LINK     PROPERTY        PERM   VALUE    EFFECTIVE  DEFAULT    POSSIBLE
net5     rxhwclntavail   r-     2        2          --         --
net5     txhwclntavail   r-     2        2          --         --
```

The output shows that you can create `2` hardware-based Rx clients and `2` hardware-based Tx clients over the physical datalink `net5`.

11. Create the VNIC `vnic4`, which is a software-based client.

```
# dladm create-vnic -l net5 -p rxrings=sw,txrings=sw vnic4
```

12. Verify the ring usage on `vnic4`.

```
# dladm show-linkprop -p rxrings,txrings vnic4
LINK     PROPERTY     PERM   VALUE    EFFECTIVE   DEFAULT    POSSIBLE
vnic4    rxrings      rw     sw       --          --         sw,hw,<1-7>
vnic4    txrings      rw     sw       --          --         sw,hw,<1-11>
```

13. Verify the ring usage on the physical datalink `net5`.

```
# dladm show-phys -H net5
LINK     RINGTYPE     RINGS       CLIENTS
nxge1    RX           0,4-7       <default,mcast>,vnic4
nxge1    TX           0,4-11      <default>,vnic4
nxge1    RX           1-2         vnic2
nxge1    RX           3           vnic3
nxge1    TX           1-2         vnic2
nxge1    TX           3           vnic3
```

The output shows that `vnic4` is software-based client that shares the default set of rings on the physical datalink `net5`. The VNIC `vnic2` is a hardware-based client that has exclusive use of two rings (`2-3`) and `vnic3` is a hardware-based client that has exclusive use of one ring (`3`).

Example 74 Configuring Clients and Allocating Rings on the `ixgbe` Device

This example is based on the `ixgbe` device and shows how to configure clients and allocate rings on the physical datalink `net4`.

1. Check the existing ring usage over the physical datalink `net4`.

```
# dladm show-phys -H net4
LINK      RINGTYPE    RINGS     CLIENTS
net4      RX          0-3       <default,mcast>
net4      RX          4-7       --
net4      RX          8-11      --
net4      RX          12-15     --
net4      TX          0-7       <default>
```

2. Check whether you can create hardware-based clients over the physical datalink `net4`.

```
# dladm show-linkprop -p rxhwclntavail,txhwclntavail,rxringsavail,txringsavail net4
LINK     PROPERTY        PERM   VALUE   EFFECTIVE  DEFAULT   POSSIBLE
net4     rxhwclntavail   r-     3       3          --        --
net4     txhwclntavail   r-     0       0          --        --
net4     rxringsavail    r-     0       0          --        --
net4     txringsavail    r-     0       0          --        --
```

   The output shows that you can create `3` hardware-based Rx clients over the physical datalink `net4`.

3. Create the VNIC `vnic3`, which is a hardware-based Rx client.

```
# dladm create-vnic -l net4 -p rxrings=hw vnic3
```

   You cannot configure the `txrings` property for `vnic3` because the available number of hardware-based Tx clients (`txhwclntavail`) is zero.

4. Verify the rings that are assigned to the VNIC `vnic3`.

```
# dladm show-linkprop -p rxrings,txrings vnic3
LINK     PROPERTY       PERM   VALUE     EFFECTIVE  DEFAULT   POSSIBLE
vnic3    rxrings         rw    hw        hw         --        sw,hw
vnic3    txrings         rw    --        8          --        --
```

5. Check whether you can create additional hardware-based clients over the physical datalink `net4`.

```
# dladm show-linkprop -p rxhwclntavail,txhwclntavail,rxringsavail,txringsavail net5
LINK     PROPERTY        PERM  VALUE     EFFECTIVE   DEFAULT   POSSIBLE
net4     rxhwclntavail   r-    2         2           --        --
net4     txhwclntavail   r-    0         0           --        --
```

```
net4      rxringsavail    r-    0         0           --        --
net4      txringsavail    r-    0         0           --        --
```

The output shows that you can create `2` hardware-based Rx clients over the physical datalink `net4`.

6. Verify the ring usage on the physical datalink `net4`.

```
# dladm show-phys -H net4
LINK      RINGTYPE    RINGS     CLIENTS
net4      RX          0-3       <default,mcast>
net4      RX          4-7       vnic3
net4      RX          8-11
net4      RX          12-15     --
net4      TX          0-7       <default>,vnic3
```

The output shows that `vnic3` is a hardware-based Rx client with exclusive use of four rings. For Tx rings, `vnic3` uses the default set of rings and also shares the rings with other datalinks when they are created on the physical datalink `net4`.

Managing Pools and CPUs

In Oracle Solaris, zone administration includes assigning a pool of CPU resources for non-networking processes by using the `zonecfg` or `poolcfg` command. To dedicate that same pool of resources to also manage network processes, use the `dladm set-linkprop` command to configure a link's `pool` property. The `pool` link property enables you to assign a pool of CPUs for the networking processes. With this property, you can better integrate network resource management with CPU allocation and administration in zones.

By setting the `pool` property for a link and assigning the link as the zone's network interface, that link becomes bound to a zone's pool. If the zone is set to become an exclusive zone, then CPU resources in the pool can no longer be used by other links that are not assigned to the zone.

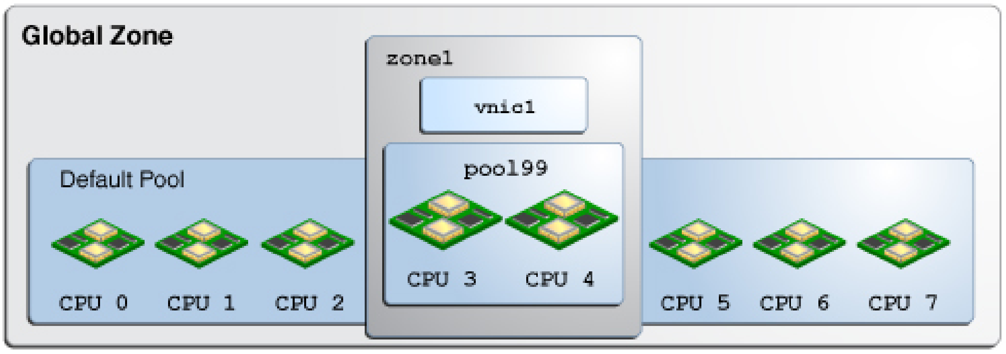
Note - A separate property, `cpus`, can be set to assign specific CPUs to a datalink. The `cpus` and `pool` properties are mutually exclusive. You cannot set both properties for a given datalink. To assign CPU resources to a datalink by using the `cpus` property, see "How to Allocate CPUs to a Datalink" on page 214.

For more information about pools within a zone, see Chapter 13, "Creating and Administering Resource Pools" in *Administering Resource Management in Oracle Solaris 11.3*. For more information about creating pools and assigning CPU sets to the pools, see the `poolcfg`(1M) man page.

Working With Pools and CPUs

The following figure shows how pools work when the `pool` property is assigned to a datalink.

FIGURE 22 `pool` Property of a VNIC Assigned to a Zone

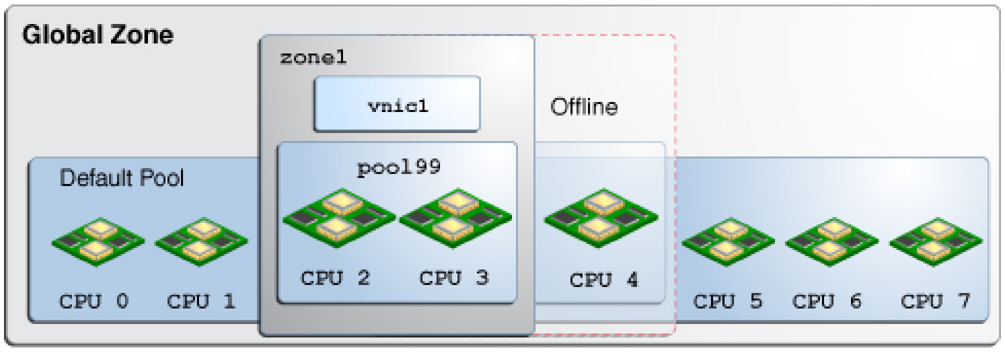


In the figure, the system has eight CPUs. When no pools are configured on the system, all the CPUs belong to the *default pool* and are used by the global zone. However, in this example, the `pool99` pool has been created and consists of `CPU 3` and `CPU 4`. This pool is associated with `zone1`, which is an exclusive zone. If `pool99` is set as a property of `vnic1`, then `pool99` becomes dedicated to also manage `vnic1`'s networking processes. After `vnic1` is assigned to be `zone1`'s network interface, the CPUs in `pool99` are reserved to manage both networking and non-networking processes of `zone1`.

The `pool` property is dynamic in nature. Zone pools can be configured with a range of CPUs, and the kernel determines which CPUs are assigned to the pool's CPU set. Changes to the pool are automatically implemented for the datalink, which simplifies pool administration for that link. In contrast, assigning specific CPUs to the link by using the `cpu` property requires you to specify the CPU to be assigned. You have to set the `cpu` property every time you want to change the CPU components of the pool.

For example, suppose that the system `CPU 4` in Figure 22, "`pool` Property of a VNIC Assigned to a Zone," on page 211 is taken offline. Because the `pool` property is dynamic, the software automatically associates an additional CPU with the pool. Hence, the pool's original configuration of two CPUs is preserved. For `vnic1`, the change is transparent. The updated configuration is shown in the following figure.

FIGURE 23 Automatic Reconfiguration of the `pool` Property



When you use the `dladm show-linkprop` command to display information for a datalink, the value in the `EFFECTIVE` column for the `pool` and `cpus` datalink properties indicates the current system-selected value of those properties.

The following read-only values are displayed for the `pool` and `cpus` properties:

- For the `pool` datalink property, the value in the `EFFECTIVE` column indicates the pool that is used for network processes.
- For the `cpus` datalink property, the value in the `EFFECTIVE` column indicates the CPUs that are used for network processes. For an example that shows how to display the `cpus` property for a datalink, see "Allocating CPUs to a Datalink" on page 214.

To manage the CPU resources of a zone, you do not need to set a datalink's pool property. You can use commands such as `zonecfg` and `poolcfg` to configure a zone to use a pool of resources. When the `cpus` and `pool` link properties are not set for a datalink, the value in the `EFFECTIVE` column of the `pool` and the `cpus` properties of the datalinks are set automatically according to the zone configurations when the zone is booted. The default pool is displayed in the `EFFECTIVE` column of the `pool` property and the system selects the value in the `EFFECTIVE` column of the `cpus` property. Therefore, if you use the `dladm show-linkprop` command, the value of the `pool` and `cpus` properties is empty but values are displayed in the `EFFECTIVE` column of the `pool` and `cpus` properties.

You can also directly set the `pool` and `cpu` properties of a datalink to assign a zone's CPU pool for networking processes. After you configure these properties, their values are reflected in the `EFFECTIVE` column of the `pool` and `cpus` properties. However, this alternative method is used less often to manage a zone's network resources.

Configuring a CPU Pool for a Datalink

This section describes how to set the `pool` property for a datalink either when the link is created or later when the link requires further configuration.

▼ How to Configure a CPU Pool for a Datalink

Before You Begin You must have completed the following tasks:

- Created a processor set with its assigned number of CPUs
- Created a pool with which the processor set will be associated
- Associated the pool with the processor set

Note - For the instructions to complete these prerequisites, see "How to Modify a Configuration" in *Administering Resource Management in Oracle Solaris 11.3*.

---

1. **Set the link's `pool` property to the pool of CPUs that you created for the zone.**

   - **If the VNIC has not yet been created, use the following syntax:**

     ```
     # dladm create-vnic -l link -p pool=pool VNIC
     ```

   - **If the VNIC exists, use the following syntax:**

     ```
     # dladm set-linkprop -p pool=pool VNIC
     ```

2. **Set the zone to use the VNIC.**

   ```
   global# zonecfg -z zone
   zonecfg:zone> add net
   zonecfg:zone:net> set physical=VNIC
   zonecfg:zone:net> end
   ```

3. **Verify and commit the changes you have implemented and then exit the zone.**

   ```
   zonecfg:zone> verify
   zonecfg:zone> commit
   zonecfg:zone> exit
   ```

Example 75 Assigning a Link's CPU Pool to a Zone

This example shows how a pool is assigned to a zone's datalink. The scenario is based on the configuration in Figure 22, "`pool` Property of a VNIC Assigned to a Zone," on page 211. The example assumes that a pool of CPUs named `pool99` has already been configured for the zone. The pool is then assigned to a VNIC. Finally, the non-global zone `zone1` is set to use the VNIC as the network interface.

```
# dladm create-vnic -l net1 -p pool=pool99 vnic1

# zonecfg -z zone1
zonecfg:zone1> add net
zonecfg:zone1:net> set physical=vnic1
zonecfg:zone1:net> end
zonecfg:zone1> verify
zonecfg:zone1> commit
zonecfg:zone1> exit
```

Allocating CPUs to a Datalink

This section describes how to assign CPU resources to a datalink by configuring the `cpu` property. Unlike rings, you cannot allocate CPUs exclusively for a datalink. You can allocate the same set of CPUs to multiple datalinks.

▼ How to Allocate CPUs to a Datalink

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **Verify the CPU assignments for the interface.**

   ```
   # dladm show-linkprop -p cpus link
   ```

3. **Assign CPUs to the link.**

   A list of CPUs that process packets for the datalink. Interrupts for the datalink might also be targeted to one of the CPUs in the list.

   ```
   # dladm set-linkprop -p cpus=cpu1,cpu2,... link
   ```

cpu1,cpu2,...	Refers to the CPU number that you want to assign to the link. You can dedicate multiple CPUs to the link.

4. **(Optional) Display the CPUs that are associated with the link.**

   ```
   # dladm show-linkprop -p cpus link
   ```

Example 76 Allocating CPUs to a Datalink

This example shows how to dedicate specific CPUs to the datalink `net0`.

```
# dladm show-linkprop -p cpus net0
LINK     PROPERTY     PERM    VALUE        EFFECTIVE    DEFAULT   POSSIBLE
net0     cpus         rw      --           0-2          --        --
```

The output shows that the system has implicitly assigned three CPUs (`0-2`) to the datalink `net0`. However, the CPUs are not exclusively allocated to the datalink `net0`.

```
# dladm set-linkprop -p cpus=0,1 net0
# dladm show-linkprop -p cpus net0
LINK     PROPERTY     PERM    VALUE        EFFECTIVE    DEFAULT   POSSIBLE
net0     cpus         rw      0-1          0-1          --        --
```

The output shows that you have explicitly assigned two CPUs (`0-1`) to the datalink `net0`. The allocated CPUs will process packets for the datalink `net0`.

Using the Large Receive Offload Feature in Oracle Solaris

In Oracle Solaris, you can use the large receive offload (LRO) feature to merge successive incoming packets into a single packet before the packets are delivered to the IP layer. The incoming packets must share the same transport protocol, local or remote IP address, and port number. This set of attributes are also known as five-tuple. If most of the packets share the same five-tuple, the packet processing overhead in the IP layer and the layers above it reduces improving network throughput. Typically, the TCP links under heavy load contain packets that share the same five-tuple.

Benefits Of Using the LRO Feature

In Oracle Solaris, the merging of the packets is implemented in the MAC layer. The NIC delivers the packets to the networking stack and the MAC layer merges the successive incoming packets that share the same five-tuple information.

The LRO feature in Oracle Solaris provides the following benefits:

- Significantly improves the system's receive-side TCP performance. This improvement is higher in the kernel zone environment.
- Allows you to enable LRO on a physical NIC that does support the LRO feature.
- Allows you to selectively enable or disable LRO for each datalink in the host that includes a physical NIC, VNIC or anet resource, and PV NIC or SR-IOV VF within the Oracle Solaris Kernel Zone.

Enabling LRO for Datalinks

You can administer the LRO feature on both physical NICs and VNICs. You can use the `lro` property to enable or disable the LRO feature on a per-VNIC-basis. By default, the VNIC `lro` property is inherited from the underlying datalink. Because the default value for the `lro` link property of a physical NIC is `off`, the `lro` property that is inherited by the VNICs from the physical NIC is disabled by default.

You can enable LRO on a datalink in the following ways:

- When you enable the `lro` link property on a physical NIC, LRO is enabled for the primary MAC client of the NIC. If the `lro` property is set to `auto` for other MAC clients such as VNICs configured on the NIC, the effective value of the `lro` property for the MAC clients is inherited from the NIC.
- When you enable the `lro` link property on a MAC client such as a VNIC, the `lro` property is enabled for only the VNIC.

Similarly, you can disable LRO on a datalink by using the `lro` link property.

You can enable or disable the `lro` link property on any network device such as a VNIC, a physical NIC, a SR-IOV VF, a link aggregation, or a para-virtualized (PV) NIC in a guest domain. You can enable or disable LRO for a network device by setting the `lro` property. You use the following command syntax to set the `lro` property for a datalink:

```
# dladm set-linkprop -p lro=value link
```

For a VNIC, you can specify the following values for the `lro` property:

`on`	Enables LRO for the VNIC MAC client.
`off`	Disables LRO for the VNIC MAC client.

`auto`	Inherits the effective value of the lower datalink and enables merging of the packets if LRO is effective on the lower datalink. This value is the default value.

For a physical NIC, you can specify the following values for the `lro` property:

`on`	Enables LRO for the primary MAC client of the NIC. The other MAC clients of the NIC inherit the state of the `lro` property if the value of the MAC client's `lro` property is `auto`.
`off`	Disables LRO for the primary MAC client of the NIC. The other MAC clients of the NIC inherit the state of the `lro` property if the value of the MAC client's `lro` property is `auto`.
`auto`	Default value of the `lro` property. When you set the `lro` property to `auto`, the effective value of the `lro` property is `off`.

For a PV NIC, you can specify the following values for the `lro` property:

`on`	Enables LRO for the primary MAC client of the PV NIC.
`off`	Disables LRO for the primary MAC client of the PV NIC.
`auto`	Inherits the effective value of the lower shadow VNIC and enables merging of packets on the shadow VNIC if LRO is enabled.

Note - The SR-IOV VF in a guest domain is considered to be like a physical NIC. When you set the `lro` property to `auto`, the effective value of the property is `off`.

EXAMPLE 77 Enabling LRO for a Physical NIC

The following example shows how to enable LRO for the physical NIC `net0` and check the status of the `lro` property.

```
# dladm set-linkprop -p lro=on net0
# dladm show-linkprop -p lro net0
LINK     PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT   POSSIBLE
net0     lro             rw   on           on           auto      on,off,auto
```

EXAMPLE 78 Enabling LRO for PV NICs and `anet` Resources

The following example shows how to enable LRO for the PV NIC `net0`.

```
# dladm set-linkprop -t -p lro=on net0
```

The following example shows the LRO status of a PV VNIC for a kernel zone after the value for the `lro` property is set to `on`.

```
# dladm show-linkprop -p lro zone1/net0
LINK            PROPERTY        PERM    VALUE   EFFECTIVE       DEFAULT POSSIBLE
zone1/net0      lro             rw      on      on              auto    on, off, auto
```

The following example shows the default LRO status of a PV VNIC for a kernel zone if the effective value is `on` for the `lro` property of the lower shadow VNIC.

```
# dladm show-linkprop -p lro zone1/net0
LINK            PROPERTY        PERM    VALUE   EFFECTIVE       DEFAULT POSSIBLE
zone1/net0      lro             rw      auto    on              auto    on, off, auto
```

The following example shows how to enable LRO for the `anet` resource `z1/net0` of the native zone `z1`.

```
# dladm set-linkprop -t -p lro=on z1/net0
```

LRO Support for Link Aggregations

The LRO feature is supported for link aggregations. For information about link aggregations, see Chapter 2, "Configuring High Availability by Using Link Aggregations" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Use the following command syntax to set the `lro` property for a link aggregation:

```
# dladm set-linkprop -p lro=value aggr
```

For a link aggregation, you can specify the following values for the `lro` property:

`on`	Enables LRO for the primary MAC client of the link aggregation.
`off`	Disables LRO for the primary MAC client of the link aggregation.
`auto`	Default value of the `lro` property. When you set the `lro` property to `auto`, the effective value of the `lro` property is `off`.

Note - The default setting on the link aggregation disables LRO on the aggregated datalinks even though LRO is enabled. To enable LRO on the aggregated datalinks, you need to explicitly set the `lro` property to `on`.

LRO Support for Zones

You can configure the `lro` link property for the `anet` resource of a kernel zone by setting the `lro` property by using the `zonecfg` command.

For the `anet` resource of a native zone, you can set the `lro` property by using the `dladm` command. See Example 78, "Enabling LRO for PV NICs and `anet` Resources," on page 217.

EXAMPLE 79 Enabling LRO for a Kernel Zone

This example shows how to enable LRO for the `anet` resource of the kernel zone `kzone1`.

```
# zonecfg -z kzone1
zonecfg:kzone1> select anet id=1
zonecfg:kzone1:anet> set lro=on
```

To show the status of the `lro` property for the `anet` resource `kzone1/net1` of the kernel zone `kzone1`:

```
# dladm show-linkprop -p lro kzone1/net1
LINK        PROPERTY        PERM VALUE        EFFECTIVE    DEFAULT    POSSIBLE
kzone1/net1 lro             rw   on           on           auto       on,off,auto
```

Managing Network Resources by Using Flows

A flow is a customized way of categorizing network packets based on a single attribute or a combination of attributes. Flows enable you to further allocate network resources. For an overview of flows, see "Network Resource Management by Using Flows" on page 24.

Using flows for managing network resources involves the following steps:

1. Creating the flow.

   A flow is created based on a single attribute or a combination of attributes that are derived from the information in a packet's header. You can use any combination of attributes to organize the packet traffic into a flow. You can use attributes such as the IP address, transport protocol, and DS field. Starting with Oracle Solaris 11.3, you can create flows that have different combination of attributes on a datalink.
2. Customizing the flow's use of resources by setting properties that pertain to network resources. Currently, bandwidth, priority, and rank properties can be associated with flows.

For more information, see "Configuring Flows" on page 220.

Commands for Resource Allocation in Flows

The commands used for allocating network resources in flows are as follows:

- To simultaneously create a flow and add resources to it, use the following command syntax:

  ```
  # flowadm add-flow -l link -a attribute=value[,attribute=value] -p prop=value[,...] flow
  ```

  The set of defined attributes that characterizes the flows constitutes the system's *flow control policy*. For the list of different attributes that you can use to organize packet traffic into a flow, see "Managing Network Resources by Using Flows" on page 219.
- To set the property of an existing flow, use the following command syntax:

  ```
  # flowadm set-flowprop -p prop=value[,...] flow
  ```

  Where *prop* refers to the flow properties that can be assigned to a flow. The flow properties are the same as the properties that are assigned directly to a link. However, only the bandwidth and priority properties can be associated with flows. To configure these properties, see "How to Configure Flows" on page 220.

For more information, see the `flowadm`(1M) man page.

Configuring Flows

This section describes how to configure flows that involves how to create flows and set flow properties to implement resource control.

▼ How to Configure Flows

1. **Become an administrator.**
   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **(Optional) List the available links to determine the link on which you will configure flows.**

   ```
   # dladm show-link
   ```

3. **Verify that IP interfaces over the selected link are properly configured with IP addresses.**

   ```
   # ipadm show-addr
   ```

4. **Create flows according to the attribute you have determined for each flow.**

   ```
   # flowadm add-flow -l link -a attribute=value[,attribute=value] flow
   ```

link	Refers to the link on which you are configuring the flow.
attribute	A single attribute or combination of attributes that organizes network packets into a flow. The direction attribute for a flow enables the classification of packets and implementing properties for flows on inbound or outbound packets. The `direction` attribute supports the values `in` for inbound only, `out` for outbound only, and `bi` for bidirectional. The default value for this attribute is `bi`. See Example 80, "Creating a Flow With the `direction` Attribute," on page 222.
flow	Refers to the name that you assign to the flow.

   For more information about flows and flow attributes, see the `flowadm`(1M) man page.

5. **(Optional) Display the possible range of values for the link's bandwidth.**

   ```
   # dladm show-linkprop -p maxbw link
   ```

link	Refers to the datalink on which the flow is configured.

   The range of values is listed under the `POSSIBLE` field of the command's output.

6. **Implement resource controls on the flows by setting the appropriate flow properties.**

   ```
   # flowadm set-flowprop -p prop=value[,...] flow
   ```

   For information about the properties that you can set for flows, see "Setting Properties for Flows" on page 223.

7. **(Optional) Display the flows that you have created over the datalink.**

   ```
   # flowadm
   ```

   Note - The `flowadm` command, if used without any subcommand, provides the same information as the `flowadm show-flow` command.

8. **(Optional) Display the property values for a specified flow.**

   ```
   # flowadm show-flowprop flow
   ```

This command displays `maxbw` and `priority` flow properties, plus the read-only `hwflow` property.

`hwflow`	A read-only property that helps you to understand the packet classification in flows. The possible values of this property are `on` and `off`. The value of `on` means that the flow has been offloaded to the NIC and packet classification for the flow is conducted at the hardware level. This property cannot be used with `-p` option in `flowadm add-flow`, `flowadm set-flowprop`, or `flowadm reset-flowprop` commands.

Note - Currently, only the flows that are defined by specifying all the transport protocols, local or remote IP address, and local or remote port can be assigned the `on` value for `hwflow`. Also, not all NICs support the `hwflow` property.

For an example about configuring flows and setting flow properties, see "Use Case: Managing Network Resources by Setting Datalink and Flow Properties" on page 225.

Example 80 Creating a Flow With the `direction` Attribute

The following example shows how to create the flows `http-in` and `http-out` by specifying the `direction` attribute.

```
# flowadm add-flow -l net4 -a transport=tcp,local_port=80,direction=in http-in
# flowadm add-flow -l net4 -a transport=tcp,local_port=80,direction=out http-out
# flowadm
FLOW        LINK     PROTO LADDR             LPORT RADDR             RPORT DIR
http-out    net4     tcp   --                80    --                --    out
http-in     net4     tcp   --                80    --                --    in
# flowadm show-flow -o flow,link,dir
FLOW        LINK     DIR
http-out    net4     out
http-in     net4     in
```

The `direction` value of `bi` is incompatible with the values `in` or `out`. If you try create a flow with the same attributes, the flow creation fails.

```
# flowadm add-flow -l net4 -a transport=tcp,local_port=80 http-flow
flowadm: add flow failed: a flow with identical attributes but with
incompatible direction exists
```

You can create a flow with a different attribute and it will succeed.

```
# flowadm add-flow -l net4 -a transport=tcp,local_port=443 ssl-flow
# flowadm
```

```
FLOW        LINK      PROTO  LADDR                  LPORT  RADDR                  RPORT  DIR
http-out    net4      tcp    --                     80     --                     --     out
http-in     net4      tcp    --                     80     --                     --     in
ssl-flow    net4      tcp    --                     443    --                     --     bi
```

Setting Properties for Flows

You can implement resource controls over flows by setting flow properties. The following properties are supported by flows:

- `maxbw` - The maximum amount of the link's bandwidth that packets identified with the flow can use. The value you set must be within the allowed range of values for the link's bandwidth. See Example 81, "Setting Maximum Bandwidth and Priority for a Flow," on page 223.
- `priority` - The priority with which packets belonging to the specified flow will be processed. The allowed values for the `priority` property are `high`, `medium`, and `low`. If the priority of a flow is set to `high`, all the packets belonging to that flow will be processed ahead of other packets on the same link. This property is used to create a flow for applications that are latency sensitive. The default value of this property is `medium`. See Example 81, "Setting Maximum Bandwidth and Priority for a Flow," on page 223.

  Note - Currently, setting the `priority` property to `low` from `medium` has no effect.

- `rank` - The rank for a flow. The considerations for setting the `rank` property are:
  - You do not have to set the `rank` property on all the flows. A flow with the `rank` property specified is always higher in the lookup order than a flow with no rank specified.
  - You can set values for the `rank` property from `1` to `65535`. A flow with a low rank value is higher in the lookup order than a flow with a high rank value.
  - You can have two flows with the same rank value. In this case, the tie is broken by following the default system policy.

  For more information about the `rank` property, see "Overlapping Flows" on page 224.

EXAMPLE 81 Setting Maximum Bandwidth and Priority for a Flow

This example shows how to set the maximum bandwidth to `2G` and a `high` priority for the flow `http`.

```
# flowadm set-flowprop -p maxbw=2G http
# flowadm set-flowprop -p priority=high http
```

Overlapping Flows

When multiple flows are configured on a datalink with different attributes, the flows might overlap. In this case, you can use the `flowadm show-flow` command to display a list of flows on a datalink based on a default ranking order. That is, the first flow in the output is searched first for a given packet and then the next flow is searched. You can change the ranking order of a flow by using the `rank` property.

For example, say you have created the flow `solaris` to limit the traffic from a remote IP address as follows.

```
# flowadm add-flow -l net4 -a remote_ip=192.0.2.3 solaris
# flowadm set-flowprop -p maxbw=10K solaris
```

If you want a packet from the IP address `192.0.2.0` to port 80 to match `solaris` instead of the `http` flow, you can set a high rank for the `solaris` flow as follows:

```
# flowadm set-flowprop -p rank=1 solaris
# flowadm show-flowprop -p rank solaris
FLOW         PROPERTY        PERM VALUE          DEFAULT        POSSIBLE
solaris      rank            rw    1             --             1-65535
```

You can use the `flowadm match-flow` command to check whether a flow that you want to create overlaps with other existing flows. If there are overlapping flows, you need to check the ranking order. Also, if you have a policy in place to disallow the creation of overlapping flows, you need to check before adding a flow. The command syntax is:

```
# flowadm match-flow [-P] [[-p] -o  field[,...]] [-l link] -a attr=value[,...]
```

`-l` *link*	Limits the match to flows on the specified link. If you do not specify a link, flows on all the links are used.
`-a` *attr*=*value*`[,...]`	A comma-separated list of attributes that are used as the key for the lookup for a matching flow or flows.

EXAMPLE 82 Checking the Overlapping Flows

This example shows how to check whether an added flow overlaps with other flows.

The following example displays a flow configured on a system.

```
# flowadm
FLOW        LINK     PROTO LADDR             LPORT RADDR             RPORT DIR
http        net4     tcp   --                80    --                --    bi
```

When you want to add a another flow `backup` with the remote IP address `203.0.113.117` on the datalink `net4`, you can check whether the `backup` flow overlaps with other flows as follows.

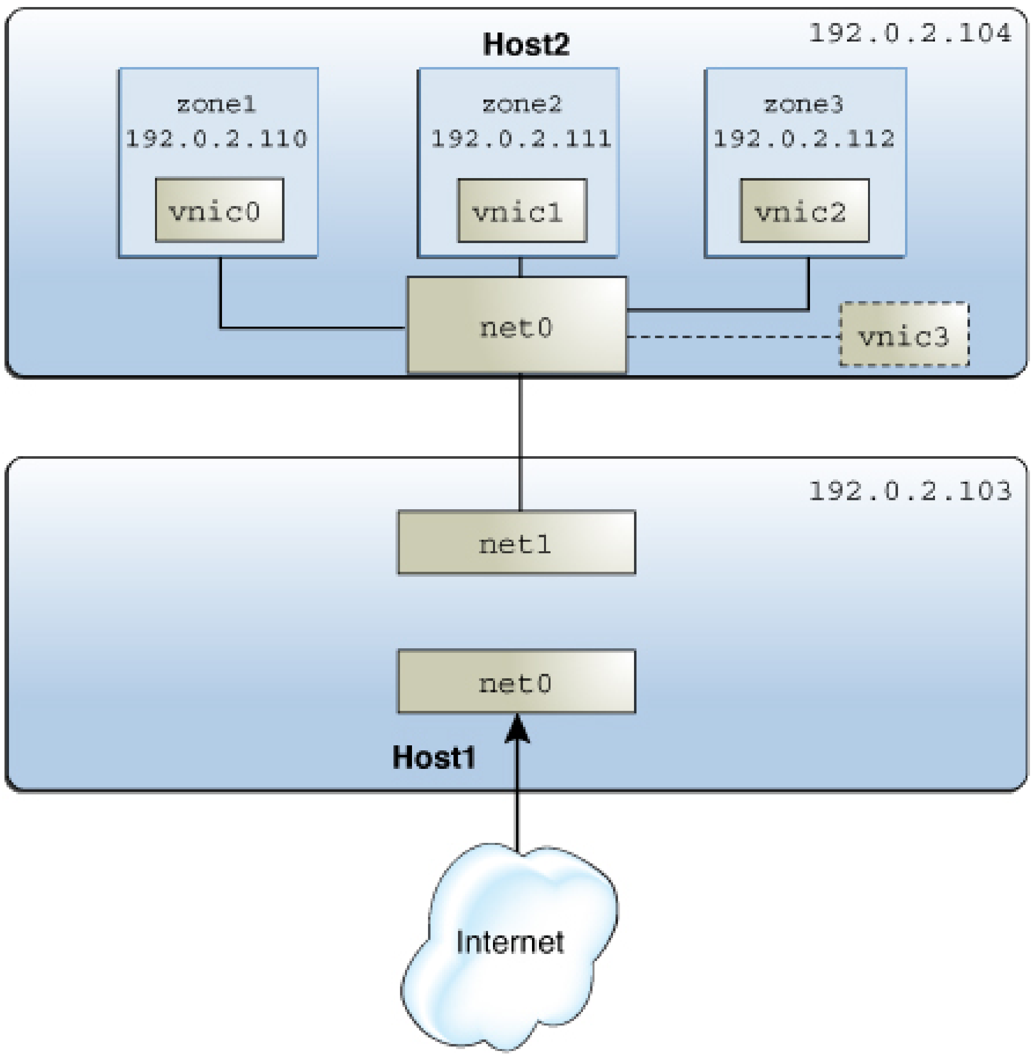
```
# flowadm match-flow -l net4 -a remote_ip=192.0.2.4
FLOW        LINK     PROTO LADDR             LPORT RADDR             RPORT DIR
http        net4     tcp   --                80    --                --    bi
```

The output shows that the flows `http` and `backup` can overlap for certain packets.

Use Case: Managing Network Resources by Setting Datalink and Flow Properties

The following use case is based on a scenario in which you increase a system's efficiency by setting both datalink and flow properties. This use case is based on the configuration shown in the following figure.

FIGURE 24 System Configuration for Managing Resources on Datalinks and Flows



The figure shows the following two physical hosts that are connected to each other:

- `Host1` has the following configuration:

- One non-global zone that functions as a server and router. Two interfaces are assigned to the zone: the `net0` interface connects to the Internet and the `net1` interface connects to the internal network including the `Host2`.
- Flows are configured over `net1` to isolate the traffic and implement control over how packets belonging to the flows use resources. For information about configuring flows, see "Managing Network Resources by Using Flows" on page 219.

■ `Host2` has the following configuration:

- Three non-global zones and their respective VNICs. The VNICs are configured over `net0`, whose NIC card supports ring allocation. For more information about ring allocation, see "Managing NIC Rings" on page 200.
- Each zone's network processing load is different. In this example, `zone1` functions as the HTTP client. The remaining zones, `zone2` and `zone3`, function as the SSH client that tries to access `Host1` through secure shell (SSH) protocol. The network traffic for `zone1` is higher than `zone2` and `zone3` and is not time sensitive. However, the network traffic for `zone2` and `zone3` is low and time sensitive. Therefore, to process the network traffic faster for `zone2` and `zone3`, you need to limit the bandwidth allocated to the network traffic for `zone1`. If the bandwidth allocated for `zone1` is not limited, it will use all the available bandwidth. This leads to the denial of bandwidth to the remaining zones: `zone2` and `zone3`.
- A separate VNIC is configured as a software-based client. For an overview of MAC clients, see "Allocating Rings in MAC Clients" on page 201.

The tasks in this use case involve the following actions:

- Creating a flow and configuring flow control – Flows are created over `net1` to create a separate resource control over packets belonging to the flows that are received by `net1` of `Host1`.
- Configuring network resource properties for the VNICs on `Host2` – Based on the processing load, each zone's VNIC is configured with a set of dedicated rings. A separate VNIC is also configured without dedicated rings as an example of a software-based client.

Note - The use case does not include any procedures for zone configuration. To configure zones, see Chapter 1, "How to Plan and Configure Non-Global Zones" in *Creating and Using Oracle Solaris Zones*.

---

1. View information about links and IP interfaces on `Host1`.

```
# ipadm
NAME              CLASS/TYPE       STATE        UNDER      ADDR
lo0               loopback    ok           --         --
```

```
   lo0/v4         static     ok           --         127.0.0.1/8
   lo0/v6         static     ok           --         ::1/128
net1              ip         ok           --         --
   net1/v4        static     ok           --         192.0.2.103/24
net0              ip         ok           --         --
   net0/v4        static     ok           --         203.0.113.129/24
```

2. Create the following flows over `net1` on `Host1`:
   - `httpflow` – Contains all the HTTP traffic between `zone1` and `net1`.

     ```
     # flowadm add-flow -l net1 -a transport=tcp,local_ip=192.0.2.103,\
     local_port=80,remote_ip=192.0.2.110 httpflow
     ```

   - `sshflow` – Contains all the SSH traffic coming in to and going out of `net1`.

     ```
     # flowadm add-flow -l net1 -a transport=tcp,local_ip=192.0.2.103,\
     local_port=22 sshflow
     ```

3. Implement resource control on the flows.
   - For `httpflow`, set the maximum bandwidth to `500M`.

     ```
     # flowadm set-flowprop -p maxbw=500M httpflow
     ```

   - For `sshflow`, set the priority to `high`.

     ```
     # flowadm set-flowprop -p priority=high sshflow
     ```

4. Verify the information about the created flows.

   ```
   # flowadm
   FLOW        LINK     PROTO LADDR            LPORT  RADDR             RPORT DSFLD
   httpflow    net1     tcp   192.0.2.103   80     192.0.2.110   --    --
   sshflow     net1     tcp   192.0.2.103   22     --                 --    --

   # flowadm show-flowprop
   FLOW         PROPERTY        PERM    VALUE        DEFAULT       POSSIBLE
   httpflow     maxbw           rw      500          --            --
   httpflow     priority        rw      medium       medium        low,medium,high
   httpflow     hwflow          r-      off          --            on,off
   sshflow      maxbw           rw      --           --            --
   sshflow      priority        rw      high         medium        low,medium,high
   sshflow      hwflow          r-      off          --            on,off
   ```

   For more information about the output, see the `flowadm`(1M) man page.

5. On `Host2`, configure VNICs over `net0` for each zone.

   ```
   # dladm create-vnic -l net0 vnic0
   # dladm create-vnic -l net0 vnic1
   ```

```
# dladm create-vnic -l net0 vnic2
```

6. Implement resource controls on each VNIC.

   ```
   # dladm set-linkprop -p rxrings=4,txrings=4 vnic0
   # dladm set-linkprop -p rxrings=2,txrings=2 vnic1
   # dladm set-linkprop -p rxrings=1,txrings=1 vnic2
   ```

7. Assign the VNICs to their respective zones.

   ```
   # zonecfg -z zone1
   # zonecfg:zone1> add net
   # zonecfg:zone1:net> set physical=vnic0
   # zonecfg:zone1:net> end
   # zonecfg:zone1> commit
   # zonecfg:zone1> exit
   # zoneadm -z zone1 reboot

   # zonecfg -z zone2
   # zonecfg:zone2> add net
   # zonecfg:zone2:net> set physical=vnic1
   # zonecfg:zone2:net> end
   # zonecfg:zone2> commit
   # zonecfg:zone2> exit
   # zoneadm -z zone2 reboot

   # zonecfg -z zone3
   # zonecfg:zone3> add net
   # zonecfg:zone3:net> set physical=vnic2
   # zonecfg:zone3:net> end
   # zonecfg:zone3> commit
   # zonecfg:zone3> exit
   # zoneadm -z zone3 reboot
   ```

8. Create a software-based client that shares rings with the primary interface `net0`.

   ```
   # dladm create-vnic -p rxrings=sw,txrings=sw -l net0 vnic3
   ```

9. Assume `pool1`, a set of CPUs in `Host2`, is assigned to `zone1`. Assign the same `pool1` of CPUs to also manage network processes for `zone1`.

   ```
   # dladm set-linkprop -p pool=pool1 vnic0
   ```

♦ ♦ ♦ CHAPTER 8

Monitoring Network Traffic and Resource Usage

This chapter describes tasks for monitoring network statistics about the use of network resources on datalinks and flows. You configure network accounting on a system to record network traffic statistics in a log file. This statistical information can help you analyze resource allocation for provisioning, consolidation, and billing purposes. This chapter introduces the two commands that you can use to display network traffic statistics: `dlstat` and `flowstat`.

This chapter contains the following topics:

For more information about the observing network traffic usage on various layers of the network protocol stack, see Chapter 2, "Using Observability Tools to Monitor Network Traffic Usage" in *Troubleshooting Network Administration Issues in Oracle Solaris 11.3*.

Overview of Monitoring Network Traffic Statistics of Datalinks and Flows

Packets traverse a path when they flow into or out of a system. On a granular level, packets are received and transmitted through receive (Rx) rings and transmit (Tx) rings of a NIC. Inbound packets from these rings are passed up the network stack for further processing while outbound packets are sent to the network.

You can combine and allocate system resources to manage the network traffic. You can monitor the receive-side and transmit-side network traffic statistics for both datalinks and flows. This chapter focuses primarily on receive-side network traffic statistics on datalinks and flows.

You can configure receive rings, transmit rings, and other resources on datalinks by setting datalink properties. Depending on the network traffic on a datalink, you can assign dedicated hardware rings to a datalink to increase the system's efficiency to process packets. For example, you can allocate more rings to a datalink, where the network traffic is most heavy. For more information about how to allocate hardware rings to a datalink, see "Configuring Clients and Allocating Rings" on page 204.

A datalink might not have dedicated hardware rings because of the following reasons:

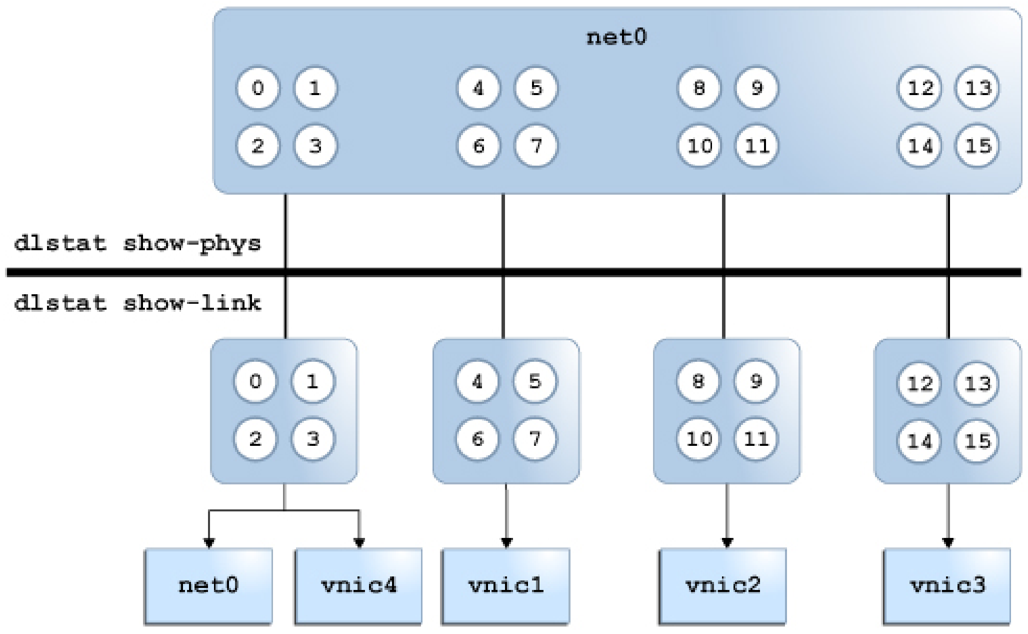
- Lack of hardware resources. For example, there might not be rings available that can be exclusively assigned to datalinks.
- Lack of hardware capabilities. For example, the NIC does not expose hardware rings.
- The datalink might not be tied to a lower hardware datalink. For example, when you create VNICs over etherstubs.

Some datalinks might be configured to share rings for the following reasons:

- The datalink might not be performing intensive processes that require dedicated rings.
- The NIC might not support ring allocation.
- The rings are no longer available to be assigned for exclusive use although the datalink supports ring allocation.

The following figure shows the allocation of hardware rings among datalinks.

FIGURE 25 Ring Allocation in Datalinks



The figure shows the following configuration:

- The `net0` datalink has 16 hardware rings (`0-15`) that can be allocated to other datalinks.
- The VNICs `vnic1`, `vnic2`, `vnic3`, and `vnic4` are configured over the datalink `net0`.
- The VNICs `vnic1`, `vnic2`, and `vnic3` are each assigned four dedicated hardware rings.
- The hardware rings (`0-3`) are shared between the datalink `net0` and the VNIC `vnic4`. The following example shows the ring allocation for the physical datalink `net0`.

```
# dladm show-phys -H net0
LINK         RINGTYPE  RINGS                 CLIENTS
net0         RX        0-3                   <default,mcast>,vnic4
net0         RX        4-7                   vnic1
net0         RX        8-11                  vnic2
net0         RX        12-15                 vnic3
net0         TX        0-7                   <default>,vnic4,vnic3,vnic2,vnic1
```

- You use the `dlstat show-phys` command to display the network traffic statistics for the physical datalink `net0`. See Example 83, "Displaying Traffic Statistics for Physical Links on the System," on page 236.
- You use the `dlstat show-link` command to display the network traffic statistics for the datalinks `net0`, `vnic1`, `vnic2`, `vnic3`, and `vnic4`. See Example 90, "Displaying Network Traffic Statistics for a Datalink With Dedicated Hardware Rings," on page 239.

Commands for Monitoring Network Traffic Statistics

The `dlstat` and `flowstat` commands enable you to monitor network traffic statistics on datalinks and flows, respectively. These commands are equivalent to the `dladm` and `flowadm` commands. The following table compares the functions of the pair of administrative commands to the pair of monitoring commands.

Administrative Commands		**Monitoring Commands**	
Command	**Function**	**Command**	**Function**
`dladm`	Configures and administers datalinks	`dlstat`	Displays traffic statistics on datalinks
`flowadm`	Configures and administers flows	`flowstat`	Displays traffic statistics on flows

Displaying Network Traffic Statistics of Links

You can use the following variants of the `dlstat` command to display network traffic information.

Command	**Information Provided**

`dlstat [`*link*`]`
`dlstat -rt [`*link*`]`
`dlstat show-link [`*link*`]`
	Displays inbound and outbound traffic statistics per datalink

`dlstat show-link -rt [`*link*`]`	Displays inbound and outbound traffic statistics per ring per datalink
`dlstat show-phys [`*link*`]`	Displays inbound and outbound traffic statistics per network physical device

Command	Information Provided
`dlstat show-phys -rt` [*link*]	Displays inbound and outbound traffic statistics per ring per network physical device
`dlstat show-aggr` [*link*] `dlstat show-aggr -rt` [*link*]	Displays inbound and outbound traffic statistics per port per aggregation
`dlstat show-bridge` [*bridge*] `dlstat show-bridge -rt [`*bridge*`]`	Displays inbound and outbound traffic statistics per bridge
`dlstat show-cap` [*link*]	Displays statistics for packets that are logged by a firewall

You can use the `-r` option to display receive-side statistics information or the `-t` option to display the transmit-side statistics information with the `dlstat` command. For more information about other options, see the `dlstat`(1M) man page.

Displaying Network Traffic Statistics of Network Devices

The `dlstat show-phys` command provides statistics that refer to the physical network device. As shown in Figure 25, "Ring Allocation in Datalinks," on page 233, the `dlstat show-phys` command operates on the hardware rings which are on the device layer of the network stack.

You can use the following command syntax to display the network traffic statistics on network devices:

```
# dlstat show-phys [-r|-t] [-Tu | -Td] [-o idrops[,idropbytes][,odrops][,odropbytes]] \
 [link] [interval [count]]
```

`-r` Displays receive-side network traffic statistics only. You should not specify the `-t` option with this option.

If you do not specify the `-r` option or the `-t` option, both the transmit-side and receive-side network statistics are displayed.

`-t` Displays transmit-side network traffic statistics only. You should not specify the `-r` option with this option.

If you do not specify the `-r` or the `-t` option, both the transmit-side and receive-side network statistics are displayed.

`-Tu` Displays the current time in internal representation.

`-Td`	Displays the current time in standard date format.
`-o idrops[, idropbytes] [,odrops][, odropbytes]]`	Displays the input and output packet drops per physical datalink. In addition to the number of input and output packet drops, this option displays the number of bytes of the drops.
link	Name of the datalink whose network statistics you want to monitor. If you do not specify the datalink, then the information about all the configured datalinks on the system are displayed.
interval	Specifies the time in seconds at which you want to refresh the network statistics.
count	Specifies the number of times you want the displayed network traffic statistics to be refreshed. If you do not specify the count value, the statistics are refreshed indefinitely.

EXAMPLE 83 Displaying Traffic Statistics for Physical Links on the System

In this example, both incoming and outgoing network traffic on each link on the system is displayed. The number of packets and their byte sizes are displayed.

```
# dlstat show-phys
LINK    IPKTS   RBYTES     OPKTS    OBYTES
net5        0        0         0         0
net6        0        0         0         0
net0   25.57K    5.10M     1.93K   226.05K
net0      179   26.63K       161    22.75K
net3        0        0         0         0
net4        0        0         0         0
net2        0        0         0         0
net8      238  137.16K       191     8.41K
net1        0        0         0         0
...
```

The output shows the following information:

`LINK`	Physical or virtual datalink, identified by a name
`IPKTS`	Number of inbound packets on the link
`RBYTES`	Number of bytes received on the link
`OPKTS`	Number of outbound packets on the link

OBYTES	Number of bytes sent on this link

EXAMPLE 84 Displaying Receive-Side Traffic Statistics for Network Devices

In this example, network traffic statistics that are being received are displayed with an interval value of 2 seconds and the count value of 3.

```
# dlstat show-phys -r 2 3
LINK  TYPE  INDEX    IPKTS   RBYTES
net0    rx      0    8.03M   12.09G
net1    rx      0        0        0
net0    rx      0    8.79K   13.28M
net1    rx      0        0        0
net0    rx      0    8.50K   12.83M
net1    rx      0        0        0
```

Consider the datalinks, net0 and net1 as a set. The first set of datalinks, net0 and net1, show the total number of packets and bytes received. In this example, 8.03M is the total number of packets received and 12.09G is the total number of bytes received by net0. The second set of datalinks, net0 and net1, show the network traffic statistics in rates per second, also known as the normalized value. That is, 8.79K is the normalized value of the packets received by net0 in the interval of 2 seconds. Similarly, the third set of datalinks, net0 and net1, also show the normalized value for the network traffic statistics in the interval of 2 seconds.

EXAMPLE 85 Displaying Receive-Side Traffic Statistics for a Network Device

In this example, the incoming traffic statistics for the datalink net0 are displayed.

```
# dlstat show-phys -r net0
LINK     TYPE     ID    INDEX    IPKTS     RBYTES
net0       rx   local      --        0          0
net0       rx      hw       1        0          0
net0       rx      hw       2    1.73M      2.61G
net0       rx      hw       3        0          0
net0       rx      hw       4    8.44M     12.71G
net0       rx      hw       5    5.68M      8.56G
net0       rx      hw       6    4.99M      7.38G
net0       rx      hw       7        0          0
```

In this example, the net0 datalink has eight receive rings, which are identified under the INDEX field. An even distribution of packets per ring is an ideal configuration that indicates that the rings are properly allocated to links according to the link's load. An uneven distribution indicates a disproportionate distribution of rings per link. The resolution of the uneven distribution depends on whether the NIC supports dynamic ring allocation. If it does, you can redistribute rings per link to process packets more evenly. For more information, see "Managing NIC Rings" on page 200.

EXAMPLE 86 Displaying Transmit-Side Traffic Statistics for a Network Device

In this example, the usage of the transmit rings for `net0` as a network device is displayed.

```
# dlstat show-phys -t net0
LINK  TYPE  INDEX    OPKTS   OBYTES
net0    tx      0       93    4.63K
net0    tx      1        0        0
net0    tx      2        0        0
net0    tx      3        0        0
net0    tx      4        0        0
net0    tx      5       47   11.02K
net0    tx      6       23    7.13K
net0    tx      7        0        0
```

EXAMPLE 87 Displaying Traffic Statistics for a Network Device With Time

The following example displays statistics about network traffic for `net0` as a network device with internal representation of the current time.

```
# dlstat show-phys -Tu net0
1401652481
           LINK    IPKTS   RBYTES    OPKTS   OBYTES
           net0      184   27.14K      165   22.91K
```

The following example displays statistics about network traffic for `net0` as a network device with the current time in standard date format.

```
# dlstat show-phys -Td net0
Sun Jun  1 12:54:47 PDT 2014
           LINK    IPKTS   RBYTES    OPKTS   OBYTES
           net0      184   27.14K      165   22.91K
```

EXAMPLE 88 Displaying Input and Output Packet Drops

The following example displays the input and output packet drop statistics for the datalink `net0`.

```
# dlstat show-phys net0 -o idrops,idropbytes,odrops,odropbytes
  IDROPS IDROPBYTES   ODROPS ODROPBYTES
   399     42.52K        0       0
```

Displaying Network Traffic Statistics of Datalinks

You can use the `dlstat show-link` command to display the network traffic statistics for a datalink.

EXAMPLE 89 Displaying Network Traffic Statistics for a Datalink

This example shows the network traffic statistics for the datalink `vnic0`.

```
# dlstat show-link vnic0
LINK    IPKTS   RBYTES    OPKTS   OBYTES
vnic0   3       180       0       0
```

EXAMPLE 90 Displaying Network Traffic Statistics for a Datalink With Dedicated Hardware Rings

This example shows the receive-side network traffic statistics for the datalink `vnic0` that has four dedicated Rx rings. The `hw` value under the `ID` column in the output indicates that the datalink `vnic0` has dedicated hardware rings.

```
# dlstat show-link -r vnic0
LINK   TYPE      ID  INDEX    IPKTS   RBYTES    INTRS    POLLS   IDROPS
vnic0    rx   local     --        0        0        0        0        0
vnic0    rx   other     --       64    2.94K        0        0        0
vnic0    rx      hw      8        0        0        0        0        0
vnic0    rx      hw      9       53    7.97K       53        0        0
vnic0    rx      hw     10        4      392        4        0        0
vnic0    rx      hw     11  153.65K  220.68M  153.65K        0        0
```

EXAMPLE 91 Displaying Transmit-Side Network Traffic Statistics for a Datalink

This example shows the transmit-side network traffic statistics for the datalink `vnic0`.

```
# dlstat show-link -t vnic0
LINK   TYPE      ID  INDEX    OPKTS   OBYTES   ODROPS
vnic0    tx   local     --        0        0        0
vnic0    tx   other     --       19      798        0
vnic0    tx      sw     --        0        0        0
```

EXAMPLE 92 Displaying Network Traffic Statistics for a Datalink Without Dedicated Hardware Rings

This example shows the network traffic statistics for the datalink `net6` that does not have dedicated Rx rings. The `sw` value under the `ID` column in the output indicates that the datalink `net6` is not configured with dedicated hardware rings.

```
# dlstat show-link -r net6
LINK  TYPE      ID  INDEX    IPKTS   RBYTES INTRS POLLS   IDROPS
net6    rx   local     --        0   0         0     0         0
net6    rx   other     --        0   0         0     0         0
net6    rx      sw     --        0   0         0     0         0
```

Displaying Network Traffic Statistics of Link Aggregations

The `dlstat show-aggr` command shows network packet statistics for each aggregation's ports when traffic traverses the aggregation on the system.

EXAMPLE 93 Displaying Network Traffic Statistics for Link Aggregations

```
# dlstat show-aggr
LINK      PORT    IPKTS   RBYTES    OPKTS   OBYTES
aggr0     --         13      832       13      780
aggr0     net0        0        0       13      780
aggr0     net3       13      832        0        0
```

In this example, the output indicates the configuration of a link aggregation `aggr0` with two underlying links, `net0` and `net3`. As network traffic is received or sent by the system through the aggregation, information about incoming and outgoing packets and their respective sizes is reported for every port. The ports are identified by the underlying links of the aggregation.

For information about link aggregations, see Chapter 2, "Configuring High Availability by Using Link Aggregations" in *Managing Network Datalinks in Oracle Solaris 11.3*.

Displaying Network Traffic Statistics of Bridges

The `dlstat show-bridge` command shows network statistics for each bridge and lists the statistics of the links connected to each bridge.

EXAMPLE 94 Displaying Network Traffic Statistics for Bridges

In this example, the network statistics for the bridges `rbblue0` and `stbred0` are displayed.

```
# dlstat show-bridge
BRIDGE        LINK     IPKTS    RBYTES     OPKTS    OBYTES     DROPS  FORWARDS
rbblue0         --     1.93K   587.29K     2.47K     3.30M         0         0
             simblue1     72     4.32K     2.12K     2.83M         0        --
             simblue2  1.86K   582.97K       348   474.04K         0        --
stbred0         --       975   976.69K     3.44K     1.13M         0        38
              simred3    347   472.54K     1.86K   583.03K         0        --
              simred4    628   504.15K     1.58K   551.51K         0        --
```

Displaying Network Traffic Statistics of Flows

Statistics on flows help you to evaluate packet traffic on all the defined flows on a system. To display the statistics on flows, use the `flowstat` command. For more information, see the `flowstat`(1M) man page.

Use the following command syntax to display network traffic statistics on flows:

```
# flowstat [-r|-t] [-l link] [-Tu | -Td] [flow] [interval [count]]
```

`-r` Displays receive-side network traffic statistics only. You should not specify the `-t` option with this option.

If you do not specify the `-r` option or `-t` option, both the transmit-side and receive-side network statistics are displayed.

`-t` Displays transmit-side network traffic statistics only. You should not the specify the `-r` option with this option.

If you do not specify the `-r` option or the `-t` option, both the transmit-side and receive-side network statistics are displayed.

`-l` *link* Name of the datalink whose network statistics you want to monitor. If you do not specify the datalink, then the information about all the configured flows on the system are displayed.

`-Tu` Displays the current time in internal representation.

`-Td` Displays the current time in standard date format.

flow	Name of the flow whose network statistics you want to monitor. If you do not specify the flow, then depending on the specified link, all the flow statistics are displayed.
interval	Specifies the time in seconds at which you want to refresh the network statistics. If you do not specify the interval value, then the total number of packets and bytes is displayed.
count	Specifies the number of times you want the displayed network traffic statistics to be refreshed. If you do not specify the count value, the statistics are refreshed indefinitely.

The following examples show different ways to display information about configured flows on the system.

EXAMPLE 95 Displaying Network Traffic Statistics for Flows

In this example, network traffic statistics for all the configured flows on the system are displayed with an interval value of `1` second and the count value of `2`.

```
# flowstat 1 2
FLOW     IPKTS   RBYTES   IDROPS    OPKTS   OBYTES   ODROPS
flow1    1.78M    2.68G      443  889.57K   58.72M        0
flow2        0        0        0        0        0        0
flow1    8.31K   12.51M      243    4.22K  280.45K        0
flow2        0        0        0        0        0        0
```

Consider the flows, `flow1` and `flow2`, as a set. The first set of flows, `flow1` and `flow2`, show the total number of network traffic statistics received and transmitted by the flows. In this example, `1.78M` is the total number of packets received by `flow1`. The second set of flows, `flow1` and `flow2`, show the network statistics in rates per second, also known as the normalized value. In this example, `8.31K` is the normalized value of the packets received by `flow1` in the interval of `1` second.

EXAMPLE 96 Displaying Transmit-Side Traffic Statistics for Flows

In this example, the network traffic statistics about outgoing traffic for all the configured flows on the system are displayed.

```
# flowstat -t
FLOW     OPKTS   OBYTES   ODROPS
flow1   24.37M    1.61G        0
flow2        0        0        0
```

EXAMPLE 97 Displaying Receive-Side Traffic Statistics for Flows on a Datalink

In this example, incoming network traffic for all the configured flows on the datalink `net0` are displayed with an interval value of `2` seconds and the count value of `5`.

```
# flowstat -r -l net0 2 5
FLOW     IPKTS   RBYTES   IDROPS
flow1    2.38M    3.59G   14.89K
flow2        0        0        0
flow1    8.24K   12.40M      180
flow2        0        0        0
flow1    8.94K   13.47M      206
flow2        0        0        0
flow1    7.43K   11.19M      161
flow2        0        0        0
flow1    8.38K   12.62M      213
flow2        0        0        0
```

Consider the flows, `flow1` and `flow2`, as a set. The first set of flows, `flow1` and `flow2`, show the total number of packets and bytes received by the flows. In this example, `2.38M` is the total number of packets received and `3.59G` is the total number of bytes received by `flow1`. The second set of flows, `flow1` and `flow2`, show the network statistics in rates per second, also known as the normalized value. In this example, `8.24K` is the normalized value of the packets received by `flow1` in the interval of `2` seconds. Similarly, the succeeding sets of flows also show the normalized value for the network traffics statistics in the periodic interval of `2` seconds.

EXAMPLE 98 Displaying Traffic Statistics for Flows With Time

The following example displays statistics about incoming traffic on all the flows that are created over the datalink `net0` with the internal representation of the current time.

```
# flowstat -r -l net0 -Tu
1364380279
          FLOW        IPKTS   RBYTES    IDROPS
          tcp-flow  183.11K  270.24M        0
          udp-flow        0        0        0
```

The following example displays statistics about incoming traffic on all the flows that are created over the datalink `net0` with the current time in standard date format.

```
# flowstat -r -l net0 -Td
Wednesday, March 27, 2013 04:01:011 PM IST
          FLOW        IPKTS   RBYTES    IDROPS
          tcp-flow  183.11K  270.24M        0
          udp-flow        0        0        0
```

About Network Accounting

You can use the extended accounting facility to set up network accounting on the system. Network accounting involves capturing statistics about network traffic in a log file. You can maintain records of traffic for tracking, provisioning, consolidation, and billing purposes. Later, you can see the log file to obtain historical information about network use over a period of time.

Configuring Network Accounting for Network Traffic

To set up network accounting, use the extended accounting facility's `acctadm` command. For more information, see the `acctadm`(1M) man page. After you have completed setting up network accounting, use the `flowstat` command to record traffic statistics.

▼ How to Set Up Network Accounting

1. **Become an administrator.**

   For more information, see "Using Your Assigned Administrative Rights" in *Securing Users and Processes in Oracle Solaris 11.3*.

2. **View the status of the accounting types that can be enabled by the extended accounting facility.**

   ```
   # acctadm [process | task | flow | net]
   ```

   The extended accounting facility can enable four types of accounting. The optional operands of the `acctadm` command correspond to the following accounting types:

   - `process` – Process accounting
   - `task` – Task accounting
   - `flow` – Flow accounting
   - `net` – Network accounting

Note - Network accounting also applies to flows that are managed by the `flowadm` and `flowstat` commands as discussed in "Managing Network Resources by Using Flows" on page 219. Therefore, to set up accounting for these flows, use the `net` option with the `acctadm` command. Do *not* use the `flow` option, which enables flow accounting for IPQoS configurations.

Specifying `net` displays the status of network accounting. If `net` is not used, then the status of all four accounting types is displayed.

---

3. **Enable the extended accounting for network traffic.**

```
# acctadm -e extended -f filename net
```

where *filename* includes the full path of the log file that captures network traffic statistics. The log file can be created in any directory that you specify.

4. **Verify that extended network accounting has been activated.**

```
# acctadm net
```

Example 99 Setting Up Network Accounting on the System

This example shows how to configure network accounting to capture and display historical traffic information on the system.

View the status of all accounting types as follows:

```
# acctadm
            Task accounting: inactive
       Task accounting file: none
     Tracked task resources: none
   Untracked task resources: extended
         Process accounting: inactive
    Process accounting file: none
  Tracked process resources: none
Untracked process resources: extended,host
            Flow accounting: inactive
       Flow accounting file: none
     Tracked flow resources: none
   Untracked flow resources: extended
             Net accounting: inactive
       Network accounting file: none
     Tracked Network resources: none
   Untracked Network resources: extended
```

The output shows that network accounting is not active. Therefore, you should enable extended network accounting.

```
# acctadm -e extended -f /var/log/net.log net
# acctadm net
            Net accounting: active
       Net accounting file: /var/log/net.log
     Tracked net resources: extended
   Untracked net resources: none
```

Displaying Historical Statistics on Network Traffic

After you have enabled network accounting, you can use the `dlstat` and `flowstat` commands to extract information from the log file.

You must enable extended accounting for the network before you can display historical data about the network. Further, to display historical data about traffic on flows, you must first configure flows on the system, as explained in "Managing Network Resources by Using Flows" on page 219.

Displaying Historical Network Traffic Statistics on Datalinks

You can display historical network traffic statistics on datalinks by using the following command syntax:

```
# dlstat show-link -h [-a] -f filename [-d date] [-F format] [-s start-time] [-e end-time]
 [link]
```

`-h`	Displays a summary of historical information about resource usage by incoming and outgoing packets on datalinks.
`-a`	Displays resource usage on all datalinks, including those that have already been deleted after the data capture.
`-f` *filename*	Specifies the log file that was defined when network accounting was enabled with the `acctadm` command.
`-d` *date*	Displays logged information for the specified date.
`-F` *format*	Displays the data in a specific format that can then be plotted for analysis. Currently, `gnuplot` is the only supported format.

`-s` *start-time*	Specifies the start time to display the logged information of the network statistics. Use the `MM/DD/YYY,hh:mm:ss` format. The `hour` (`hh`) must use 24-hour clock notation. If you do not include the date, then data for the specified time range for the current date is displayed.
`-e` *end-time*	Specifies the end time to display the logged information of the network statistics. Use the `MM/DD/YYY,hh:mm:ss` format. The `hour` (`hh`) must use 24-hour clock notation. If you do not include the date, then data for the specified time range for the current date is displayed.
link	Displays historical data for a specified datalink. If you do not use this option, then historical network data for all configured datalinks is displayed.

EXAMPLE 100 Displaying Historical Statistics About Resource Usage on Datalinks

In this example, the historical statistics about network traffic and its use of resources on all the datalinks in a system are displayed.

```
# dlstat show-link -h -f /var/log/net.log
LINK  DURATION  IPKTS    RBYTES     OPKTS  OBYTES     BANDWIDTH
net0   80        1031    546908      0        0       2.44 Mbps
net1   100       2045    235977      0        0       9.67 Mbps
```

Displaying Historical Network Traffic Statistics on Flows

You can display historical network traffic statistics on flows by using the following command syntax:

```
# flowstat -h [-a] -f filename [-d date] [-F format] [-s start-time] [-e end-time] [flow]
```

`-h`	Displays a summary of historical information about resource usage by incoming and outgoing packets on configured flows.
`-a`	Displays resource usage on all configured flows, including those that have already been deleted after the data capture.
`-f` *filename*	Specifies the log file that was defined when network accounting was enabled with the `acctadm` command.
`-d`	Displays logged information for the specified date.

`-F` *format*	Displays the data in a specific format. Currently, `gnuplot` is the only supported format.
`-s` *start-time*	Specifies the start time to display the logged information of the network statistics. Use the `MM/DD/YYY,hh:mm:ss` format. The `hour` (`hh`) must use 24-hour clock notation. If you do not include the date, then data for the specified time range for the current date is displayed.
`-e` *end-time*	Specifies the end time to display the logged information of the network statistics. Use the `MM/DD/YYY,hh:mm:ss` format. The `hour` (`hh`) must use 24-hour clock notation. If you do not include the date, then data for the specified time range for the current date is displayed.
flow	Displays historical data for a specified flow. If you do not use this option, then historical network data for all configured flows is displayed.

EXAMPLE 101 Displaying Historical Statistics About Resource Usage on Flows

The following example displays historical statistics of resource usage by traffic on the flows in a system.

```
# flowstat -h -f /var/log/net.log
FLOW      DURATION  IPACKETS RBYTES      OPACKETS OBYTES    BANDWIDTH
flowtcp   100       1031     546908      0        0         43.76Kbps
flowudp   0         0        0           0        0          0.00Mbps
```

The following example displays historical statistics of resource usage by traffic on `flowtcp` over a given date and time range.

```
# flowstat -h -s 02/19/2008,10:39:06 -e 02/19/2008,10:40:06 \
-f /var/log/net.log flowtcp

FLOW      START       END         RBYTES   OBYTES     BANDWIDTH
flowtcp   10:39:06    10:39:26    1546     6539         3.23 Kbps
flowtcp   10:39:26    10:39:46    3586     9922         5.40 Kbps
flowtcp   10:39:46    10:40:06    240      216        182.40 bps
flowtcp   10:40:06    10:40:26    0        0            0.00 bps
```

The following example displays historical statistics of resource usage by traffic on `flowtcp` over a given date and time range by using `gnuplot` format.

```
# flowstat -h -s 02/19/2008,10:39:06 -e 02/19/2008,10:40:06 \
-F gnuplot -f /var/log/net.log flowtcp
# Time tcp-flow
10:39:06 3.23
10:39:26 5.40
```

```
10:39:46 0.18
10:40:06 0.00
```

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