IMPLEMENTING A LAYER 2 ENTERPRISE INFRASTRUCTURE WITH VIRTUAL CHASSIS TECHNOLOGY

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Introduction

The focus of this document is on implementing a Layer 2 design for enterprise networks using Virtual Chassis technology. Both Juniper Networks® EX Series Ethernet Switches and MX Series 3D Universal Edge Routers run the Juniper Networks Junos® operating system and support a similar set of Layer 2 features with some variations. By supporting Layer 2, Layer 3, or a combination of both, these devices give flexibility in designing and deploying networks. For example, Layer 2 can be implemented initially, and Layer 3 functionality can be enabled later on the same devices at no additional costs. Juniper Networks EX4200 Ethernet Switch also offers the flexibility to group up to ten switches into one single chassis using Virtual Chassis technology.

After an overview of the design considerations and protocols used, we will highlight some of the differences between EX Series and MX Series supported features. Finally, we will present an implementation example of a Virtual Chassis and provide configuration guidelines as well as verification and troubleshooting procedures.

Scope

This document provides guidelines and an implementation example for Layer 2 enterprise environments that use Juniper Networks EX Series Ethernet Switches in the access layer and Juniper Networks MX Series 3D Universal Edge Routers for core and aggregation. A brief features and protocols overview is followed by a topology implementation that includes configuration guidelines, verification, and troubleshooting procedures. The design presented in this document groups the EX Series into a Virtual Chassis to prevent loops. Other design options that use Rapid Spanning Tree Protocol (RSTP), Multiple Spanning Tree Protocol (MSTP), and Redundant Trunk Group (RTG) are presented in separate implementation guides.

This document is intended for network design and operation engineers or other technical audiences who support enterprise customers with Layer 2 deployments using the EX Series and MX Series.

Design Considerations

The network architecture presented in this document is based on a collapsed campus model where the EX Series is used in the access layer, while the core and aggregation layers are combined using the MX Series. The access switches are dual-homed to two aggregation/core switches. This is needed in order to provide physical redundancy while allowing for load balancing. Device redundancy at Layer 2 introduces the potential of broadcast storms with packets traveling endlessly and crippling the network. A mechanism is therefore needed to prevent Layer 2 loops. In this document, this is done by grouping the EX Series devices into a single Virtual Chassis.

Layer 3 is enabled only at the aggregation/core layer. MX Series routers are configured with integrated routing and bridging (IRB) and Virtual Router Redundancy Protocol (VRRP). They also act as Dynamic Host Configuration Protocol (DHCP) relay agents to allow clients in the access layer to obtain IP addresses dynamically.

Virtual Chassis

Flexibility, high availability, and simplified management are all important design considerations for an enterprise network implementation. With Virtual Chassis technology, which is a feature unique to the EX Series, up to ten EX4200 line devices can be interconnected using 64 Gbps Virtual Chassis backplane cables or 10-Gigabit Ethernet uplinks to create a single logical device. When two or more EX4200 Ethernet Switches are configured as a single Virtual Chassis, they share a common control plane among all member switches. An election process is automatically initiated to assign a master (active) and backup (hot-standby) Routing Engine. The remaining switch elements act as line cards and are available to assume the backup Routing Engine position should the designated master fail.

All members of the Virtual Chassis share a single management interface, a single version of Junos OS, and a copy of the configuration and chassis-like slot/module/port numbering scheme. Additionally, aggregated Ethernet links can be created across Virtual Chassis members.

Aggregated Ethernet or Link Aggregation Group

Using aggregated Ethernet for an enterprise network implementation provides the following benefits:

- Increased bandwidth
- Link redundancy
- Better link utilization
- Per-flow load balancing across multiple virtual switch members
- Hashing based on L2/L3/L4

Aggregated Ethernet is supported on both EX Series and MX Series devices. One aggregated Ethernet interface can group up to eight links into a virtual bundle. Aggregated Ethernet interfaces can be created statically or using Link Aggregation Control Protocol (LACP, 802.3 ad). On the EX Series, the ports that are part of a Link Aggregation Group (LAG) do not have to be contiguous and can belong to different Virtual Chassis switch members. However, they need to be of the same speed and duplex. The Junos OS implementation of LACP does some basic error-checking and does not activate the aggregated Ethernet if a misconfiguration is detected.

VLANs and 802.1Q

A VLAN is a logical grouping of end devices allowing communication as if they were on the same LAN.

On the EX Series, ports that are assigned to a VLAN can be configured as either access or trunk ports. A port in access mode connects to a network device such as a desktop computer, an IP telephone, a printer, a file server, or a security camera. The interface itself belongs to a single VLAN. Trunk interfaces are generally used to interconnect switches to one another. The frames on a trunk port are tagged as defined in 802.1Q standard. Juniper Networks EX3200 Ethernet Switch and EX4200 Ethernet Switch both support a maximum of 4096 VLANs. VLANs 0 and 4095 are reserved by Junos OS.

Integrated Routing and Bridging

Integrated routing and bridging (IRB) interfaces on the MX Series allow the flexibility of supporting both Layer 2 bridging and Layer 3 routing on the same interface. Frames are bridged if they are not sent to the router's media access control (MAC) address. Frames sent to the router's MAC address are routed to other interfaces configured for Layer 3 routing.

The EX Series also supports routed interfaces called Routed VLAN Interfaces (RVIs). (These are not implemented in this guide.) As opposed to IRBs which route bridge domains, RVIs route VLANs. A port of a switch VLAN is identified by an interface and a VLAN-id which is globally significant across the switch.

Virtual Router Redundancy Protocol

EX Series switches and MX Series routers support Virtual Router Redundancy Protocol (VRRP). With VRRP, routers viewed as a redundancy group share the responsibility for forwarding packets as if they owned the IP address corresponding to the default gateway configured on the hosts. At any time, one of the VRRP routers acts as the master, while other VRRP routers act as backup routers. If the master router fails, a backup router becomes the new master. Using this approach, router redundancy is always provided, allowing traffic on the LAN to be routed without relying on a single router.

DHCP Relay

DHCP requests sent from a client to a server are normally restricted to the same physical segment, LAN, or VLAN on which the client resides. In the event that the server and client are on different LANs or VLANs, a relay agent is needed. The main advantage of this feature is that a single DHCP server can serve clients on remote LANs or VLANs, eliminating the need for a dedicated DHCP server in each LAN or VLAN environment. Both EX Series switches and MX Series routers can be configured to relay requests to a DHCP/BOOTP server and use the DHCP Relay Agent option (option 82) in the relayed messages. Since Layer 3 is not implemented on the access switches in this guide, the MX Series routers act as the DHCP relay agents.

Implementation

Configuration Guidelines

Virtual Chassis Provisioning

Individual Ethernet management ports (me0s) on the EX4200 Ethernet Switch are tied to a special management VLAN associated with a Layer 3 virtual management (vme) interface by default. The first step to configure a Virtual Chassis is to delete the me0 interfaces on the members (if applicable). Configuring Virtual Chassis members with individual me0 interfaces is not recommended, as it takes them out of the management VLAN, thus leaving them out of vme reach.

The Virtual Chassis components can be defined statically by configuring the master member with Virtual Chassis pre-provisioning (as shown in the configuration example below). Each member is identified by its serial number and assigned a role in the Virtual Chassis—either Routing Engine or line card. The two members configured as Routing Engines (members 0 and 2) get a mastership priority of 129. By powering up EX-VC-1 first, we ensure that it becomes the master member. The two other members that are defined as line cards get a priority of 0 and are therefore not eligible to become Routing Engines.

EX-VC-1:

```
virtual-chassis {
    pre-provisioned;
    /* Master: EX-VC-1 */
    member 0 {
        role routing-engine;
        serial-number BM0208105257;
    }
    /* Line Card 1: EX-VC-2 */
    member 1 {
        role line-card;
        serial-number BR0208138123;
    }
    /* Backup: EX-VC-3 */
    member 2 {
        role routing-engine;
        serial-number BR0208112075;
    }
    /* Line Card 2: EX-VC-4 */
    member 3 {
        role line-card;
        serial-number BP0208137931;
    }
}
```

Another way to influence the master selection process without Virtual Chassis pre-provisioning is through mastership priority configuration. Priorities range between 0 and 255 and the default priority is 128. The member with the highest user-configured priority is selected as the master. Below is a configuration example:

EX-VC-1:

```
virtual-chassis {
    member 0 {
        mastership-priority 255;
    }
}
```

Notes:

1. In the Virtual Chassis pre-provisioning, it is not possible to set the master priority. Both master and backup members are configured as Routing Engines and other members as line cards. The first of the Routing Engines that is powered up becomes the master.
2. When members of a Virtual Chassis are connected through the Virtual Chassis Port (VCP) cables in a ring topology, it is recommended to choose the members' roles in a way that minimizes the hop counts between the line cards and Routing Engines.
3. When not using Virtual Chassis pre-provisioning, Juniper recommends giving the master and backup the same priority. This way, if the master goes down, the backup takes over and remains the master even if the previous master comes back up.

Interface and VLAN Configuration

Switch ports can be configured with either access mode or trunk mode. Access ports typically belong to a single VLAN and transmit and receive untagged Ethernet frames. A trunk port typically connects to another switch or to a customer's edge router. Interfaces configured for trunk mode handle traffic for multiple VLANs, multiplexing the traffic for all configured VLANs over the same physical connection, and separating the traffic by tagging it with the appropriate VLAN-id.

Below are sample interface and VLAN configurations for both the EX Series and MX Series:

EX-VC-1

```
vlans {
      ENG {
        vlan-id 200;
    }
    HR {
        vlan-id 100;
    }
    SALES {
        vlan-id 300;
    }
    SERVER {
        vlan-id 600;
    }
}

interfaces {
    /* Access port examples */
    ge-0/0/0 {
            unit 0 {
                family ethernet-switching {
                    port-mode access;
                    vlan {
                        members HR;
                    }
                }
            }
        }
    ge-0/0/1 {
        unit 0 {
            family ethernet-switching {
                port-mode access;
                vlan {
                    members ENG;
                }
            }
```

EX-VC-14

```
interfaces {
    ge-8/0/0 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 100 {
            vlan-id 100;
        }
        unit 200 {
            vlan-id 200;
        }
        unit 600 {
            vlan-id 600;
        }
    }
    ge-8/0/1 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 300 {
            vlan-id 300;
        }
    }
    ge-8/0/2 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 300 {
            vlan-id 300;
        }
    }
    ge-8/0/3 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        gigether-options {
            no-auto-negotiation;
        }
        unit 100 {
```

```
        }
    }
   /*Trunk port example */
   ge-0/1/0 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG SERVER
];
                }
            }
        }
    }
```

```
            vlan-id 100;
        }
        unit 200 {
            vlan-id 200;
        }
    }
```

The example above shows a port-based assignment of VLANs on the EX Series where VLANs are added under the interface stanza. It is also possible to use a VLAN-based assignment where interfaces are added under the VLAN stanza (as shown below). Some users may be more familiar with the first form of configuration. Others may prefer the second method in that functionalities are grouped by feature rather than per interface. Both methods result in the same configuration from a software perspective.

EX Series:

```
vlans {
    HR {
        vlan-id 100;
        interface {
            ge-0/0/0.0;
            ge-0/0/1.0;
        }
    }
}
```

Aggregated Ethernet Configuration

Aggregated Ethernet interfaces can be configured statically in three steps:

1. Setting the device count of the chassis.
2. Assigning aggregated Ethernet interfaces to physical interfaces under “ether-options” in the interface stanza.
3. Configuring the aggregated Ethernet interfaces as access or trunk ports and assigning VLANs to them just like other regular interfaces.

Note that aggregated Ethernet interfaces are created starting from ae0 upwards. For example, if the chassis aggregated Ethernet device count is set to 2, interfaces ae0 and ae1 are created. It is therefore recommended to number the interfaces continuously starting from 0. The maximum number of aggregated Ethernet interfaces per chassis is 128.

In the example below, the EX Series Virtual Chassis has two aggregated Ethernet interfaces (one for each aggregation switch), and the MX Series has one. The aggregated Ethernet interfaces are configured with VLAN tagging, encapsulation, and VLAN-ids similar to the interface configuration in non-aggregated Ethernet scenarios:

EX Series:

```
vlans {
    aggregated-devices {
        ethernet {
            device-count 2;
        }
    }
}

interfaces {
    ge-2/1/0 {
        ether-options {
            802.3ad ae0;
        }
    }
    ge-2/1/1 {
        ether-options {
            802.3ad ae1;
        }
    }
    ae0 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG SERVER
SALES ];
                }
            }
        }
    }
    ae1 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG SERVER
SALES ];
                }
            }
        }
    }

}
```

MX-A:

```
interfaces {
    ge-8/0/0 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 100 {
            vlan-id 100;
        }
        unit 200 {
            vlan-id 200;
        }
        unit 600 {
            vlan-id 600;
        }
    }
    ge-8/0/1 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 300 {
            vlan-id 300;
        }
    }
    ge-8/0/2 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 300 {
            vlan-id 300;
        }
    }
    ge-8/0/3 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        gigether-options {
            no-auto-negotiation;
        }
        unit 100 {
       }
    }
```

IRBs and VRRP Configuration

An IRB is configured on the MX Series in two steps:

1. Configuring the IRB interface using the IRB statement.
2. Referencing the IRB interface at the bridge domain level of the configuration.

VRRP can be configured on the IRB interface so that redundant links can be used to carry traffic between the bridge domain and the router network.

The example below shows IRBs configured with VRRP groups and virtual addresses. The priority is set to 254 for groups 1, 2, and 4 on MX-A. This makes MX-A the master for these groups, while MX-B will be left with the default priority of 100 and will act as the backup. The "accept-data" command allows an IRB interface to accept packets destined for a virtual IP address.

MX-A:

```
vlans {
interfaces {
    irb {
        unit 100 {
            family inet {
                address 10.10.10.4/24 {
                    vrrp-group 1 {
                        virtual-address
10.10.10.1;
                        priority 254;
                        accept-data;
                    }
                }
            }
        }
        unit 200 {
            family inet {
                address 20.20.20.4/24 {
                    vrrp-group 2 {
                        virtual-address
20.20.20.1;
                        priority 254;
                        accept-data;
                    }
                }
            }
        }
```

```
        unit 300 {
            family inet {
                address 30.30.30.4/24 {
                    vrrp-group 3 {
                        virtual-address
30.30.30.1;
                        accept-data;
                    }
                }
            }
        }
        unit 600 {
            family inet {
                address 60.60.60.4/24 {
                    vrrp-group 4 {
                        virtual-address
60.60.60.1;
                        priority 254;
                        accept-data;
                    }
                }
            }
        }
    }
}
```

Bridge Domains Configuration

Bridge domains limit the scope of media access control (MAC) learning and thereby the size of the MAC table. They also determine where the device should propagate frames sent to broadcast, unknown unicast, and multicast MAC addresses. Each interface that belongs to a bridge domain must be referenced under the corresponding bridge domain stanza. IRB interfaces are also referenced using the “routing-interface” statement as shown below:

MX-A:

```
bridge-domains {
    ENG {
        domain-type bridge;
        vlan-id 200;
        interface ge-8/0/0.200;
        interface ge-8/0/3.200;
        interface xe-2/0/0.200;
        routing-interface irb.200;
    }
    HR {
        domain-type bridge;
        vlan-id 100;
        interface ge-8/0/0.100;
        interface ge-8/0/3.100;
        interface xe-2/0/0.100;
        routing-interface irb.100;
    }
```

```
        SALES {
        domain-type bridge;
        vlan-id 300;
        interface ge-8/0/1.300;
        interface ge-8/0/2.300;
        interface xe-2/0/0.300;
        routing-interface irb.300;
    }
   SERVER {
        domain-type bridge;
        vlan-id 600;
        interface ge-8/0/0.600;
        interface xe-2/0/0.600;
        routing-interface irb.600;
    }
}
```

DHCP Relay Configuration

The DHCP server is configured under the “forwarding option” stanza as illustrated in the example below. Here, the MX Series routers are configured to forward BOOTP/DHCP requests coming from IRBs 100 and 200 to the DHCP server address. This is accomplished with the relay-agent-option (option 82) in the relayed messages.

MX-A:

```
forwarding-options {
    helpers {
        bootp {
            server 60.60.60.2;
            relay-agent-option;
            interface {
                irb.100;
                irb.200;
            }
        }
    }
}
```

Verification

Below are some of the commands that can be used to verify the Virtual Chassis setup:

EX Series:

- show virtual-chassis status
- show virtual-chassis vc-port all-members
- show virtual-chassis vc-port statistics <vcp_port_name> detail member <member_id>
- show virtual-chassis active-topology
- show virtual-chassis protocol route all
- show ethernet-switching interfaces
- show ethernet-switching table

MX Series:

- show bridge mac-table
- show vrrp summary
- show vrrp extensive
- show interface irb terse

Trouble………

The following commands can be used for troubleshooting in the Virtual Chassis scenario:

EX Series:

- request virtual-chassis renumber member-id <member_id> new-member-id <member_id>
- request virtual-chassis vc-port set interface disable <vcp_port_name> member <member_id>
- clear ethernet-switching table
- restart ethernet-switching

MX Series:

- show bootp statistics

Both:

- monitor traffic interface <interface_name> layer2-headers
- monitor traffic interface <interface_name> size <size> detail
- show system core-dumps

Implementation Example

Network Topology

The following diagram shows the logical topology with a Virtual Chassis:

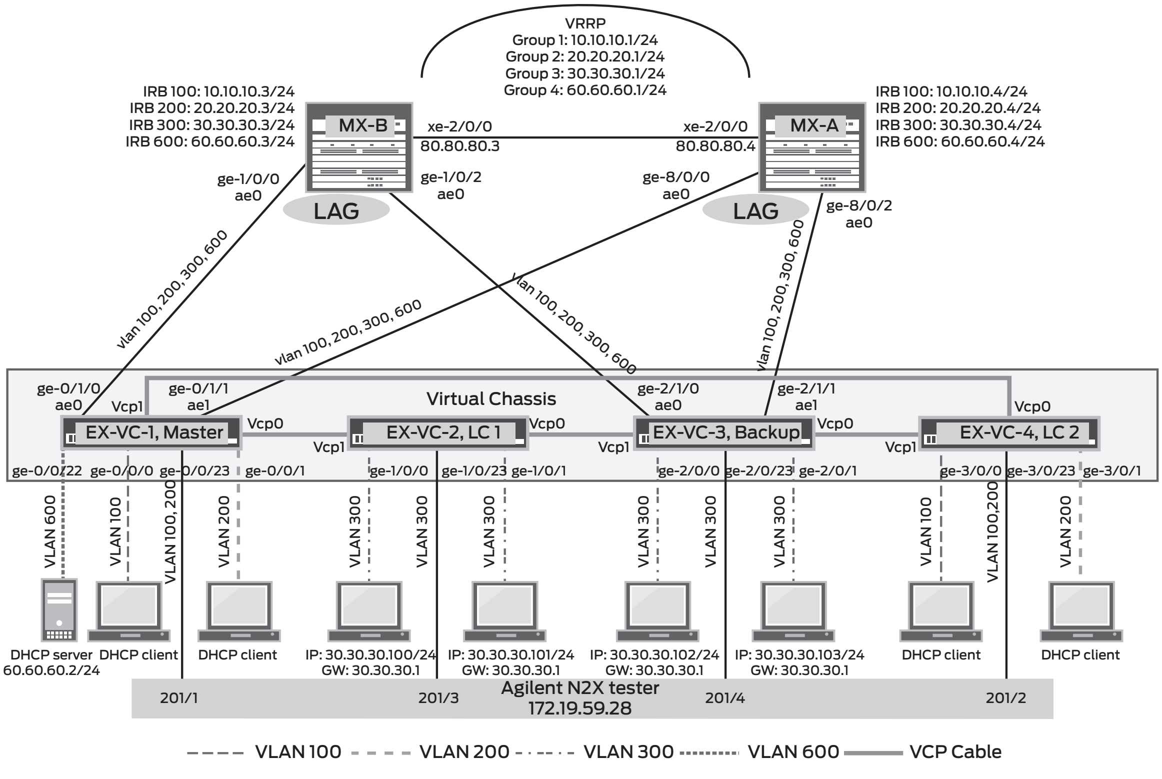

Figure 1: Logical diagram with a Virtual Chassis

Hardware Used for Validation

The following devices are required to implement the topology described:

- Four EX4200 line switches
- Two MX Series routers: Juniper Networks MX240 3D Universal Edge Router, MX480 3D Universal Edge Router, or MX960 3D Universal Edge Router. We have used one MX480 and one MX960 for the aggregation devices.

Table 1: Hardware

EQUIPMENT	COMPONENTS
4 x EX4200	• 2 x 4-port uplink Gigabit Ethernet module (EX-UM-4SFP) • 17 small form-factor pluggable transceivers (SFPs)
1 x MX480 1 x MX960	(XFPs)

Testing Equipment Used for Validation

Table 2: Testing Hardware

EQUIPMENT	COMPONENTS
Agilent N2X tester	4 x 10/100/1000 Mb ports
Linux DHCP server	

Software Used for Validation

Table 3: Software

EQUIPMENT	COMPONENTS
EX Series and MX Series	Junos OS 9.0

Detailed Configurations

The detailed configurations for EX-VC-1 and MX-A are listed below. For the rest of the configurations, please refer to Appendix B: Detailed Configurations.

EX-VC-1

…truncated

```
chassis {
    aggregated-devices {
        ethernet {
            device-count 2;
        }
    }
}
interfaces {
    ge-0/0/0 {
        unit 0 {
            family ethernet-switching {
                port-mode access;
                vlan {
                    members HR;
                }
            }
        }
    }
    ge-0/0/1 {
        unit 0 {
            family ethernet-switching {
                port-mode access;
                vlan {
                    members ENG;
                }
            }
        }
    }
        ge-0/0/22 {
        ether-options {
            link-mode full-duplex;
            speed {
                100m;
            }
        }
        unit 0 {
            family ethernet-switching {
                port-mode access;
                vlan {
                    members SERVER;
                }
            }
        }
    }
    ge-0/0/23 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG ];
                }
```

MX-A

…truncated

```
chassis {
    aggregated-devices {
        ethernet {
            device-count 1;
        }
    }
}
interfaces {
    ge-1/0/0 {
        gigether-options {
            802.3ad ae0;
        }
    }
    ge-1/0/2 {
        gigether-options {
            802.3ad ae0;
        }
    }
    xe-2/0/0 {
        unit 0 {
            family inet {
                address 80.80.80.3/24;
            }
        }
    }
    ae0 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 100 {
            vlan-id 100;
        }
        unit 200 {
            vlan-id 200;
        }
        unit 300 {
            vlan-id 300;
        }
        unit 600 {
            vlan-id 600;
        }
    }
    irb {
        unit 100 {
            family inet {
                address 10.10.10.3/24 {
                    vrrp-group 1 {
                        virtual-address
10.10.10.1;
                        accept-data;
                    }
                }
```

```
        }
    }
}
ge-0/1/0 {
    ether-options {
        802.3ad ae0;
    }
}
ge-0/1/1 {
    ether-options {
        802.3ad ae1;
    }
}
ge-0/1/2 {
    unit 0 {
        family ethernet-switching;
    }
}
ge-0/1/3 {
    unit 0 {
        family ethernet-switching;
    }
}
ge-1/0/23 {
    unit 0 {
        family ethernet-switching {
            port-mode access;
            vlan {
                members SALES;
            }
        }
    }
}
ge-2/0/0 {
    unit 0 {
        family ethernet-switching {
            port-mode access;
            vlan {
                members SALES;
            }
        }
    }
}
ge-2/0/1 {
    unit 0 {
        family ethernet-switching {
            port-mode access;
            vlan {
                members SALES;
            }
        }
    }
}
ge-2/0/23 {
    unit 0 {
        family ethernet-switching {
            port-mode access;
            vlan {
                members SALES;
```

```
                }
            }
            unit 200 {
                family inet {
                    address 20.20.20.3/24 {
                        vrrp-group 2 {
                            virtual-address
20.20.20.1;
                            accept-data;
                        }
                    }
                }
            }
            unit 300 {
                family inet {
                    address 30.30.30.3/24 {
                        vrrp-group 3 {
                            virtual-address
30.30.30.1;
                            accept-data;
                        }
                    }
                }
            }
            unit 600 {
                family inet {
                    address 60.60.60.3/24 {
                        vrrp-group 4 {
                            virtual-address
60.60.60.1;
                            accept-data;
                        }
                    }
                }
            }
        }
        lo0 {
            unit 0 {
                family inet {
                    address 127.0.0.1/32;
                }
            }
        }
    }
forwarding-options {
    helpers {
        bootp {
            server 60.60.60.2;
            relay-agent-option;
            interface {
                irb.100;
                irb.200;
            }
        }
    }
}
bridge-domains {
    ENG {
        domain-type bridge;
```

```
                }
            }
        }
    }
    ge-2/1/0 {
        ether-options {
            802.3ad ae0;
        }
    }
    ge-2/1/1 {
        ether-options {
            802.3ad ae1;
        }
    }
    ge-3/0/0 {
        unit 0 {
            family ethernet-switching {
                vlan {
                    members HR;
                }
            }
                port-mode access;
        }
    }
    ge-3/0/1 {
        unit 0 {
            family ethernet-switching {
                port-mode access;
                vlan {
                    members ENG;
                }
            }
        }
    }
    ge-3/0/23 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG ];
                }
            }
        }
    }
    ae0 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
                vlan {
                    members [ HR ENG SERVER
SALES ];
                }
            }
        }
    }
    ae1 {
        unit 0 {
            family ethernet-switching {
                port-mode trunk;
```

```
        vlan-id 200;
        interface ae0.200;
        routing-interface irb.200;
    }
    HR {
        domain-type bridge;
        vlan-id 100;
        interface ae0.100;
        routing-interface irb.100;
    }
    SALES {
        domain-type bridge;
        vlan-id 300;
        interface ae0.300;
        routing-interface irb.300;
    }
    SERVER {
        domain-type bridge;
        vlan-id 600;
        interface ae0.600;
        routing-interface irb.600;
    }
}
```

```
                vlan {
                    members [ HR ENG SERVER
SALES ];
                }
            }
        }
    }
    vme {
        unit 0 {
            family inet {
                address 172.19.59.190/24;
            }
        }
    }
}
vlans {
    ENG {
        vlan-id 200;
    }
    HR {
        vlan-id 100;
    }
    SALES {
        vlan-id 300;
    }
    SERVER {
        vlan-id 600;
    }
}
virtual-chassis {
    pre-provisioned;
    /* Master: EX VC-1 */
    member 0 {
        role routing-engine;
        serial-number BM0208105257;
    }
    /* Backup: EX VC-4 */
    member 3 {
        role line-card;
        serial-number BP0208137931;
    }
    /* Line Card: EX VC-2 */
    member 1 {
        role line-card;
        serial-number BR0208138123;
    }
    /* Line Card: EX VC-3 */
    member 2 {
        role routing-engine;
        serial-number BR0208112075;
    }
}
```

Summary

With the EX Series Ethernet Switches and MX Series 3D Universal Edge Routers, Juniper Networks offers its enterprise customers compelling end-to-end solutions that can meet the requirements of either Layer 2 or Layer 3 deployments. In Layer 2 environments, network administrators are faced with the task of preventing and possibly troubleshooting loops. This can be accomplished with different technologies including RSTP, MSTP, RTGs, and Virtual Chassis. This document has shown how to implement a layer design using a Virtual Chassis. Three other designs using RSTP, MSTP, and RTG are described in separate implementation guides.

With the guidelines presented in these documents, Juniper customers can integrate the EX Series and MX Series into their Layer 2 networks. They can later enable Layer 3 on the same devices at no additional cost to leverage the feature-rich, Junos OS while minimizing capital and operational expenses.

Appendix A: Conventions/Glossary

BOOTP	Bootstrap Protocol
BPDU	Bridge protocol data unit
DHCP	Dynamic Host Configuration Protocol
DPC	Dense Port Concentrator
IRB	Integrated routing and bridging
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group
MSTP	Multiple Spanning Tree Protocol
RSTP	Rapid Spanning Tree
RTG	Redundant Trunk Group
RVI	Routed VLAN Interface
STP	Spanning Tree Protocol
SFP	Small form-factor pluggable transceiver
VLAN	Virtual LAN
VRRP	Virtual Router Redundancy Protocol
VSTP	Virtual Spanning Tree Protocol
XFP	10-gigabit small form-factor pluggable transceiverAppendix B: Detailed Configurations

Appendix B: Detailed Configurations

MX-B:

```
…truncated
```

```
interfaces {
    chassis {
    aggregated-devices {
        ethernet {
            device-count 1;
        }
    }
}
interfaces {
    xe-2/0/0 {
        unit 0 {
            family inet {
                address 80.80.80.4/24;
            }
        }
    }
    ge-8/0/0 {
        gigether-options {
            802.3ad ae0;
        }
    }
    ge-8/0/2 {
        gigether-options {
            802.3ad ae0;
        }
    }
    ae0 {
        vlan-tagging;
        encapsulation extended-vlan-bridge;
        unit 100 {
            vlan-id 100;
        }
        unit 200 {
            vlan-id 200;
        }
        unit 300 {
            vlan-id 300;
        }
        unit 600 {
            vlan-id 600;
        }
    }
    irb {
        unit 100 {
            family inet {
                address 10.10.10.4/24 {
                    vrrp-group 1 {
                        virtual-address 10.10.10.1;
                        priority 254;
                        accept-data;
                    }
                }
```

```
                }
            }
            unit 200 {
                family inet {
                    address 20.20.20.4/24 {
                        vrrp-group 2 {
                            virtual-address 20.20.20.1;
                            priority 254;
                            accept-data;
                        }
                    }
                }
            }
            unit 300 {
                family inet {
                    address 30.30.30.4/24 {
                        vrrp-group 3 {
                            virtual-address 30.30.30.1;
                            priority 254;
                            accept-data;
                        }
                    }
                }
            }
            unit 600 {
                family inet {
                    address 60.60.60.4/24 {
                        vrrp-group 4 {
                            virtual-address 60.60.60.1;
                            priority 254;
                            accept-data;
                        }
                    }
                }
            }
        }
    }
    forwarding-options {
        helpers {
            bootp {
                server 60.60.60.2;
                relay-agent-option;
                interface {
                    irb.100;
                    irb.200;
                }
            }
        }
    }
    bridge-domains {
        ENG {
            domain-type bridge;
            vlan-id 200;
            interface ae0.200;
            routing-interface irb.200;
        }
        HR {
            domain-type bridge;
            vlan-id 100;
```

```
            interface ae0.100;
            routing-interface irb.100;
        }
        SALES {
            domain-type bridge;
            vlan-id 300;
            interface ae0.300;
            routing-interface irb.300;
        }
        SERVER {
            domain-type bridge;
            vlan-id 600;
            interface ae0.600;
            routing-interface irb.600;
        }
    }
```

About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses. Additional information can be found at www.juniper.net.

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