ERICSSON

Configuring Link Aggregation

SYSTEM ADMINISTRATOR GUIDE

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Contents

1 Overview

This document describes how to configure, monitor, and administer Ethernet media link groups.

This document applies to both the Ericsson SmartEdge® and SM family routers. However, the software that applies to the SM family of systems is a subset of the SmartEdge OS; some of the functionality described in this document may not apply to SM family routers.

For information specific to the SM family chassis, including line cards, refer to the SM family chassis documentation.

For specific information about the differences between the SmartEdge and SM family routers, refer to the Technical Product Description *SM Family of Systems* (part number 5/221 02-CRA 119 1170/1) in the **`Product Overview`** folder of this Customer Product Information library.

In this document, the term link group refers to link-aggregated FE or GE ports with IP over Ethernet (IPoE) or 802.1Q encapsulation and link-aggregated ports. The term standby link describes a port in the link group bundle that currently is not carrying traffic but stands by ready to carry traffic if any of the active ports fail.

Link aggregation provides increased bandwidth and availability. When a number of ports are bundled in a link group, the failure or replacement of one link in the bundle does not cause the link group to be taken down because the other links take on the traffic of the one that is out of service. Load balancing and load distribution over the ports in the link group result in increased bandwidth.

The Glossary on page 41 defines the terminology used in this document.

Figure 1 shows a typical application of bridged link groups:

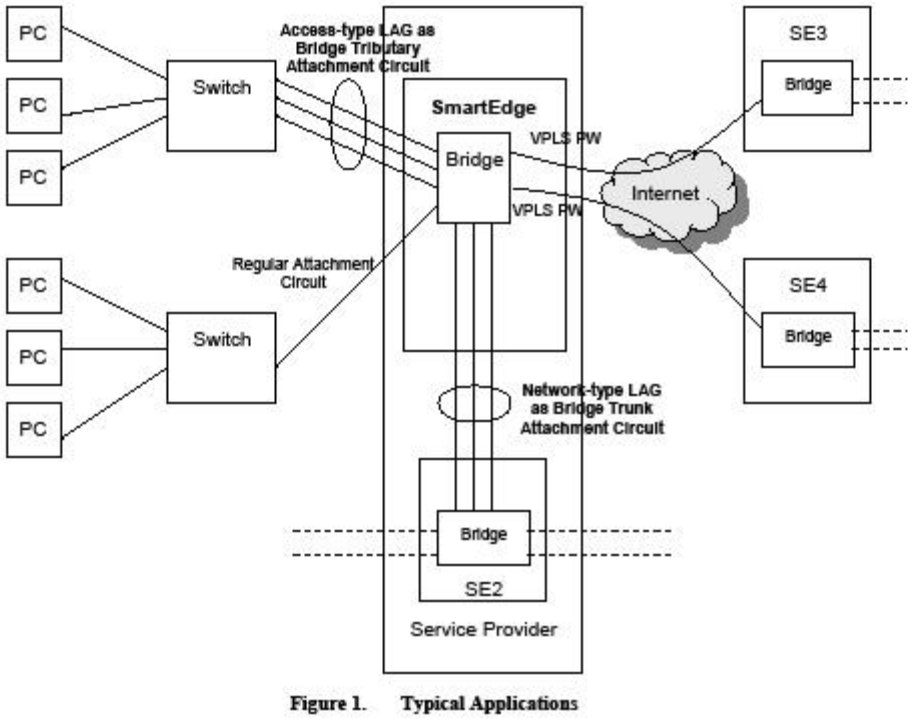

Figure 1. Typical Applications

Figure 1 Typical Application of Bridged Link Groups

1.1 IEEE 802.3ad Link Groups for FE and GE Ports

The SmartEdge router supports the aggregation of FE or GE ports into a single, larger logical pipe, as specified in Part 3 of the IEEE 802.3ad 2000 specification, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*. The SmartEdge router supports 802.3ad Link Groups with IPoE, PPPoE, and 802.1Q encapsulation for IPv4, IPv6, or dual-stack (IPv4 and IPv6) traffic.

Three types of non-MLPPP link groups for FE and GE ports are supported by the SmartEdge router. IPv4 and IPv6 traffic is supported for all three types. OSPF, RIP, ISIS, BGP, and DHCP protocols are supported for IPv4 traffic on all link groups. OSPFv3, RIPng, BGP, and DHCPv6-PD are supported for IPv6 traffic on all link groups. ISIS is not supported for IPv6 traffic on access link

groups. Route distribution among the supported routing protocols for each type of traffic is supported on all link groups.

An overview of each type of link group follows:

- Ethernet link group: An IEEE 802.3ad network-facing link group that bundles IPoE encapsulated circuits.

  Ports in an Ethernet link group must be network-facing and IPoE encapsulated and have identical configurations, but need not be configured on the same traffic card. You cannot mix FE ports with GE ports in the same link group. You cannot mix ports on different types of GE traffic cards.

  The ports of an Ethernet link group can be bridged. Details and restrictions are in Section 2 on page 7. A typical application of bridged link groups is shown in Figure 1.

  The outgoing traffic load in a dot1q link group or Ethernet link group is distributed stream by stream; that is, using the source and destination MAC addresses of each traffic stream, a hash algorithm assigns streams to circuits in the link group bundle. Incoming traffic can arrive on any active link. For details, see *Load Balancing*.

- dot1q link group: An IEEE 802.3ad network-facing link group that bundles 802.1Q encapsulated circuits; in other words, 802.1Q PVCs.

  Ports in a dot1q link group must be network-facing and be 802.1Q encapsulated and have identical configurations, but need not be configured on the same traffic card. You cannot mix FE ports with GE ports in the same link group. You cannot mix ports on different the types of GE traffic cards.

  The ports and circuits of a dot1q link group can be bridged. Details and restrictions are in Section 2 on page 7.

  The outgoing traffic load in a dot1q link group or Ethernet link group is distributed stream by stream; that is, using the source and destination MAC addresses of each traffic stream, a hash algorithm assigns streams to circuits in the link group bundle. Incoming traffic can arrive on any active link. For details, see *Load Balancing*.

- Access link group: A link group that bundles either PPPoE or 802.1Q single- or double-encapsulated (Q-in-Q) circuits. Access link groups support untagged traffic, single-tagged VLAN traffic, and double-tagged VLAN traffic. Access link group are used in subscriber-facing applications such as QOS. Specified in Part 3 of the IEEE 802.3ad 2000 specification, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*.

  The ports and circuits of an access link group can be bridged. Details and restrictions are in Section 2 on page 7.

The outgoing traffic in an access link group is distributed among the active ports but is not load balanced; that is, the various links in the link bundle, as determined by session and circuit parameters, are assigned subgroup IDs, sub-protection group IDs (SPG-IDs), and are distributed for each ID (not by source and destination address as in load balancing) so that all traffic in the same subgroup goes through the same port. Incoming traffic can arrive on any active link.

When more than one port is active in an access link group, the system selects one of the active ports as an egress port for the circuit's traffic. By default, the system attempts to distribute circuits evenly across all active ports using a round-robin algorithm. For example, if there are two active ports in the link group, half of the circuits will use the one active port for egress traffic and the other half will use the other active port for egress traffic. You can change this behavior by using the **`protect-group incoming-port`** command (in access link-group configuration mode). In this case, subscriber egress traffic will egress on the same port on which the subscriber authentication request came in. For example, if a PPPoE subscriber request was received on port 2, the subscriber's egress traffic will egress on port 2.

An access LAG can be configured in either non-economical or economical mode. The economical mode reduces the SmartEdge router resources used by the access link group, allowing more of these resources to become available to other applications. In non-economical mode (the default), circuit information on active ports is replicated on all standby ports. After an active port fails, no packets are lost when the standby port becomes active. In economical mode, which must be explicitly configured, the circuit information for 802.1Q single- or double-encapsulated (Q-in-Q) circuits on active ports is not replicated on the standby ports. After an active port fails and its standby port becomes active, a small number of packets on these circuits are lost in the transition. Circuit information on IPoE- (the default) or PPPoE-encapsulated circuits is replicated on all standby ports regardless of mode.

An MDRR policy can be applied to an access link group including 802.1Q VLANs under the link group. For more information, see *Modified Deficit Round-Robin Policies*.

1.2 QoS Support for 802.3ad LAGs

The SmartEdge OS supports QoS for the following types of 802.3ad LAGs:

- Ethernet
- Dot1q
- Access

For detailed information about QoS support for 802.3ad LAGs, see *Configuring Circuits for QoS*.

1.3 Load Balancing and Load Distribution

For information on load balancing and load distribution, see *Load Balancing*.

1.4 Supported Link Aggregation Standards and Recommendations

The SmartEdge router supports the following link aggregation recommendations and standards:

- Ethernet link groups that comply with the IEEE 802.3ad 2000 specification.
- dot1q link groups that comply with the IEEE 802.3ad 2000 specification.
- Access link groups that comply with the specification for 802.3ad-based link aggregation using Link Aggregation Control Protocol (LACP).

1.5 Multilink PPP Link Groups of Channelized Ports

For information on Multilink PPP link groups, see the *Configuring MLPPP* document.

2 Configurations and Operations Tasks and Examples

This section provides tasks and examples for configuring and operating link aggregation.

Note: Unless otherwise noted, the SmartEdge 100 router supports all commands described in this document.

2.1 Configuring an Ethernet Link Group

This section includes the following topics:

- Configure an Ethernet Link Group
- Add an FE or a GE Port to an Ethernet Link Group
- Ethernet Link Group Example

2.1.1 Configuring an Ethernet Link Group

Ports in an Ethernet link group must be network-facing and IPoE-encapsulated, and have identical configurations, but need not be configured on the same traffic card. You cannot mix FE ports with GE ports in the same link group. You cannot mix ports on different types of GE traffic cards.

To configure an Ethernet link group, perform the tasks described in Table 1. Enter all commands in link group configuration mode, unless otherwise noted.

Table 1 Configure an Ethernet Link Group

Step	Task	Root Command	Notes
1.	Specify the context and access the context configuration mode.	*context*	Enter this command in global configuration mode.
2.	Create an interface for the link group and access the interface configuration mode.	*interface (context)*	Enter this command in context configuration mode.
3.	Assign an IPv4 address to the interface for the Ethernet link group.	*ip address (interface)*	This command does not apply to bridge link groups. Enter this command in interface configuration mode.

Table 1 Configure an Ethernet Link Group

Step	Task	Root Command	Notes
4.	Assign an IPv6 address to the interface for the link group.	*ipv6 address*	Use this command for either IPv6 or dual-stack (IPv4 and IPv6) traffic. This command does not apply to bridge link groups. Enter this command in interface configuration mode.
5.	Create an empty Ethernet link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	Enter this command in global configuration mode. Specify the **`ether`** keyword.
6.	Enter the following commands (step 6 through step 15) in link group configuration mode to set the parameters of the Ethernet link group:(1)		
7.	Bind the link group to an interface.	*bind interface*	You can bind to an IP interface or to a bridged interface. To create bridged LAG ports, bind to a bridged interface.
8.	Specify the static MAC addresses.	*bridge mac-entry*	This command applies only when bound to a bridged interface. Enter this command for the MAC address of each station known to be on this link group. The bridge dynamically learns the addresses of other stations as they connect to the link group.
9.	Assign a bridge profile.	*bridge profile*	This command applies only when bound to a bridged interface. The default trunk bridge profile is assigned automatically if you do not enter this command.(2)
10.	Configure bulk statistics for this link-group	*bulkstats schema*	Enter this command in link-group configuration mode
11.	Associate a description with the link group.	*description (link group)*	
12.	Enable LACP for the link group.	*lacp*	For all practical link-group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **`lacp`** command in link group configuration mode to enable LACP and set its parameters.

Table 1 Configure an Ethernet Link Group

Step	Task	Root Command	Notes
13.	Specify a MAC address for the link group.	*mac-address (link group)*	
14.	Specify the maximum number of links that can be in the active state.	*maximum-links*	If the number of links (ports) in the link group bundle exceeds the **`maximum-links`** setting, those links are set in standby mode, should any of the active links fail. The default is 8.
15.	Specify the minimum number of links that should be in the up state for the link group to be active.	*minimum-links*	The default is 1.
16.	Assign a spanning-tree profile.	*spanning-tree profile*	This command applies only when bound to a bridged interface.

*(1) The **rate circuit** and **qos** commands are not supported for Ethernet link groups.*
(2) Supported only if the bridge is a trunk type. Not supported if the bridge is a tributary type.

Note: An Ethernet link group is always enabled (operational). The **`shutdown`** command is not available in link group configuration mode for Ethernet link groups.

2.1.2 Adding an FE or a GE Port to an Ethernet Link Group

You configure the constituent FE or GE ports for a link group as described in *Configuring ATM, Ethernet, and POS Ports* but with these restrictions:

- The configuration of each port to be added to the link group must be identical; the only exception is the description of the port.
- You cannot attach a quality of service (QoS) metering, policing, or scheduling policy to an Ethernet or dot1q link group.
- All ports must have IPoE encapsulation; this encapsulation is the default.
- All ports must run at the same speed.
- You do not bind any port that you are adding to a link group; instead, you bind the link group to its interface.
- You must enable each port with the **`no shutdown`** command (in port configuration mode).

To add a constituent port to an Ethernet link group, perform the task in Table 2. Enter this command in port configuration mode.

Table 2 Add an FE or a GE Port to an Ethernet Link Group

Task	Root Command
Add an FE or a GE port to an Ethernet link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*

Each Ethernet link group is limited to eight ports. You cannot mix FE ports with GE ports in the same access link group or GE3, GE1020, or 10GE ports with any other type of GE ports. You can mix ports on FE traffic cards if the ports on the FE traffic cards are configured to run at 100 Mbps.

2.1.3 Ethernet Link Group Example

The following example shows how to create an interface, **etherx**, and assign it an IPv4 address, in the **local** context, create an Ethernet link group, **lg-ether** and bind it to the interface, **etherx**. Then the FE or GE ports are configured and added to the link group. In a dual stack configuration, also use the **`ipv6 address`** command to assign the interface an IPv6 address; in an IPv6-only configuration, use the **`ipv6 address`** command instead of the **`ip address`** command.

Create the link group interface and assign an IP address to it:

```
[local]Redback(config)#context local
[local]Redback(config-ctx)#interface etherx
[local]Redback(config-if)#ip address 172.16.0.1/24
[local]Redback(config-if)#exit
```

Create the link group and bind it to its interface:

```
[local]Redback(config)#link-group lg-ether ether
[local]Redback(config-link-group)#bind interface etherx local
```

Configure an FE port and add it to the link group:

```
[local]Redback(config-config)#port ethernet 5/4
[local]Redback(config-port)#no shutdown
[local]Redback(config-port)#link-group lg-ether
[local]Redback(config-port)#exit
```

Configure another FE port and add it to the link group:

```
[local]Redback(config-config)#port ethernet 5/5
[local]Redback(config-port)#no shutdown
[local]Redback(config-port)#link-group lg-ether
[local]Redback(config-port)#exit
```

2.2 Configuring a dot1q Link Group

This section describes how to configure network-facing ports with 802.1Q encapsulation.

2.2.1 Configuring a dot1q Link Group for 802.1Q-Encapsulated FE or GE Ports

Ports in a dot1q link group must be network-facing and 802.1Q encapsulated and have identical configurations, but need not be configured on the same traffic card. You cannot mix FE ports with GE ports in the same link group. You cannot mix ports on different the types of GE traffic cards.

To configure a dot1q link group for 802.1Q-encapsulated FE or GE ports, perform the tasks described in Table 3. Enter all commands in link group configuration mode, unless otherwise noted.

Table 3 Configure a dot1q Link Group for 802.1Q-Encapsulated FE or GE Ports

Step	Task	Root Command	Notes
1.	Specify the context and access the context configuration mode.	*context*	Enter this command in global configuration mode.
2.	Create an interface for the link group and access the interface configuration mode.	*interface (context)*	Enter this command in context configuration mode.
3.	Assign an IPv4 address to the interface for the link group.	*ip address (interface)*	This command applies only when the link group is not bound to a bridged interface. Enter this command in interface configuration mode.
4.	Assign an IPv6 address to the interface for the link group.	*ipv6 address*	Use this command for either IPv6 or dual-stack (IPv4 and IPv6) traffic. This command applies only when the link group is not bound to a bridged interface. Enter this command in interface configuration mode.
5.	Create an empty dot1q link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	Enter this command in global configuration mode. Specify the **`dot1q`** keyword.
6.	Enter the commands in step 6 through step 15 link group configuration mode to set the parameters of the dot1q link group.(1)		

Table 3 Configure a dot1q Link Group for 802.1Q-Encapsulated FE or GE Ports

Step	Task	Root Command	Notes
7.	Bind the link group to an interface.	*bind interface*	You can bind to an IP interface or a bridged interface. To create bridged LAG ports, bind to a bridged interface.
8.	Specify the static MAC addresses.	*bridge mac-entry*	This command applies only when bound to a bridged interface. Enter this command for the MAC address of each station known to be on this link group. The bridge dynamically learns the addresses of other stations as they connect to the link group.
9.	Assign a bridge profile.	*bridge profile*	This command applies only when bound to a bridged interface. The default trunk bridge profile is assigned automatically if you do not enter this command. Supported only if the bridge is a trunk type. Not supported if the bridge is a tributary type.
10.	Configure bulk statistics for this link-group	*bulkstats schema*	Enter this command in link-group configuration mode
11.	Associate a description with the link group.	*description (link group)*	
12.	Enable LACP for the link group.	*lacp*	For all practical link group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **`lacp`** command in link group configuration mode to enable LACP and set its parameters.
13.	Specify a MAC address for the link group.	*mac-address (link group)*	
14.	Specify the maximum number of links that can be in the active state.	*maximum-links*	If the number of links (ports) in the link group bundle exceeds the **`maximum-links`** setting, those links are set in standby mode, should any of the active links fail. The default is 8.

Table 3 Configure a dot1q Link Group for 802.1Q-Encapsulated FE or GE Ports

Step	Task	Root Command	Notes
15.	Specify the minimum number of links that should be in the up state for the link group to be active.	*minimum-links*	The default is 1.
16.	Assign a spanning-tree profile.	*spanning-tree profile*	This command applies only when bound to a bridged interface.

*(1) The **rate circuit** and **qos** commands are not supported for dot1q link groups.*

Note: A dot1q link group is always enabled (operational). The **`shutdown`** command is not available in link group configuration mode for dot1q link groups.

2.2.2 Configuring an Aggregated 802.1Q PVC in the dot1q Link Group

Ports in a dot1q link group must be 802.1Q encapsulated and have identical configurations, but need not be configured on the same traffic card. You cannot mix FE ports with GE ports in the same link group. You cannot mix ports on different the types of GE traffic cards.

For FE or GE ports configured with 802.1Q encapsulation, the 802.1Q PVCs and the untagged traffic on each port are referred to as the constituent PVCs. If the constituent PVCs are aggregated in a link group as separate logical pipes, they are referred to as aggregated PVCs.

You create an aggregated 802.1Q PVC to represent the PVCs with the same tag value on the FE or GE ports that you intend to add to the dot1q link group.

To configure an aggregated 802.1Q PVC in the dot1q link group, perform the tasks described in Table 4; enter all commands in link PVC configuration mode, unless otherwise noted.

Table 4 Configure an Aggregated 802.1Q PVC in the 802.1Q Link Group

Step	Task	Root Command	Notes
1.	Select an existing dot1q link group and access the link group configuration mode.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	Enter this command in global configuration mode. Specify the **`dot1q`** keyword and the name of an existing dot1q link group.
2.	Enter the commands in step 3 through step 13 in link group configuration mode to set the parameters of the dot1q link group.(1)		

Table 4 Configure an Aggregated 802.1Q PVC in the 802.1Q Link Group

Step	Task	Root Command	Notes
3.	Specify the static MAC addresses.	*bridge mac-entry*	This command applies only when bound to a bridged interface. Enter this command for the MAC address of each station known to be on this link group. The bridge dynamically learns the addresses of other stations as they connect to the link group.
4.	Assign a bridge profile.	*bridge profile*	This command applies only when bound to a bridged interface. The default trunk bridge profile is assigned automatically if you do not enter this command. Supported only if the bridge is a trunk type. Not supported if the bridge is a tributary type.
5.	Associate a description with the link group.	*description (Dot1Q)*	Enter this command in dot1q configuration mode.
6.	Assign a spanning-tree profile.	*spanning-tree profile*	This command applies only when bound to a bridged interface.
7.	Specify the forward output or policy.	• *forward output (circuit)* • *forward policy out* • *forward policy in*	
8.	Enable LACP for the link group.	*lacp*	For all practical link group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **`lacp`** command in link group configuration mode to enable LACP and set its parameters.

Table 4 Configure an Aggregated 802.1Q PVC in the 802.1Q Link Group

Step	Task	Root Command	Notes
9.	Specify a MAC address for the link group.	*mac-address (link group)*	
10.	Specify the maximum number of links that can be in the active state.	*maximum-links*	If the number of links (ports) in the link group bundle exceeds the **`maximum-links`** setting, those links are set in standby mode, should any of the active links fail. The default is 8.
11.	Specify the minimum number of links that should be in the up state for the link group to be active.	*minimum-links*	The default is 1.
12.	Create an aggregated 802.1Q PVC in the link group and access the link PVC configuration mode.	*dot1q pvc*	Multiple PVC can be created in the dot1q link group.
13.	Bind the aggregated 802.1Q PVC to its interface.	*bind interface*	Enter in link PVC configuration mode. Bind each PVC created in the previous step. You can bind to an IP interface or a bridged interface. To create bridged LAG 802.1Q PVCs, bind to a bridged interface.(2)

*(1) The **rate circuit** and **qos** commands are not supported for dot1q link groups.*
(2) The SmartEdge router does not support binding an aggregated 802.1Q PVC in an dot1q link group to a bridged interface.

2.2.3 Adding an FE or a GE Port to the dot1q Link Group

You configure the FE or GE ports for a link group as described in *Configuring ATM, Ethernet, and POS Ports* but with these restrictions:

- The configuration of each port to be added to the link group must be identical; the only exception is the description of the port.
- All ports must have 802.1Q encapsulation; IPoE encapsulation is the default.
- All ports must be at the same speed.

- You cannot attach a quality of service (QoS) metering, policing, or scheduling policy to an Ethernet or dot1q link group.
- You do not bind any port that you are adding to a link group; instead, you bind the link group and the aggregated PVCs to their interfaces.
- You must enable each port with the **`no shutdown`** command (in port configuration mode).

To add a constituent port to a dot1q link group, perform the task described in Table 5. Enter this command in port configuration mode.

Table 5 Configure and Add an FE or a GE Port to the dot1q Link Group

Task	Root Command
Add an FE or a GE port to a dot1q link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*

Each dot1q link group is limited to eight ports. You cannot mix FE ports with GE ports in the same access link group or GE3, GE1020, or 10GE ports with any other type of GE ports. You can mix ports on FE traffic cards if the ports on the FE traffic cards are configured to run at 100 Mbps.

Note: Adding an FE or a GE port to the link group creates an 802.1Q PVC on that port for each aggregated 802.1Q PVC that you created.

2.2.4 dot1q Link Group Aggregated PVCs Example

The following example shows how to create the interfaces, **vlans**, **vlan10**, and **vlan20**, in the **local** context, assigns an IP address to each one, creates a dot1q link group, **lg-vlans** and binds it to the **vlans** interface. Then, the example shows how to configure two 802.1Q PVCs and binds them to the **vlan10** and **vlan20** interfaces. Finally, the FE or GE ports are configured and added to the link group. In a dual stack configuration, also use the **`ipv6 address`** command to assign the interfaces an IPv6 address; in an IPv6-only configuration, use the **`ipv6 address`** command instead of the **`ip address`** command.

Create the link group interface and assign an IP address to it:

```
[local]Redback(config)#context local
[local]Redback(config-ctx)#interface vlans
[local]Redback(config-if)#ip address 172.16.0.1/24
[local]Redback(config-if)#exit
```

Create the link group and bind it to its interface:

```
[local]Redback(config)#link-group lg-vlans dot1q
[local]Redback(config-link-group)#bind interface vlans local
```

Create the PVC interfaces and assign an IP address to each one:

```
[local]Redback(config)#context local
[local]Redback(config-ctx)#interface vlan10
[local]Redback(config-if)#ip address 172.16.1.1/24
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#interface vlan20
[local]Redback(config-if)#ip address 172.16.2.1/24
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#exit
```

Create PVC 10 and bind it to its interface:

```
[local]Redback(config)#link-group lg-vlans dot1q
[local]Redback(config-link-group)#dot1q pvc 10
[local]Redback(config-link-pvc)#bind interface vlan10 local
[local]Redback(config-link-pvc)#exit
```

Create PVC 20 and bind it to its interface:

```
[local]Redback(config-link-group)#dot1q pvc 20
[local]Redback(config-link-pvc)#bind interface vlan20 local
[local]Redback(config-link-pvc)#exit
[local]Redback(config-link-group)#exit
```

Configure another FE port and add it to the link group:

```
[local]Redback(config-config)#port ethernet 5/2
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#no shutdown
[local]Redback(config-port)#link-group lg-vlans
[local]Redback(config-port)#exit
```

Configure another FE port and add it to the link group:

```
[local]Redback(config-config)#port ethernet 5/3
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#no shutdown
[local]Redback(config-port)#link-group lg-vlans
[local]Redback(config-port)#exit
```

2.3 Configuring an Access Link Group

This section describes how to configure subscriber-facing ports with PPPoE or 802.1Q encapsulation.

2.3.1 Configuration Guidelines for Access Link Groups

Consider the following guidelines when configuring access link groups:

- Ports in an access link group must have PPPoE or 802.1Q encapsulation and identical configurations, but need not be configured on the same traffic card. The encapsulation of the port and encapsulation of the link group must match. The system displays an error message if they do not match.

- All member ports in an access link-group bundle must belong to the same type of traffic card - PPA2 or PPA3. Additionally, all member ports must have same port speed.

- You can create individual 802.1Q PVCs, ranges of static 802.1Q PVCs, or ranges of on-demand 802.1Q PVCs as aggregated PVCs within an access link group. You can also create and aggregate these PVCs within an 802.1Q tunnel, a range of static 802.1Q tunnels, or a range of on-demand 802.1Q tunnels.

- In addition to tunnel encapsulation, encapsulation types include 802.1Q, PPPoE, and multiprotocol. Raw encapsulation is not supported.

- You configure any 802.1Q tunnel or PVC in link PVC configuration mode as you would in dot1q PVC configuration mode, including the assignment of an 802.1Q profile For information about configuring 802.1Q tunnels and PVCs, see *Configuring Circuits*.

- The encapsulation of the link group determines which of the various **`bind`** commands are available to bind the link group to its interface. For access link groups with PPPoE encapsulation, the choices are **`bind authentication`** or **`bind subscriber`** (in link group configuration mode). The maximum number the sessions must be greater than one if you specify the **`bind authentication`** command. For access link groups with 802.1Q encapsulation, the only choice is **`bind interface`**.

- You can configure both static and dynamic clientless IP service selection (CLIPS) circuits on Ethernet ports and aggregated 802.1Q PVCs within an access link group. CLIPS over access link groups with internal DHCP server is also supported.

- Table 6 lists the types of cross-connections that you can configure with 802.1Q PVCs and tunnels within an access link group.

Table 6 Access Link Group Cross-Connections

Circuit Inside Access Link Group	Circuit Outside Access Link Group
802.1Q PVC	802.1Q PVC
802.1Q PVC inside an 802.1Q tunnel	802.1Q PVC inside an 802.1Q tunnel
802.1Q PVC	802.1Q PVC inside an 802.1Q tunnel
802.1Q PVC inside an 802.1Q tunnel	802.1Q PVC
802.1Q PVC	ATM RFC 1483 bridged PVC
802.1Q PVC inside an 802.1Q tunnel	ATM RFC 1483 bridged PVC

- You can specify quality of service (QoS) parameters, such as maximum and minimum rates, priority, and hierarchical mode; and QoS policies, such as metering, policing, and scheduling.
- The encapsulation of the 802.1Q PVC, whether it is a tunnel or a PVC and whether it is a range of PVCs, determines which of the various bind commands are available to bind the PVC or its range to its interface.
- For FE or GE ports configured with 802.1Q encapsulation, the 802.1Q PVCs and the untagged traffic on each port are referred to as the constituent PVCs. If the constituent PVCs are aggregated in a link group as separate logical pipes, they are referred to as aggregated PVCs.
- You can create an aggregated 802.1Q PVC or 802.1Q tunnel to represent the PVCs with the same tag value on the FE or GE ports that you intend to add to an access link group with 802.1Q encapsulation.

2.3.2 Configuring an Access Link Group for FE or GE Ports

Use Table 7 to configure an access link group for FE or GE ports with no aggregated 802.1Q PVCs or tunnels. Use Table 9 to configure an access link group with aggregated 802.1Q PVCs or tunnels.

Table 7 Configure an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
1.	Specify the context and access the context configuration mode.	*context*	Enter this command in global configuration mode.
2.	Create an interface for the link group and access the interface configuration mode.	*interface (context)*	Enter this command in context configuration mode.

Table 7 Configure an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
3.	Assign an IPv4 address to the interface for the link group.	*ip address (interface)*	This command does not apply to bridge link groups. Enter this command in interface configuration mode.
4.	Assign an IPv6 address to the interface for the link group.	*ipv6 address*	Use this command for either IPv6 or dual-stack (IPv4 and IPv6) traffic. This command does not apply to bridge link groups. Enter this command in interface configuration mode.
5.	Create an access link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	Enter this command in global configuration mode. Specify the **`access`** keyword.
6.	Enable LACP for the link group.	*lacp*	For all practical link group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **`lacp`** command in link group configuration mode to enable LACP and set its parameters.
7.	Configure the link group to operate in strict hierarchical mode.	*qos hierarchical mode strict*	Enter this command in link group configuration mode. For access link group configurations on PPA2 (TM cards), QoS hierarchical mode strict is required.
8.	Use Table 8 to set the optional parameters of the link group.		
9.	To bind the access link group, enter one of the following commands in link group configuration mode:		
	- Create a static binding to the interface.	*bind interface*	Applies if the link group encapsulation command is set to **`dot1q`** (802.1Q) or IPoE (the default). You can bind to an IP interface or a bridged interface. To create bridged LAG ports, bind to a bridged interface.

Table 7 Configure an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
	- Create a dynamic binding to the interface.	*bind authentication*	Applies if the link group **encapsulation** command is set to **pppoe**. You must specify a value greater than 1 for the ***max-ses*** argument.
	- Create a static binding through a subscriber record to the interface.	*bind subscriber*	Applies if the link group **encapsulation** command is set to **pppoe**.

Note: An access link group is always enabled (operational). The **shutdown** command is not available in link group configuration mode for access link groups.

2.3.3 Configuring the Optional Parameters of an Access Link Group for FE or GE Ports

Use Table 8 to configure the optional parameters of an access link group for FE or GE ports. Enter all commands in link group configuration mode unless otherwise noted.

Table 8 Configure the Optional Parameters of an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
1.	Optional. Specify an encapsulation type for the link group.	*encapsulation (link group mode)*	The default encapsulation is IPoE.
2.	Optional. Specify the static MAC addresses.	*bridge mac-entry*	This command applies only when the link group is bound to a bridged interface. Enter this command for the MAC address of each station known to be on this bridge. The bridge dynamically learns the addresses of other stations as they connect to the link group.
3.	Optional. Assign a bridge profile.	*bridge profile*	This command applies only to link groups bound to a bridged interface. The default tributary bridge profile is assigned automatically if you do not enter this command.(1)
4.	Configure bulk statistics for this link-group	*bulkstats schema*	Enter this command in link-group configuration mode

Table 8 Configure the Optional Parameters of an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
5.	Optional. Specify a text string description of the access link group.	*description (link group)*	This string is used as the prefix to the NAS-PORT-ID attribute in RADIUS if the command **`radius attribute nas-port-id format modified-agent-circuit-id prefix-lg-description`** has been entered. This step applies only to link group subscribers.
6.	Optional. Specify the forward output or policy.	• *forward output (circuit)* • *forward policy out* • *forward policy in*	
7.	Optional. Enable L2VPN bindings on this link group.	*l2vpn (ctx-name)*	
8.	Optional. Specify a MAC address for the link group.	*mac-address (link group)*	
9.	Optional. Specify the maximum number of links that can be in the active state.	*maximum-links*	If the number of links (ports) in the link group bundle exceeds the **`maximum-links`** setting, those links are set in standby mode, should any of the active links fail. The default is eight.
10.	Optional. Specify the minimum number of links that should be in the up state for the link group to be active.	*minimum-links*	The default is one.
11.	Optional. Specify the algorithm by which the port for outgoing subscriber traffic is chosen.	*protect-group*	
12.	Optional. Configure the optional QoS parameters of the 802.1Q PVC.	See the document, *Configuring Circuits for QoS* for use of the **`qos`** commands.	For access link group configurations on PPA2 (TM cards), QoS hierarchical mode strict is required.

Table 8 Configure the Optional Parameters of an Access Link Group for FE or GE Ports

Step	Task	Root Command	Notes
13.	Optional. Configure a different rate for a circuit that has a QoS metering, policing, modified deficit round-robin (MDRR), or priority weighted fair queuing (PWFQ) policy attached to it.	*rate circuit*	
14.	Optional. Enable clientless IP service selection (CLIPS).	*service clips dhcp* , *service clips (static)*	See *Configuring CLIPS* for the full set of CLIPS configuration commands.
15.	Optional. Assign a spanning-tree profile.	*spanning-tree profile*	This command applies only when bound to a bridged interface.

(1) Supported only if the bridge is a tributary type. Not supported if the bridge is a trunk type.

2.3.4 Configuring an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Use Table 9 to configure an access link group with aggregated 802.1Q PVCs or tunnels. 802.1Q PVCs are also called VLANs. Use Table 7 to configure an access link group for FE or GE ports with no aggregated 802.1Q PVCs or tunnels.

Table 9 Configure an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Step	Task	Root Command	Notes
1.	Specify the context and access the context configuration mode.	*context*	Enter this command in global configuration mode.
2.	Create an interface for the link group and access the interface configuration mode.	*interface (context)*	Enter this command in context configuration mode.
3.	Assign an IPv4 address to the interface for the link group.	*ip address (interface)*	This command does not apply to bridge link groups. Enter this command in interface configuration mode.
4.	Assign an IPv6 address to the interface for the link group.	*ipv6 address*	Use this command for either IPv6 or dual-stack (IPv4 and IPv6) traffic. This command does not apply to bridge link groups. Enter this command in interface configuration mode.

Table 9 Configure an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Step	Task	Root Command	Notes
5.	Create an access link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	Enter this command in global configuration mode. Specify the **access** keyword. See Table 12 for economical link groups.
6.	Enable LACP for the link group.	*lacp*	For all practical link group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **lacp** command in link group configuration mode to enable LACP and set its parameters.
7.	Configure the link group for hierarchical mode strict.	*qos hierarchical mode strict*	Enter this command in link group configuration mode. For access link group configurations on PPA2 (TM cards), QoS hierarchical mode strict is required.
8.	Specify 802.1Q encapsulation type for the link group.	*encapsulation (link group mode)*	Enter the **encapsulation** command with the **dot1q** keyword in link group configuration mode.
9.	Optional. Associate a description with the link group.	*description (link group)*	Enter this command in link group configuration mode.
10.	Optional. Specify the tunnel type for this link group. Applies only if configuring an 802.1Q tunnel in the next step.	*dot1q tunnel*	Enter this command in link group configuration mode.

Table 9 Configure an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Step	Task	Root Command	Notes
11.	Create an aggregated 802.1Q PVC or tunnel in the link group and access the link PVC configuration mode.	*dot1q pvc* or *dot1q pvc transport*	Enter this command in link group configuration mode: • To create an 802.1Q tunnel, enter this command with the **`encapsulation 1qtunnel`** keywords. • To create an aggregated 802.1Q PVC not in a tunnel, enter this command with no specified encapsulation or specify the **`multi`**, **`raw`**, or **`pppoe`** encapsulation. • To create an aggregated 802.1Q PVC within an 802.1Q tunnel, first create the tunnel. Next, exit dot1q PVC configuration mode to re-enter the link group configuration mode for this access link group (step 4). Enter the **`dot1q PVC`** command with the ***`tunl-vlan-id:start-vlan-id`*** arguments.
12.	Use Table 10 to set the optional parameters of the aggregated 802.1Q PVC or 802.1Q tunnel.		
13.	Bind the aggregated 802.1Q PVC with one of the following tasks: Unless otherwise stated, enter these commands in link PVC configuration mode.		

Table 9 Configure an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Step	Task	Root Command	Notes
	- Create a static binding to an interface.	*bind interface*	This binding is supported on PVCs with: • IPoE encapsulation (default) • Multiprotocol encapsulation Enter this command only if you are not cross-connecting the PVC. You can bind to an IP interface or a bridged interface. To create bridged aggregated 802.1Q PVCs, bind to a bridged interface. The SmartEdge router does not support binding an aggregated 802.1Q PVC in an access link group to a bridged interface when the interface encapsulation is PPPoE or multibind.
	- Create a restricted or an unrestricted dynamic binding.	*bind authentication*	This binding is supported on PVCs with PPPoE encapsulation. You must specify the context to create a restricted dynamic binding. This binding is also supported on child circuits in dot1q child protocol configuration mode, but it is not supported on ipv6oe child circuit encapsulation.

Table 9 Configure an Access Link Group for Aggregated 802.1Q PVCs or 802.1Q Tunnels

Step	Task	Root Command	Notes
	- Create a static binding through a subscriber record or records to an interface.	*bind subscriber* *bind auto-subscriber*	Enter either of these commands only if you are not cross-connecting the PVC. This binding is supported on PVCs with: • IPoE encapsulation (default) • PPPoE encapsulation (**`bind subscriber`** command only) • Multiprotocol encapsulation This binding is also supported on child circuits in dot1q child protocol configuration mode, but it is not supported on ipv6oe child circuit encapsulation. You must specify the context to create a restricted dynamic binding.
	- Bind the PVC to a bypass for cross-connecting.	*bind bypass*	This binding is supported on all PVC encapsulations. Enter this command only if you are cross-connecting the PVC and have no child circuits on it. If the PVC has child circuits, you can bind them to a bypass.

2.3.5 Configuring the Optional Parameters of an Aggregated 802.1Q PVC (VLAN) of an Access Link Group

Use Table 10 to configure the optional parameters of an aggregated 802.1Q PVC of an access link group. Enter all commands in link PVC configuration mode unless otherwise noted.

Table 10 Configure the Optional Parameters of the Aggregated 802.1Q PVCs of an Access Link Group

Step	Task	Root Command	Notes
1.	Optional. Configure the access-line parameters.	*access-line access-node-id*, *access-line adjust*, *access-line agent-circuit-id*, *access-line rate*	

Table 10 Configure the Optional Parameters of the Aggregated 802.1Q PVCs of an Access Link Group

Step	Task	Root Command	Notes
2.	Optional. Specify the static MAC addresses.	*bridge mac-entry*	This command applies only when the aggregated 802.1Q PVC is bound to a bridged interface. Enter this command for the MAC address of each station known to be on this bridge. The bridge dynamically learns the addresses of other stations as they connect to the bridge. Not supported when the interface encapsulation is PPPoE or multibind.
3.	Optional. Assign a bridge profile.	*bridge profile*	This command applies only when bound to a bridged interface. The default tributary bridge profile is assigned automatically if you do not enter this command. Supported only if the bridge is a tributary type. Not supported if the bridge is a trunk type. Not supported when the interface encapsulation is PPPoE or multibind.
4.	Optional. Create a child circuit on a multiprotocol 802.1Q PVC, specify an encapsulation for it, and enter dot1q child protocol configuration mode.	*circuit protocol*	Enter this command only if you have encapsulated the PVC by using the **`multi`** keyword in the **`dot1q pvc`** command.
5.	Create a binding for cross-connecting the child circuit created in the previous step.	*bind bypass*	Enter this command only if you are cross-connecting the child circuit.
6.	Optional. Specify that the PVCs in the link group being configured are members of the specified circuit group.	*circuit-group-member*	

Table 10 Configure the Optional Parameters of the Aggregated 802.1Q PVCs of an Access Link Group

Step	Task	Root Command	Notes
7.	Optional. Associate a description with the aggregated 802.1Q PVC or tunnel.	*description (Dot1Q)*	
8.	Optional. Specify the forward output or policy.	• *forward output (circuit)* • *forward policy out* • *forward policy in*	
9.	Optional. Enable a watchdog timer for PVCs created on demand.	*idle-down*	This command applies only to PVCs created by using the **`on-demand`** keyword.
10.	Optional Specify IP ACL filters, if any.	*ip access-group (circuits)*	
11.	Optional. Associate the PVC with the IP address of the remote host on the circuit.	*ip host (PVC)*	Perform this task only for a PVC that you intend to bind directly to an interface. You cannot perform this task if you have created the PVC as part of a range of PVCs.
12.	Optional. Enable L2VPN bindings on this PVC.	*l2vpn (ctx-name)*	
13.	Optional. Specify a MAC address for the PVC.	*mac-address (link group)*	
14.	Optional. Configure the optional QoS parameters of the 802.1Q PVC.	See the document, *Configuring Circuits for QoS* for use of the **`qos`** commands.	For access link group configurations on PPA2 (TM cards), QoS hierarchical mode strict is required.
15.	Optional. Configure a different rate for a circuit that has a QoS metering, policing, modified deficit round-robin (MDRR), or priority weighted fair queuing (PWFQ) policy attached to it.	*rate circuit*	
16.	Optional. Enable clientless IP service selection (CLIPS).	*service clips (static)*, *service clips dhcp*	See *Configuring CLIPS* for the CLIPS configuration commands.
17.	Optional. Assign a spanning-tree profile.	*spanning-tree profile*	This command applies only when bound to a bridged interface.

2.3.6 Adding an FE or a GE Port to the Access Link Group

If the FE or GE ports are configured with 802.1Q encapsulation, the 802.1Q PVCs and the untagged traffic on each port, referred to as the constituent PVCs, are aggregated in separate logical pipes, referred to as aggregated PVCs.

You configure the FE or GE ports for an access link group as described in *Configuring ATM, Ethernet, and POS Ports* but with these restrictions:

- The configuration of each port to be added to the link group must be identical; the only exception is the description of the port.
- All ports must be at the same speed.
- You do not bind any port that you are adding to the access link group; instead, you bind the link group to its interface and the aggregated PVCs to their interfaces.
- You must enable each port with the **`no shutdown`** command (in port configuration mode).

To add a constituent FE or GE port to an access link group, perform the task described in Table 11. Enter this command in port configuration mode.

Table 11 Configure and Add an FE or a GE Port to the Access Link Group

Task	Root Command	Notes
Add an FE or a GE port to an existing access link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	The number of ports you can add to an access link group depends on the type of port and is described in the reference page for this command. Enter in port configuration mode.

You cannot mix FE ports with GE ports in the same access link group or GE3, GE1020, or 10GE ports with any other type of GE ports. You can mix ports on FE traffic cards if the ports on the FE traffic cards are configured to run at 100 Mbps.

Note: Adding an FE or a GE port to the link group creates an 802.1Q PVC on that port for each aggregated 802.1Q PVC that you created.

2.3.7 Configuring an Economical Access Link Group

To configure economical hierarchical nodes in access link groups follow the steps in Table 12. This table does not describe other features of access link groups, but this information can be found in other tables in this section.

Table 12 Configuring an Economical Access Link Group

Step	Task	Root Command	Notes
1.	Create an economical access link group.	*link-group (Global, DS-1, E1, Port Configuration Modes)*	In global configuration mode, enter the **`link-group`** command with the **`access`** and **`economical`** keywords. For a description of the restrictions and uses of economical access link groups see the link-group command page.
2.	Enable LACP for the link group.	*lacp*	For all practical link group configurations, LACP must be enabled. You can turn off LACP for debugging purposes. Use the **`lacp`** command in link group configuration mode to enable LACP and set its parameters.
3.	Configure the link group for hierarchical mode strict.	*qos hierarchical mode strict*	Enter this command in link group configuration mode. For access link group configurations on PPA2 (TM cards), QoS hierarchical mode strict is required.
4.	Optionally, create aggregated 802.1Q tunnel circuits and replicate their features on the active links in the bundle.	*dot1q pvc* or *dot1q pvc transport*	In link group configuration mode, enter the **`dot1q pvc`** command with the **`encapsulation 1qtunnel`** and **`replicate`** keywords. The *dot1q pvc* command description contains important information on the restrictions and uses of the **`replicate`** keyword.

2.3.8 Example of Access Link Group with Aggregated On-Demand PVCs

The following example shows how to create an access link group that aggregates two GE ports on a ge3–4–port traffic card. On-demand PVCs are created for the link group as they are needed to support link redundancy:

```
[local]Redback#config
Enter configuration commands, one per line, 'end' to exit
[local]Redback(config)#link-group test1 access
[local]Redback(config-link-group)#encapsulation dot1q
[local]Redback(config-link-group)#dot1q pvc on-demand 10 through 19
[local]Redback(config-dot1q-pvc)#end
[local]Redback#config
Enter configuration commands, one per line, 'end' to exit
[local]Redback(config)#port ethernet 5/2
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#link-group test1
[local]Redback(config-port)#end
[local]Redback#config
Enter configuration commands, one per line, 'end' to exit
[local]Redback(config)#port ethernet 5/3
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#link-group test1
[local]Redback(config-port)#end
```

After configuring the **test1** link group, use the **`show link-group... detail`** command to display the details of its configuration. Notice that the link group ID is **26**. The SmartEdge router automatically sets the link group ID value as shown in the following:

```
[local]Redback#show link-group test1 detail
Link-Group: test1, ID   : 26, State : Down
--------------------------------------------------------------------------------
Ccct count      : 2                                 Grouping        : LoadShare
Card Type       : ge-10-port                         Type            : access

Bindings        : Unbound                           Minimum-links   : 1

Maximum-links   : 1                                 Prot-Group-Type : round-robin
Internal Handle : 255/22:1:27/1/1/20
Description     :
Constituent Circuits:
 1. 5/2               (Down)|  0.00%
 2. 5/3               (Down)|  0.00%
```

2.3.9 Example of Aggregated 802.1Q Tunnel in a Cross Connected Access Link Group

The following example shows the creation of an aggregated 802.1Q tunnel configured in a cross connected access link group. An IP ACL filter is applied to the 802.1Q PVC in the tunnel:

```
[local]Redback(config)#link-group LGXC7 access
[local]Redback(config-link-group)#encapsulation dot1q
[local]Redback(config-link-group)#qos hierarchical mode strict
[local]Redback(config-link-group)#dot1q pvc 200 encapsulation 1qtunnel
[local]Redback(config-dot1q-pvc)#exit
[local]Redback(config-link-group)#dot1q pvc 200:1
[local]Redback(config-dot1q-pvc)#ip access-group ACL_1 context CTX_1 in count
[local]Redback(config-dot1q-pvc)#bind bypass
!
[local]Redback(config)#link-group LGXC8 access
[local]Redback(config-link-group)#encapsulation dot1q
[local]Redback(config-link-group)#qos hierarchical mode strict
[local]Redback(config-link-group)#dot1q pvc 200 encapsulation 1qtunnel
[local]Redback(config-dot1q-pvc)#exit
[local]Redback(config-link-group)#dot1q pvc 100:1
[local]Redback(config-dot1q-pvc)#bind bypass
!
[local]Redback(config)#port ethernet 11/2
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#link-group LGXC7
! Cannot add NON-TM card based port to an access link-group when qos hierarchical mode
! strict is set
!
[local]Redback(config)#port ethernet 11/3
[local]Redback(config-port)#encapsulation dot1q
[local]Redback(config-port)#link-group LGXC8
! Cannot add NON-TM card based port to an access link-group when qos hierarchical mode
! strict is set
!
[local]Redback(config)#xc-group xcg4
[local]Redback(config-xc-group)xc lg LGXC8 vlan-id 100:1 to lg LGXC7 vlan-id 200:1
```

2.3.10 Example of Economical Access Link Group

The following example shows the configuration of an economical access link group. In an economical access link group, replicas of the circuit features of active ports are not maintained on the standby ports; therefore, when an active port fails and its standby port becomes active, a small number of packets are lost in the transition. The economic behavior reduces the SmartEdge router resources used by the access link group, allowing more of these resources to become available to other applications. The **replicate** keyword applies to economical access link groups and specifies whether the circuit features of active ports are replicated on the other active ports as shown in the following:

```
[local]Redback(config)#link-group abc access economical
[local]Redback(config-link-group)#qos hierarchical mode strict
[local]Redback(config-link-group)#maximum-links 8
[local]Redback(config-link-group)#encapsulation dot1q
[local]Redback(config-link-group)#dot1q pvc 100 encapsulation 1qtunnel replicate
[local]Redback(config-dot1q-pvc)#qos policy queuing pwfq1
[local]Redback(config-dot1q-pvc)#dot1q pvc 100:1 encapsulation pppoe
[local]Redback(config-dot1q-pvc)#qos policy metering mymeter1 inherit
[local]Redback(config-dot1q-pvc)#qos rate maximum 300
[local]Redback(config-dot1q-pvc)#bind auth chap max 10
```

2.4 BFD Over 802.3ad Ethernet and dot1q Link Groups

The router supports single-session and multiple-session Bidirectional Forwarding Detection (BFD) over 802.3ad Ethernet and dot1q link groups. For more information about configuring BFD over link groups, see *Configuring BFD* and the *link-group (BFD)* command.

2.5 Monitoring and Troubleshooting

To monitor and troubleshoot link groups, perform the appropriate task listed in Table 13. Enter the **debug** commands in exec mode; enter the **show** commands in any mode.

Table 13 Link Group Operations

Task	Root Command
Enable the generation of debug messages for link group events.	*debug lg*
Display link groups, circuits, and bindings.	*show link-group*
Display LACP links on subscriber-facing Ethernet ports.	*show lacp actor*
Display the counters for all LACP links on the system.	*show lacp counters*
Display the LACP link group with a given identification number.	*show lacp lg-id*
Display LACP information for a link group with the specified name.	*show lacp lg-name*
Display the partner information for all the LACP circuits or the LACP circuit with a specified circuit handle.	*show lacp partner*
Display the counters for all LACP links on the system.	*show lacp system-id*

2.6 Bridged Link Groups Examples

In the following scenario, four link groups are created. Two network link groups, `lg1` and`lg3`, are bound to the `ac1` and `ac3` interfaces, respectively. Two access link groups, `lg2` and `lg4`, are bound to the `ac2` and `ac4` interfaces, respectively. The `ac1` and `ac2` interfaces are part of the `SE1` bridge, while the `ac3` and `ac4` interfaces are part of the `SE2` bridge.

Configure a network-facing bridge profile, `bp1`:

```
[local]Redback#config
Enter configuration commands, one per line, 'end' to exit
[local]Redback(config)#service multiple-service
[local]Redback(config)#bridge profile bp1
[local]Redback(config-bridge-profile)#trunk
[local]Redback(config-bridge-profile)#exit
```

Configure a subscriber-facing bridge profile, `bp2`:

```
[local]Redback(config)#bridge profile bp2
[local]Redback(config-bridge-profile)#mac-limit 10
[local]Redback(config-bridge-profile)#broadcast rate-limit 10 burst 333
[local]Redback(config-bridge-profile)#exit
```

Configure two bridge groups in the `local` context, `bridgeSE1` and `bridgeSE2`:

```
[local]Redback(config)#context local
[local]Redback(config-ctx)#bridge bridgeSE1
[local]Redback(config-ctx)#exit
[local]Redback(config-ctx)#bridge bridgeSE2
[local]Redback(config-ctx)#exit
```

In the `local` context, configure four bridged interfaces named `ac1`, `ac2`, `ac3`, and `ac4`. Attach two interfaces to each bridge; specifically, attach `ac1` and `ac2` to `bridgeSE1` bridge and attach `ac3` and `ac4` to `bridgeSE2` bridge:

```
[local]Redback(config-ctx)#interface ac1 bridge
[local]Redback(config-if)#bridge name bridgeSE1
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#interface ac2 bridge
[local]Redback(config-if)#bridge name bridgeSE1
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#interface ac3 bridge
[local]Redback(config-if)#bridge name bridgeSE2
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#interface ac4 bridge
[local]Redback(config-if)#bridge name bridgeSE2
[local]Redback(config-if)#exit
[local]Redback(config-ctx)#exit
```

Configure `lg1` as an Ethernet link group. Because Ethernet link groups must be network-facing, `lg1` is provisioned by `bp1` (a network-facing bridge profile), and bound to `ac1` (an interface to the `bridgeSE1` bridge group:

```
[local]Redback(config)#link-group lg1 ether
[local]Redback(config-link-group)#bind interface ac1 local
[local]Redback(config-link-group)#bridge profile bp1
[local]Redback(config-bridge-profile)#exit
```

Configure `lg2` as an access link group. Because access link groups must be subscriber facing, `lg2` is provisioned by bp2 (a subscriber-facing bridge profile) and bound to `ac2` (an interface to the `bridgeSE1` bridge group). The `bridgeSE1` bridge group has two interfaces, one that is network facing and the other that is subscriber facing:

```
[local]Redback(config)#link-group lg2 access
[local]Redback(config-link-group)#bind interface ac2 local
[local]Redback(config-link-group)#bridge profile bp2
[local]Redback(config-bridge-profile)#exit
```

Configure `lg3` as a dot1q link group. Because dot1q link groups must be network-facing, `lg3` is provisioned by `bp1` (a network-facing bridge profile), and bound to `ac3` (an interface to the `bridgeSE2` bridge group:

```
[local]Redback(config)#link-group lg3 dot1q
[local]Redback(config-link-group)#dot1q pvc 1
[local]Redback(config-link-pvc)#bind interface ac3 local
[local]Redback(config-link-pvc)#bridge profile bp1
[local]Redback(config-bridge-profile)#exit
```

Configure `lg4` as an access link group. Because access link groups must be subscriber facing, `lg4` is provisioned by bp2 (a subscriber-facing bridge profile) and bound to `ac4` (an interface to the `bridgeSE2` bridge group). The `bridgeSE2` bridge group has two interfaces, one that is network- facing and the other that is subscriber facing:

```
[local]Redback(config)#link-group lg4 access
[local]Redback(config-link-group)#encap dot1q
[local]Redback(config-link-group)#dot1q pvc 1
[local]Redback(config-dot1q-pvc)#bind interface ac4 local
[local]Redback(config-dot1q-pvc)#bridge profile bp2
[local]Redback(config-dot1q-pvc)#exit
[local]Redback(config-link-group)#exit
```

The following lines show the resulting configuration:

```
[local]Redback#show config link-group
Building configuration...

Current configuration:
!
link-group lg2 access
 bind interface ac2 local
!
link-group lg4 access
 encapsulation dot1q
 dot1q pvc 1
  bind interface ac4 local
!
link-group lg1 ether
 bind interface ac1 local
!
link-group lg3 dot1q
 dot1q pvc 1
   bind interface ac3 local
!
!
end
[local]Redback#show config interface
Building configuration...

Current configuration:
context local
!
 interface ac1 bridge
  bridge name bridgeSE1
!
 interface ac2 bridge
  bridge name bridgeSE1
!
 interface ac3 bridge
  bridge name bridgeSE2
!
 interface ac4 bridge
  bridge name bridgeSE2
!
 interface mgmt
  ip address 10.18.17.102/24
!
```

2.7 Multichassis Link Aggregation Example

This section provides an example of multichassis link aggregation, where two systems share a common endpoint in a SmartEdge router. LACP manages the

connections in an access link group bundle so that only one link to one satellite chassis is active at any time:

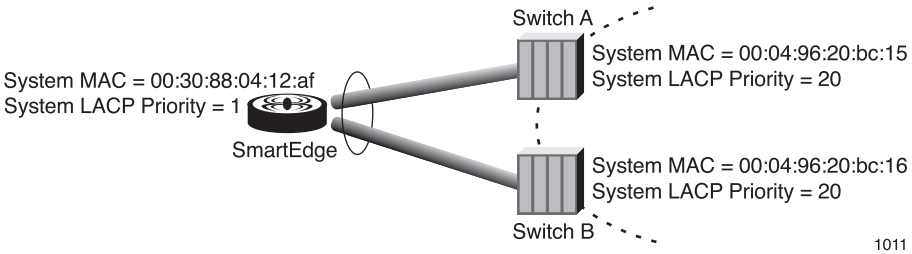

Figure 2 Multichassis Link Aggregation

The following example shows how to configure the preceding illustrated system. The first set of commands create and configure the access link group named `LAG-1`, which bundles the two links to the two external chassis:

```
[local]Redback(config)#system lacp priority 1
[local]Redback(config)#link-group LAG-1 access
[local]Redback(config-link-group)#bind interface LAG-1 local
[local]Redback(config-link-group)#mac-address auto
[local]Redback(config-link-group)#lacp active
[local]Redback(config-link-group)#lacp ignore-system-id
[local]Redback(config-link-group)#maximum-links 1
```

The second set of commands adds the SmartEdge router port that interfaces to Switch A into the link group bundle:

```
[local]Redback(config)#port ethernet 2/6
[local]Redback(config-port)#link-group LAG-1
[local]Redback(config-link-group)#lacp priority 20
```

The third set of commands adds the SmartEdge router port that interfaces to Switch B into the link group bundle:

```
[local]Redback(config)#port ethernet 3/6
[local]Redback(config-port)#link-group LAG-1
[local]Redback(config-link-group)#lacp priority 20
```

The following configuration guidelines apply to configuration of the multichassis access link groups:

- Set the SmartEdge router priority to 0, 1, or any other value that is higher in priority than the satellite LACP systems so that the system is elected the LACP master.

  `system lacp priority` command (global configuration mode)

The satellite LACP systems should have system priorities set to `2` or higher (lower priority than the SmartEdge router). The default value is `2`.

- Configure the link aggregation group by using the **`link-group`** command as one of the following types:
  - **`link-group`**... **`access`**
  - **`link-group`**... **`ether`**
  - **`link-group`**... **`dot1q`**

  Multichassis link aggregation is supported only in access, Ethernet, and dot1q link groups.
- Set the maximum number of active links in the link group to 1.

  `maximum-links` command (link group configuration mode)
- Configure the link group to ignore the system ID.

  `lacp ignore-system-id` command (link group configuration mode)

Glossary

802.1Q PVC
802.1Q PVCs are also referred to as VLANs.

Access link group
A link group that bundles either PPPoE or 802.1Q single- or double-encapsulated (Q-in-Q) circuits. Access link groups support untagged traffic, single-tagged VLAN traffic, and double-tagged VLAN traffic. Access link group are used in subscriber-facing applications such as QOS. Specified in Part 3 of the IEEE 802.3ad 2000 specification, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*.

dot1q link group
A network-facing link group that bundles 802.1Q-encapsulated circuits; in other words, 802.1Q PVCs. Specified in Part 3 of the IEEE 802.3ad 2000 specification, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*.

Ethernet link group
A network-facing link group that bundles IPoE-encapsulated circuits. Specified in Part 3 of the IEEE 802.3ad 2000 specification, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

inner VLAN
An 802.1Q PVC inside an outer VLAN.

LAG
Link aggregation group; specifically, 802.3ad link groups.

link group
The term link group as used in this document includes MLPPP, MFR, and LAG link groups.

outer VLAN
A VLAN inside which multiple VLANs have been configured. The inner VLANs are double-tagged 802.1Q PVCs; that is, the outer VLAN is given an ID and each of the inner VLANs is given its own ID.

Q-in-Q
A configuration consisting of an 802.1Q tunnel containing one or more single-tagged VLANs.

VLAN
A virtual LAN. Also referred to as an 802.1Q PVC. Optionally, the VLAN can be an inner VLAN.

A VLAN is a separate, administratively defined, subgroup of a bridged LAN. Bridged LANs and 802.1Q encapsulation are described in the *802.1Q IEEE Standard for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks* specification, which defines an architecture and bridging protocols for the partitioning of a bridged LAN into VLANs.