CHAPTER 34

Configuring Link Aggregation on the ML-MR-10 card

This chapter applies to the ML-MR-10 card and describes how to configure link aggregation for the ML-Series cards, both EtherChannel and packet-over-SONET/SDH (POS) channel. For additional information about the Cisco IOS commands used in this chapter, refer to the *Cisco IOS Command Reference* publication.

This chapter contains the following major sections:

Understanding Link Aggregation

The ML-MR-10 card offers both EtherChannel and POS channel. Traditionally EtherChannel is a trunking technology that groups together multiple full-duplex IEEE 802.3 Ethernet interfaces to provide fault-tolerant high-speed links between switches, routers, and servers. EtherChannel forms a single higher bandwidth routing or bridging endpoint and was designed primarily for host-to-switch connectivity. The ML-MR-10 card extends this link aggregation technology to bridged POS interfaces. POS channel is only supported with LEX encapsulation.

Link aggregation provides the following benefits:

- Logical aggregation of bandwidth
- Load balancing
- Fault tolerance

Port channel is a term for both POS channel and EtherChannel. The port channel interface is treated as a single logical interface although it consists of multiple interfaces. Each port channel interfaces consists of one type of interface, either Fast Ethernet, Gigabit Ethernet, or POS. You must perform all port channel configurations on the port channel (EtherChannel or POS channel) interface rather than on the individual member Ethernet or POS interfaces. You can create the port channel interface by entering the **interface port-channel** interface configuration command.

Note You must perform all Cisco IOS configurations—such as bridging, routing, or parameter changes such as an MTU change—on the port channel (EtherChannel or POS channel) interface rather than on individual member Ethernet or POS interfaces.

Port channel connections are fully compatible with IEEE 802.1Q trunking and routing technologies. IEEE 802.1Q trunking can carry multiple VLANs across a port channel.

Each ML-MR-10 card supports up to ten port channel interfaces. A maximum of ten Gigabit Ethernet ports can be added into one Port-Channel.

Note If the number of POS ports configured on the ML-MR-10 are 26, the MLMR-10 card supports two port channel interfaces. However, a maximum of ten Gigabit Ethernet ports can be added into one port channel.

Caution The EtherChannel interface is the Layer 2/Layer 3 interface. Do not enable Layer 3 addresses on the physical interfaces. Do not assign bridge groups on the physical interfaces because doing so creates loops.

Caution Before a physical interface is removed from an EtherChannel (port channel) interface, the physical interface must be disabled. To disable a physical interface, use the **shutdown** command in interface configuration mode.

Note Link aggregation across multiple ML-Series cards is not supported.

Note Policing is not supported on port channel interfaces.

Note The ML-Series does not support the routing of Subnetwork Access Protocol (SNAP) or Inter-Switch Link (ISL) encapsulated frames.

Configuring EtherChannel

You can configure an FEC or a GEC by creating an EtherChannel interface (port channel) and assigning a network IP address. All interfaces that are members of a FEC or a GEC should have the same link parameters, such as duplex and speed.

To create an EtherChannel interface, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)#` **`interface port-channel`** *`channel-number`*	Creates the EtherChannel interface. You can configure up to 6 FECs on the ML100T-12, 4 FECs on the ML100X-8, and 1 GEC on the ML1000-2.
Step 2	`Router(config-if)#` **`ip address`** *`ip-address subnet-mask`*	Assigns an IP address and subnet mask to the EtherChannel interface (required only for Layer 3 EtherChannel).
Step 3	`Router(config-if)#` **`end`**	Exits to privileged EXEC mode.
Step 4	`Router#` **`copy running-config startup-config`**	(Optional) Saves configuration changes to NVRAM.

For information on other configuration tasks for the EtherChannel, refer to the *Cisco IOS Configuration Fundamentals Configuration Guide*.

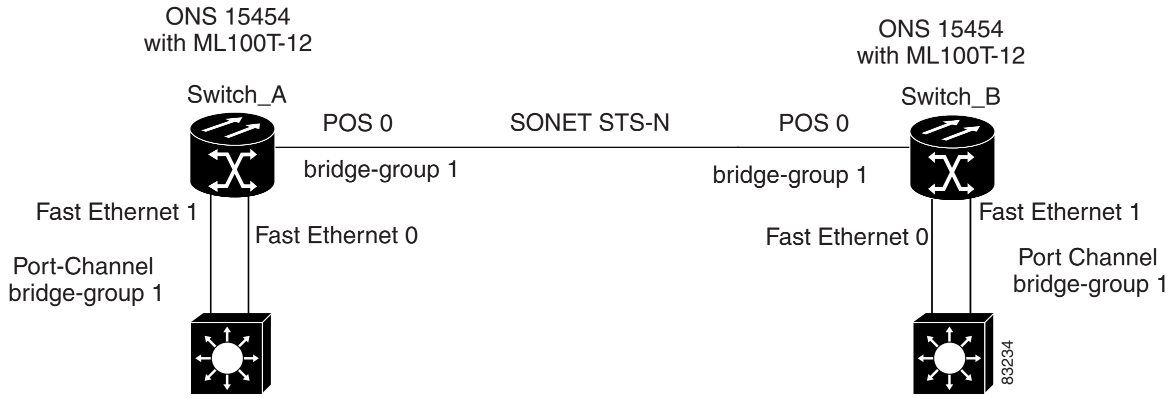
To assign Ethernet interfaces to the EtherChannel, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)#` **`interface fastethernet`** *`number`* or `Router(config)#` **`interface gigabitethernet`** *`number`*	Enters one of the interface configuration modes to configure the Fast Ethernet or Gigabit Ethernet interface that you want to assign to the EtherChannel. You can assign any Ethernet interface on the system to the EtherChannel, but both interfaces must be either FEC or GEC.
Step 2	`Router(config-if)#` **`channel-group`** *`channel-number`*	Assigns the Fast Ethernet or Gigabit Ethernet interfaces to the EtherChannel. The channel number must be the same channel number you assigned to the EtherChannel interface.
Step 3	`Router(config-if)#` **`end`**	Exits to privileged EXEC mode.
Step 4	`Router#` **`copy running-config startup-config`**	(Optional) Saves configuration changes to NVRAM.

EtherChannel Configuration Example

Figure 34-1 shows an example of EtherChannel. The associated commands are provided in Example 34-1 (Switch A) and Example 34-2 (Switch B).

Figure 34-1 EtherChannel Example



Example 34-1 Switch A Configuration

```
hostname Switch A
!
bridge 1 protocol ieee
!
interface Port-channel 1
 no ip address
 bridge-group 1
 hold-queue 150 in
!
interface FastEthernet 0
 no ip address
 channel-group 1
!
interface FastEthernet 1
 no ip address
 channel-group 1
!
interface POS 0
no ip routing
no ip address
 crc 32
bridge-group 1
 pos flag c2 1
```

Example 34-2 Switch B Configuration

```
hostname Switch B
!
bridge 1 protocol ieee
!
interface Port-channel 1
no ip routing
no ip address
 bridge-group 1
 hold-queue 150 in
!
interface FastEthernet 0
 no ip address
 channel-group 1
!
```

```
interface FastEthernet 1
 no ip address
 channel-group 1
!
interface POS 0
 no ip address
 crc 32
bridge-group 1
 pos flag c2 1
!
```

Understanding Encapsulation over EtherChannel or POS Channel

When configuring encapsulation over FEC, GEC, or POS, be sure to configure IEEE 802.1Q on the port-channel interface, not its member ports. However, certain attributes of port channel, such as duplex mode, need to be configured at the member port levels. Also make sure that you do not apply protocol-level configuration (such as an IP address or a bridge group assignment) to the member interfaces. All protocol-level configuration should be on the port channel or on its subinterface. You must configure IEEE 802.1Q encapsulation on the partner system of the EtherChannel as well.

Configuring Encapsulation over EtherChannel or POS Channel

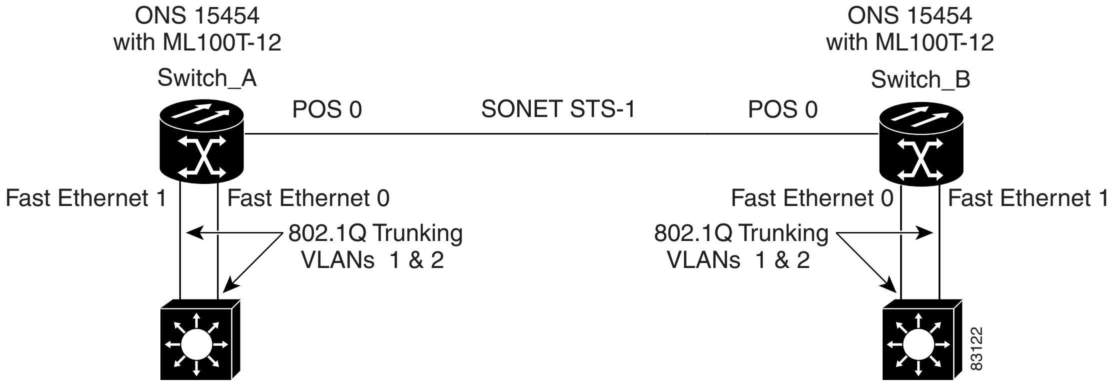
To configure encapsulation over the EtherChannel or POS channel, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)#` **`interface port-channel`** *`channel-number.subinterface-number`*	Configures the subinterface on the created port channel.
Step 2	`Router(config-subif)#` **`encapsulation dot1q`** *`vlan-id`*	Assigns the IEEE 802.1Q encapsulation to the subinterface.
Step 3	`Router(config-subif)#` **`bridge-group`** *`bridge-group-number`*	Assigns the subinterface to a bridge group.
Step 4	`Router(config-subif)#` **`end`**	Exits to privileged EXEC mode. **Note** Optionally, you can remain in interface configuration mode and enable other supported interface commands to meet your requirements.
Step 5	`Router#` **`copy running-config startup-config`**	(Optional) Saves the configuration changes to NVRAM.

Encapsulation over EtherChannel Example

Figure 34-2 shows an example of encapsulation over EtherChannel. The associated code is provided in Example 34-3 (Switch A) and Example 34-4 (Switch B).

Figure 34-2 Encapsulation over EtherChannel Example



This encapsulation over EtherChannel example shows how to set up two ONS 15454s with ML100T-12 cards (Switch A and Switch B) to interoperate with two switches that also support IEEE 802.1Q encapsulation over EtherChannel. To set up this example, use the configurations in the following sections for both Switch A and Switch B.

Example 34-3 Switch A Configuration

```
hostname Switch A
!
bridge irb
bridge 1 protocol ieee
bridge 2 protocol ieee
!
interface Port-channel1
 no ip address
 hold-queue 150 in
!
interface Port-channel1.1
 encapsulation dot1Q 1 native
bridge-group 1
!
interface Port-channel1.2
 encapsulation dot1Q 2
bridge-group 2

!
interface FastEthernet0
 no ip address
 channel-group 1
!
interface FastEthernet1
 no ip address
 channel-group 1
!
interface POS0
 no ip address
 crc 32
pos flag c2 1
!
interface POS0.1
 encapsulation dot1Q 1 native
 bridge-group 1
!
interface POS0.2
```

```
 encapsulation dot1Q 2
 bridge-group 2
```

Example 34-4 Switch B Configuration

```
hostname Switch B
!
bridge irb
bridge 1 protocol ieee
bridge 2 protocol ieee
!
interface Port-channel1
 no ip address
 hold-queue 150 in
!
interface Port-channel1.1
 encapsulation dot1Q 1 native
bridge-group 1
!
interface Port-channel1.2
 encapsulation dot1Q 2
bridge-group 2
!
interface FastEthernet0
 no ip address
 channel-group 1
!
interface FastEthernet1
 no ip address
 channel-group 1
!
interface POS0
 no ip address
 crc 32
pos flag c2 1
!
interface POS0.1
 encapsulation dot1Q 1 native
 bridge-group 1
!
interface POS0.2
 encapsulation dot1Q 2
 bridge-group 2
!
```

Monitoring and Verifying EtherChannel and POS

After FEC, GEC, or POS is configured, you can monitor its status using the **show interfaces port-channel** command.

Example 34-5 show interfaces port-channel Command

```
Router# show int port-channel 1
Port-channel1 is up, line protocol is up
  Hardware is FEChannel, address is 0005.9a39.6634 (bia 0000.0000.0000)
  MTU 1500 bytes, BW 200000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
```

```
Encapsulation ARPA, loopback not set
Keepalive set (10 sec)
Unknown duplex, Unknown Speed
ARP type: ARPA, ARP Timeout 04:00:00
  No. of active members in this channel: 2
      Member 0 : FastEthernet0 , Full-duplex, Auto Speed
      Member 1 : FastEthernet1 , Full-duplex, Auto Speed
Last input 00:00:01, output 00:00:23, output hang never
Last clearing of "show interface" counters never
Input queue: 0/150/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue :0/80 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
   820 packets input, 59968 bytes
   Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
   0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
   0 watchdog, 0 multicast
   0 input packets with dribble condition detected
   32 packets output, 11264 bytes, 0 underruns
   0 output errors, 0 collisions, 0 interface resets
   0 babbles, 0 late collision, 0 deferred
   0 lost carrier, 0 no carrier
   0 output buffer failures, 0 output buffers swapped out.
```

Understanding Link Aggregation Control Protocol

In Software Release 8.5.0 and later, ML-MR-10 and CE-100T-8 cards can utilize the link aggregation control protocol (LACP) to govern reciprocal peer packet transmission with respect to LACP's detection of flawed packets. The cards' ports transport a signal transparently (that is, without intervention or termination). However, this transparent packet handling is done only if the LACP is not configured for the ML- MR-10 card.

Passive Mode and Active Mode

Passive or active modes are configured for a port and they differ in how they direct a card to transmit packets: In passive mode, the LACP resident on the node transmits packets only after it receives reciprocal valid packets from the peer node. In active mode, a node transmits packets irrespective of the LACP capability of its peer.

LACP Functions

LACP performs the following functions in the system:

- Maintains configuration information in order to control aggregation
- Exchanges configuration information with other peer devices
- Attaches or detaches ports from the link aggregation group based on the exchanged configuration information
- Enables data flow when both sides of the aggregation group are synchronized

In addition, LACP provides the following benefits:

- Logical aggregation of bandwidth
- Load balancing
- Fault tolerance

LACP Parameters

LACP utilizes the following parameters to control aggregation:

System Identifier—A unique identification assigned to each system. It is the concatenation of the system priority and a globally administered individual MAC address.

Port Identification—A unique identifier for each physical port in the system. It is the concatenation of the port priority and the port number.

Port Capability Identification—An integer, called a key, that identifies one port's capability to aggregate with another port. There are two types of key: administrative and operational. An administrative key is configured by the network administrator, and an operational key is assigned by LACP to a port based on its aggregation capability.

Aggregation Identifier—A unique integer that is assigned to each aggregator and is used for identification within the system.

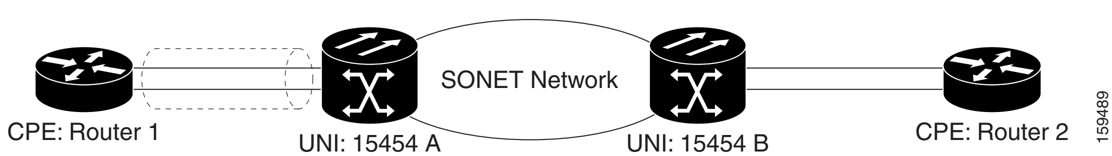
LACP Usage Scenarios

In Software Release 8.5.0 and later, LACP functions on ML-MR-10 cards in termination mode and on the CE-Series cards in transparent mode.

Termination Mode

In termination mode, the link aggregation bundle terminates or originates at the ML-MR-10 card. To operate in this mode, LACP should be configured on the Ethernet interface. One protect SONET or SDH circuit can carry the aggregated Ethernet traffic of the bundle. The advantage of termination mode over transparent mode is that the network bandwidth is not wasted. However. the disadvantage is that there is no card protection between the CPE and UNI (ONS 15454) because all the links in the ML card bundle belong to the same card.

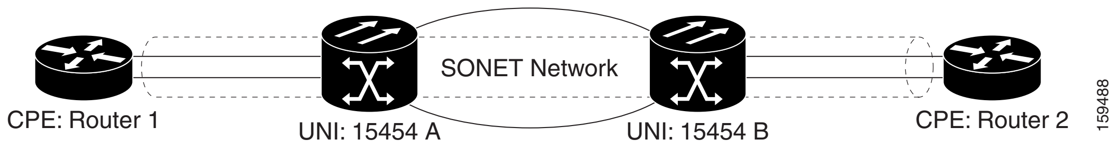
Figure 34-3 LACP Termination Mode Example



Transparent Mode

In Figure 34-4, the link aggregation bundle originates at router 1 and terminates at router 2. Transparent mode is enabled when the LACP packets are transmitted without any processing on a card. While functioning in this mode, the ML-100T-8 cards pass through LACP packets transparently so that the two CPE devices perform the link aggregation. To operate in this mode, no LACP configuration is required on the ML-100T-8 cards.

Figure 34-4 LACP Transparent Mode Example



Configuring LACP

To configure LACP over the EtherChannel, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	`Router(config)# int port <interface-number>`	Accesses the port interface where you will create the LACP.
Step 2	`Router(config-if)# int fa <facility-number>`	Access the facility number on the port.
Step 3	`Router(config-if)# channel`	Accesses the channel group of commands.
Step 4	`Router(config-if)# channel-group <channel-number> mode ?`	Queries the current mode of the channel group. Options include active and passive.
Step 5	`Router(config-if)# channel-group <channel-number> mode active`	Places the channel group in active mode.
Step 6	`Router(config-if)# exit`	Exits the channel group configuration.
Step 7	`Router(config-if)# int fa <facility-number>`	Accesses the facility.
Step 8	`Router(config-if)# lacp-port`	Access the link aggregation control protocol commands for the port.
Step 9	`Router(config-if)# lacp port-priority <priority number>`	Sets the LACP port's priority. Range of values is from 1 through 65535.
Step 10	`Router(config-if)# exit`	Exits the port's configuration mode.
Step 11	`Router(config)# lacp sys`	Accesses the system LACP settings.
Step 12	`Router(config)# lacp system-priority <system priority>`	Sets the LACP system priority in a range of values from 1 through 65535.
Step 13	`Router(config)# exit`	Exits the global configuration mode.
Step 14	`Router# copy running-config startup-config`	(Optional) Saves the configuration changes to NVRAM.

In Example 34-6, the topology includes two nodes with a GEC or FEC transport between them. This example shows one GEC interface on Node 1. (Up to four similar types of links per bundle are supported.)

Example 34-6 LACP Configuration Example

```
ML2-Node1# sh run int gi0
Building configuration...

Current configuration : 150 bytes
```

```
!
interface GigabitEthernet0
 no ip address
 no keepalive
 duplex auto
 speed auto
 negotiation auto
 channel-group 1 mode active
 no cdp enable
end

ML2-Node1#
ML2-Node1# sh run int por1
Building configuration...

Current configuration : 144 bytes
!
interface Port-channel1
 no ip address
 no negotiation auto
 service instance 30 ethernet1
  encapsulation dot1q 30
bridge-domain 30
 !
end

ML2-Node1#
ML2-Node1# sh lacp int
Flags:  S - Device is requesting Slow LACPDUs
        F - Device is requesting Fast LACPDUs
        A - Device is in Active mode       P - Device is in Passive mode

Channel group 1
                            LACP port     Admin     Oper    Port     Port
Port      Flags   State     Priority      Key       Key     Number   State
Gi0       SA      bndl      32768         0x1       0x1     0x5      0x3D
ML2-Node1#
Configuration  remains same for the ML2-Node2 also.
```

Load Balancing on the ML-MR-10 card

The load balancing on the ML-MR-10 card can be configured through the following options:

- source and destination MAC addresses
- VLAN ID contained in the SVLAN (outer) tag

Note The default load balancing mechanism on ML-MR-10 card is the source and destination MAC address.

MAC address based load balancing

The MAC address based load balancing is achieved by performing "XOR" (exclusive OR) operation on the last 4 least significant bits of the source MAC address and the destination MAC address.

Table 34-1 displays the ethernet traffic with 4 Gigabit Ethernet members on the port channel interfaces.

1.

Table 34-1 4 Gigabit Ethernet Port Channel Interface

XOR Result	Member Interface used for Frame Forwarding on the Port Channel Interface
0	member-0
1	member-1
2	member-2
3	member-0
4	member-1
5	member-2
6	member-0
7	member-1
8	member-2
9	member-0
10	member-1
11	member-2
12	member-0
13	member-1
14	member-2
15	member-0

Table 34-2 displays the ethernet traffic with 3 Gigabit Ethernet members on the port channel interfaces.

Table 34-2 3 Gigabit Ethernet Port Channel Interface

XOR Result	Member Interface used for Frame Forwarding on the Port Channel Interface
0	member-0
1	member-1
2	member-2
3	member-0
4	member-1
5	member-2
6	member-0
7	member-1
8	member-2
9	member-0
10	member-1

Table 34-2 3 Gigabit Ethernet Port Channel Interface

XOR Result	Member Interface used for Frame Forwarding on the Port Channel Interface
11	member-2
12	member-0
13	member-1
14	member-2
15	member-0

Note The member of the port channel interface depends on the order in which the Gigabit Ethernet becomes an active member of the port channel interface. The order in which the members are added to the port channel can be found using the **show interface port channel** <port channel number> command in the EXEC mode.

VLAN Based Load Balancing

VLAN based load balancing is achieved by using the last 4 least significant bits of the incoming VLAN ID in the outer VLAN.

Table 34-3 displays the ethernet traffic with 3 Gigabit Ethernet members on the port channel interfaces.

Table 34-3 3 Gigabit Ethernet Port Channel Interface

Last 4 bits in VLAN	Member Interface used for the Frame forwarding on the Port-Channel Interface
0	member-0
1	member-1
2	member-2
3	member-3
4	member-0
5	member-1
6	member-2
7	member-3
8	member-0
9	member-1
10	member-2
11	member-3
12	member-0
13	member-1

Table 34-3 3 Gigabit Ethernet Port Channel Interface

Last 4 bits in VLAN	Member Interface used for the Frame forwarding on the Port-Channel Interface
14	member-2
15	member-3

Note The member of the port channel interface depends on the order in which the Gigabit Ethernet becomes an active member of the port channel interface. The order in which the members are added to the port channel can be found using the **show interface port-channel** <port-channel number> command in the EXEC mode.

With the 4 Gigabit Ethernet members, if the incoming VLAN ID is 20, the traffic will be sent on member-0. If the incoming VLAN ID is 30, the traffic will be sent on member-2.

Load Balancing Configuration Commands

Table 34-4 details the commands used to configure load balancing on the ML-Series cards and the ML-MR-10 card.

Table 34-4 Configuration Commands for Load Balancing

	Command	Purpose
Step 1	**Router(config) #int port-channel 10**	Accesses the port interface
Step 2	**Router(config-if)#load-balance vlan**	To change the load-balancing based on outer vlan
Step 3	**Router(config)#exit**	Exits the global configuration mode.
Step 4	**Router# copy running-config startup-config**	(Optional) Saves the configuration changes to NVRAM.

Example 34-7 show command configuration

```
Configuration:

!
interface Port-channel10
 no ip address
 no negotiation auto
 load-balance vlan
 service instance 20 ethernet
  encapsulation dot1q 20
   bridge-domain 20
 !
 service instance 30 ethernet
  encapsulation dot1q 30
```

```
   bridge-domain 30
  !
 !
 !
interface GigabitEthernet1
 no ip address
 speed auto
 duplex auto
 negotiation auto
 channel-group 10
 no keepalive
!
interface GigabitEthernet2
 no ip address
 speed auto
 duplex auto
 negotiation auto
 channel-group 10
 no keepalive
!
interface GigabitEthernet9
 no ip address
 speed auto
 duplex auto
 negotiation auto
 channel-group 10
 no keepalive


Router#sh int port-channel 10
Port-channel10 is up, line protocol is up
  Hardware is GEChannel, address is 001b.54c0.2643 (bia 0000.0000.0000)
  MTU 9600 bytes, BW 2100000 Kbit, DLY 10 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
    No. of active members in this channel: 3
        Member 0 : GigabitEthernet9 , Full-duplex, 100Mb/s
        Member 1 : GigabitEthernet1 , Full-duplex, 1000Mb/s
        Member 2 : GigabitEthernet2 , Full-duplex, 1000Mb/s
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/225/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/120 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 watchdog, 0 multicast, 0 pause input
     48 packets output, 19080 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier, 0 PAUSE output
     0 output buffer failures, 0 output buffers swapped out
Router#


Router#show port-channel load-balance interface Port-channel 10 hash-table
Hash-value             Interface
  0                GigabitEthernet9
```

```
  1                GigabitEthernet1
  2                GigabitEthernet2
  3                GigabitEthernet9
  4                GigabitEthernet1
  5                GigabitEthernet2
  6                GigabitEthernet9
  7                GigabitEthernet1
  8                GigabitEthernet2
  9                GigabitEthernet9
  10                GigabitEthernet1
  11                GigabitEthernet2
  12                GigabitEthernet9
  13                GigabitEthernet1
  14                GigabitEthernet2
  15                GigabitEthernet9
Router#
```