

Configuring Multilink PPP

14

This chapter describes how to configure a Multilink PPP interface on the ERX system.

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Overview

Multilink PPP (MLPPP; also referred to as PPP Multilink, MLP, and MP) aggregates multiple physical links into a single logical bundle. More specifically, MLPPP bundles multiple link-layer channels into a single network-layer channel. Peers negotiate MLPPP during the initial phase of Link Control Protocol (LCP) option negotiation. Each system indicates that it is multilink capable by sending the multilink option as part of its initial LCP configuration request.

An MLPPP bundle can consist of multiple physical links of the same type—such as multiple asynchronous lines—or can consist of physical links of different types—such as leased synchronous lines and dial-up asynchronous lines.

The system treats MLPPP like another PPP network control protocol (NCP). Packets received with an MLPPP header are subject to fragmentation, reassembly, and sequencing. Packets received without the MLPPP header cannot be sequenced and can be delivered only on a first-come, first-served basis.

Application

Some users need more bandwidth than a T1 or an E1 channel can provide, but cannot afford the expense or do not need the bandwidth of T3 or E3. Equal-cost multipath (ECMP) is one way to achieve the desired bandwidth. MLPPP is commonly used as an alternative to ECMP to deliver *NxT1* service. *NxT1* service provides bandwidth greater than DS1 service without going up to the expense and infrastructure required for DS3 service. Cost-analysis of *NxT1* versus DS3 service typically imposes a practical limit of 8xT1 service; that is, aggregation of no more than eight T1 or E1 connections into an MLPPP bundle.

The *NxT1* implementation of MLPPP logically aggregates up to eight T1 or E1 connections into a single virtual connection, or bundle, to a given customer site as shown in Figure 14-1.

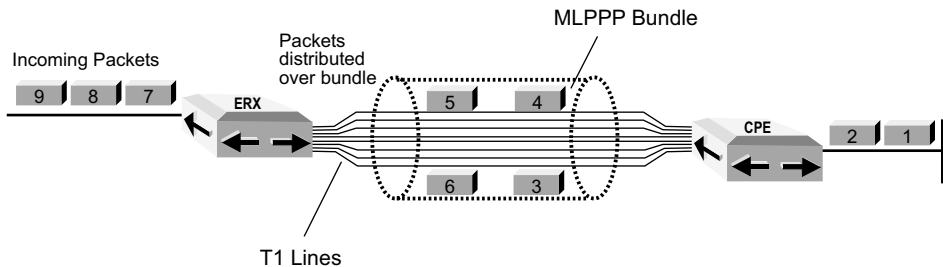


Figure 14-1 MLPPP aggregation of T1 lines into a single bundle

Because MLPPP aggregates multiple link-layer channels onto a single network-layer IP interface, protocol layering within the system is different than it is for non-multilink PPP.

Figure 14-2 illustrates interface stacking with MLPPP.

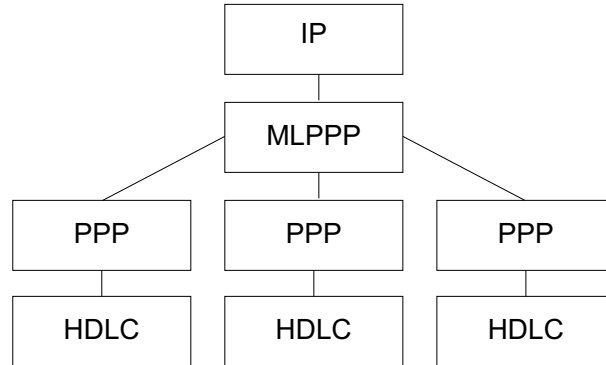


Figure 14-2 Structure of MLPPP

MLPPP LCP Extensions

Multilink PPP adds three new LCP negotiation options:

- Multilink maximum received reconstructed unit (MRRU) option – The MRRU option has two functions. First, it tells the other end of the link the maximum size of the PPP packet payload that the system can receive. Second, it tells the other end that the system supports MLPPP. When you enable multilink on your system, the system includes the MRRU option in LCP negotiation with the value set to the MRU value for PPP. If the remote system rejects this option, the local system assumes that the remote system does not support multilink PPP and it terminates the link without negotiation.



Note: *The system will not bring up a link if the MRU value received from a peer device differs from the MRRU value received from the peer.*

- Short sequence number (SSN) header format option (not currently supported) – The SSN option indicates that the transmitting system wants to use a short sequence number (12 bits) in the MLPPP header rather than a long sequence number (24 bits). The system currently supports only long sequence numbers.
- Endpoint discriminator option – The endpoint discriminator option identifies the system transmitting the packet. If the receiving system determines that packets on another link have the same endpoint discriminator option, this link must be joined to that bundle. If the receiving system determines that no packets on other links have the same option, the receiving system must create a new bundle from this link. The endpoint discriminator is generated internally; you cannot configure it. The endpoint discriminator option is the same for all links on one end of the bundle; at the other end, all links also share a

common endpoint discriminator. The two endpoint discriminators will be different if the MLPPP bundle is set up between two ERX systems.

References

For more information about the MLPPP protocol, consult the following resources:

- RFC 1661 – The Point-to-Point Protocol (PPP) (July 1994)
- RFC 1990 – The PPP Multilink Protocol (MP) (August 1996)

Supported MLPPP Features

The system currently supports both the static configuration of the links participating in a multilink bundle and the dynamic creation of MLPPP bundles over L2TP (only on the LNS) when the LNS detects multilink LCP option negotiation in LCP proxy data.

The following MLPPP features are available for both static and dynamic MLPPP on the cOCx/STMx, CE1, CT1, and CT3 modules:

- Logical aggregation of up to eight T1 links in a bundle – A CT3 module can support up to 28 bundles (one T1 link per bundle) per T3 interface.
- Monotonically increasing sequence numbers – All packets distributed across the member links have monotonically increasing sequence numbers. This feature enables the remote system on the customer premises to perform resequencing (if it is configured to do so).
- Long sequence numbers.
- Round-robin packet distribution – Packet distribution across the member links in a bundle is handled only in a round-robin fashion. The round-robin approach is used even when the member links have different line rates.
- Authentication for interfaces with MLPPP encapsulation or for MLPPP bundles.

You can configure bundles as follows:

- On a CE1 line module and corresponding I/O module, you can configure:
 - > Member links from different CE1 ports in the same bundle
 - > Any combination of bundles that does not exceed the 20 available E1 channels (for example, 20 single-link E1 bundles or 2 eight-link bundles and 4 single-link bundles)
- On a cOCx/STMX line module and corresponding I/O module, you can configure:
 - > Member links from different OC3/STM1 ports in the same bundle
 - > Any combination of bundles that does not exceed the 336 available T1 channels (for example, 336 single-link T1 bundles, 42 eight-link bundles, or 41 eight-link bundles and 8 single-link bundles)
 - > Any combination of bundles that does not exceed the 252 available E1 channels (for example, 252 single-link T1 bundles, 34 eight-link bundles, or 33 eight-link bundles and 8 single-link bundles)
- On a CT1 line module and corresponding I/O module, you can configure:
 - > Member links from different CT1 ports in the same bundle
 - > Any combination of bundles that does not exceed the 24 available T1 channels (for example, 24 single-link T1 bundles, 3 eight-link bundles, or 2 eight-link bundles and 8 single-link bundles)
- On a CT3 line module with CT3/T3 I/O module, you can configure:
 - > Only member links from the same T3 interfaces into the same bundle. You cannot configure member links from different T3 ports in the same bundle.
 - > Any combination of bundles that does not exceed the 28 available T1 channels per port (for example, 28 single-link T1 bundles or 3 eight-link bundles and 4 single-link bundles per port)
- On a CT3 12 FO line module with CT3/T3 I12 /O module, you can configure:
 - > Member links from different T3 ports in the same bundle.
 - > Any combination of bundles that does not exceed the 336 available T1 channels (for example, 336 single-link T1 bundles, 42 eight-link bundles, or 41 eight-link bundles and 8 single-link bundles)

Unsupported MLPPP Features

The system does not support the following MLPPP features:

- Fragmentation – The system sets the multilink maximum received reconstructed unit (MRRU) of the bundle and the maximum received unit (MRU) of all of the member links to the same value. The local system presents these values to the remote system on the other end of the multilink via the LCP. If the member links have different MRU values, the system determines the smallest MRU and sets the MRRU to this value for the multilink bundle. If links with a lower MRU are added subsequently, they are not joined to the bundle. This ensures that the no-fragmentation rule is enforced on the companion multilink system.
- Resequencing of out-of-order packets in the absence of fragmentation – Given the location in the network where the system resides, the *NxT1* links to a customer site represent one of many places across the IP network where packets might be received out of order. For example, if the system has multiple uplinks to a core router, packets might be received out of order across these links. Packet resequencing is therefore left as an exercise for the end station rather than the aggregation router.
- Short sequence numbers
- Forwarding of multilink traffic to L2TP tunnels

Before You Configure Static MLPPP

Before you begin configuring static MLPPP, you must configure the physical line interfaces that will be aggregated by MLPPP. See the following chapters:

- *Chapter 1, Configuring Channelized T3 Interfaces*
- *Chapter 2, Configuring T3 and E3 Interfaces*
- *Chapter 3, Configuring CT1 and CE1 Interfaces*
- *Chapter 4, Configuring Unchannelized SONET/SDH Interfaces*

The procedures described in this chapter assume that a physical line interface has been configured.

Configuration Tasks

Static MLPPP configuration consists of two general tasks, each with several subtasks:

- 1 Create the member links to be aggregated into a multilink bundle.
 - a From Global Configuration mode, specify the individual interface on which you want to configure MLPPP.

```
host1(config)#interface serial 2/0:1/1
```
 - b Specify MLPPP as the encapsulation method on the interface.

```
host1(config-if)#encapsulation mlppp
```
 - c (Optional) Specify the keepalive timeout value for the member link interface.

```
host1(config-if)#ppp keepalive 50
```
 - d (Optional) Specify the authentication method for the member link interface.

```
host1(config-if)#ppp authentication pap chap
```
- 2 Add member links to a multilink bundle.
 - a Define the MLPPP bundle.

```
host1(config)#interface mlppp group1
```
 - b Add each member link.

```
host1(config-if)#member-interface serial 2/0:1/1
```
 - c Assign an IP address to the MLPPP bundle.

```
host1(config-if)#ip address 10.10.100.1 255.255.255.0
```
 - d (Optional) Specify the keepalive timeout value for the MLPPP network interface (the entire MLPPP bundle).

```
host1(config-if)#ppp keepalive 50
```
 - e (Optional) Specify the authentication method for the MLPPP network interface (the entire MLPPP bundle).

```
host1(config-if)#ppp authentication pap chap
```

Example The following example configures three T1 lines and aggregates them into a multilink bundle called *group1*:

```
host1(config)#interface serial 2/0:1/1
host1(config-if)#encapsulation mlppp
```

```
host1(config-if)#exit
host1(config)#interface serial 2/0:2/1
host1(config-if)#encapsulation mlppp
host1(config-if)#exit
host1(config)#interface serial 2/0:3/1
host1(config-if)#encapsulation mlppp
host1(config-if)#ppp keepalive 50
host1(config-if)#exit
host1(config)#interface mlppp group1
host1(config-if)#member-interface serial 2/0:1/1
host1(config-if)#member-interface serial 2/0:2/1
host1(config-if)#member-interface serial 2/0:3/1
host1(config-if)#ppp authentication pap chap
host1(config-if)#ip address 10.10.100.1 255.255.255.0
```

Contextual Command Differences

The MLPPP configuration commands have different effects depending on the interface context. If you issue an MLPPP configuration command in the context of an individual interface, the command affects only the MLPPP link interface associated with that individual interface.

For example, the following commands disable negotiation of the local magic number only for serial interface 2/0:1/1.

```
host1(config-if)#member-interface serial 2/0:1/1
host1(config-if)#encapsulation mlppp
host1(config-if)#ppp magic-number disable
```

If you issue an MLPPP configuration command in the context of an MLPPP bundle—the MLPPP network interface—the command affects all the member links of the bundle. This feature prevents you from having to issue MLPPP configuration commands for each member link interface. For example, the following commands disable negotiation of the local magic number for the entire bundle, *group1*.

```
host1(config)#interface mlppp group1
host1(config-if)#member-interface serial 2/0:1/1
host1(config-if)#ip address 10.10.100.1 255.255.255.0
host1(config-if)#ppp magic-number disable
```

Configuring Authentication

Perform the following optional tasks to configure authentication on interfaces with MLPPP encapsulation or MLPPP bundles.

- Specify the PPP authentication type(s).
- Specify the maximum number of retries.

ppp authentication

- Use to require authentication from the PPP peer.
- Specify PAP or CHAP as the primary authentication protocol and the other authentication protocol as the alternative. For example, suppose you specify **pap** as the primary authentication protocol and **chap** as the alternate:

```
host1(config-if)#ppp authentication pap chap
```

The system requests the use of PAP as the authentication protocol (because it appears first in the command line). If the peer refuses to use PAP, the system requests the CHAP protocol. If the peer refuses to negotiate authentication, the system terminates the PPP session.

- Specify a virtual router for the authentication virtual router context.

```
host1(config-if)#ppp authentication virtual-router boston  
pap chap
```

This command is available in static configurations and in profiles.

- The system supports the MD5 authentication algorithm for CHAP authentication.
- Use the **no** version to specify that the system does not require authentication.

ppp max-bad-auth

- Use to specify the maximum number of authentication retries the system allows before terminating a PPP session
- This value applies to PAP and CHAP authentication.
- The range is 0–7. The default is 0, which indicates that no retries are allowed.
- Example

```
host1(config-if)#ppp max-bad-auth 3
```

- Use the **no** version to return the number of retries to the default, 0.

Configuring Other PPP Attributes

The **ppp** command options available are the same for interfaces whether they are configured with PPP or MLPPP.

encapsulation mlppp

- Use to configure MLPPP as the encapsulation method on an individual interface.
- Use this command only within the context of an individual interface. Issuing this command creates an MLPPP link interface, also referred to as an MLPPP bundle member.
- Example

```
host1(config)#interface serial 2/0:1/1  
host1(config-if)#encapsulation mlppp
```

- Use the **no** version to disable MLPPP on an interface.

interface mlppp

- Use to create an MLPPP network interface, also known as the MLPPP bundle.
- Example

```
host1(config-if)#interface mlppp group2
```
- Use the **no** version to delete the MLPPP bundle.

member-interface

- Use to add an MLPPP link interface—also known as an MLPPP bundle member—to an MLPPP bundle.
- Example

```
host1(config-if)#member-interface serial 2/0:1/1
```
- Use the **no** version to remove the specified interface from the MLPPP bundle.

ppp keepalive

- Use to specify the keepalive timeout value in the range 10–300 seconds. If issued in the context of an individual interface, the command affects only that interface. If issued in the context of an MLPPP bundle, the command affects all MLPPP link interfaces that are member links of that bundle.
- When the keepalive timer expires, the interface always sends an LCP echo request, regardless of whether the peer is silent.
- With a keepalive interval is 30 seconds, a failed link is detected between 90 and 120 seconds after failure.
- Example

```
host1(config-if)#ppp keepalive 50
```
- Use the **no** version to restore the default value, 30.

ppp log

- Use to enable PPP packet or state machine logging on any dynamic interface that uses the profile being configured. Specify one of the following keywords:
 - › **pppPacket** – enables PPP packet logging
 - › **pppStateMachine** – enables PPP state machine logging
- Example

```
host1(config-profile)#ppp log pppPacket
```



Note: This command is equivalent to the **log severity debug pppPacket** and **log severity debug pppStateMachine** commands.

- Use the **no** version to disable packet or state machine logging.

ppp magic-number disable

- Use to disable negotiation of the local magic number. If issued in the context of an individual interface, the command affects only that interface. If issued in the context of an MLPPP bundle, the command affects all MLPPP link interfaces that are member links of that bundle.
- Example

```
host1(config-if)#ppp magic-number disable
```
- Issuing this command prevents the system from detecting loopback configurations.
- Use the **no** version to restore negotiation of the local magic number.

ppp mru

- Use to set the maximum allowable size in bytes of the MRU for MLPPP serial interfaces.
- If the command is executed from an encapsulated MLPPP serial interface, it affects only that interface. If executed from an MLPPP bundle, it affects all serial member links within that bundle.
- Example

```
host1(config-if)#ppp mru 300
```
- Use the **no** version to restore the default value, which varies according to module type.

ppp passive-mode

- Use to force a static or dynamic PPP interface into passive mode before LCP negotiation begins, for a period of one second. This delay enables slow clients to start up and initiate the LCP negotiation.
- Example

```
host1(config-if)#ppp passive-mode
```
- Use the **no** version to disable passive mode.

ppp shutdown

- Use to terminate an MLPPP session.
- If you use the **ip** or **osi** keyword, disables the Internet Protocol Control Protocol (IPCP) or OSI Network Layer Control Protocol (OSINLCP) service for the MLPPP network interface (MLPPP bundle). Issue only in the context of a network interface.
- If no keywords are issued, issuing this command has the following effect:
 - › If issued in the context of an individual interface, the command affects only that interface. The **ip** and **osi** keywords are not functional in this context.
 - › If issued in the context of an MLPPP bundle, the command affects all MLPPP link interfaces that are member links of that bundle. The **ip** and **osi** keywords are functional only in this context.
- The **ppp shutdown** command administratively disables the interface.

- Example


```
host1(config-if)#ppp shutdown
```
- If you issue the **ppp shutdown** command in the context of an MLPPP bundle, you cannot bring up an individual member link by subsequently issuing the **no ppp shutdown** command in the context of that member. You can bring up only the entire bundle; to do so, you must issue the **no ppp shutdown** command in the context of the bundle. If you add new member links while a bundle is shut down, those new members are also in the shut-down state until the entire bundle is brought up.
- Use the **no** version to restart a disabled session.

Configuring Profiles for Dynamic MLPPP

You can define a profile to dynamically create MLPPP bundles over L2TP on the LNS. The profile consists of commands to define the bundle attributes, just as you would for static configuration. For more information on profiles for dynamic interfaces, see *Chapter 21, Configuring Dynamic Interfaces*.

- 1 Create a profile by assigning it a name.


```
host1(config)#profile dynmlppp
```
- 2 Enable creation of dynamic MLPPP interfaces.


```
host1(config-profile)#ppp multilink enable
```
- 3 Specify a virtual router to which dynamic IP interfaces created using this profile will be assigned.


```
host1(config-profile)#ip virtual-router egypt
```
- 4 Specify an IP loopback interface with which dynamic IP interfaces created using this profile will be associated.


```
host1(config-profile)#ip unnumbered loopback 0
```
- 5 Optionally set other desired PPP characteristics using the ppp commands described in *Configuring Authentication* and *Configuring Other PPP Attributes* earlier in this chapter.

ppp multilink enable

- Use in a profile to enable the creation of dynamic MLPPP interfaces.
- Example


```
host1(config-profile)#ppp multilink enable
```
- Use the **no** version to cause the LNS to reject any incoming requests to create dynamic MLPPP interfaces.

profile

- Use to create a profile.
- You specify a profile name with up to 80 characters.
- Example

```
host1(config)#profile dynmlppp1
```

- Use the **no** version to remove a profile.

Monitoring MLPPP

Use the commands in this section to display information about MLPPP interfaces.

You can set a statistics baseline for MLPPP serial (member link) or bundle (multilink) interfaces using the **baseline ppp** command. Use the **delta** keyword with the **show** commands described below to display statistics with the baseline values subtracted.

After you configure multilink PPP, you can use the **show ppp interface** commands to view information about the multilink.

You can use the output filtering feature of the **show** command to include or exclude lines of output based on a text string you specify. Refer to *show Commands* in *ERX System Basics Configuration Guide, Chapter 2, Command Line Interface*, for details.

baseline ppp interface

- Sets a statistics baseline for PPP interfaces—including MLPPP interfaces, either individual serial (member link) interfaces or multilink (bundle) interfaces.
- Use only the **serial** or **mlppp** keywords.
- For serial interfaces, specify the interface location in the format *slot/port:channel/subchannel* for CT3 modules, or in the format *slot/port:subchannel* for CT1 and CE1 modules
- For mlppp interfaces, specify the interface location as the name of the MLPPP bundle.
- The system implements the baseline by reading and storing the statistics at the time the baseline is set and then subtracting this baseline whenever baseline-relative statistics are retrieved.
- When baselining is requested, the time since the last baseline was set is displayed in *hours:minutes:seconds* or *days/hours* format. If a baseline was not set, the message “No baseline has been set” is displayed instead.
- Use the optional **delta** keyword with MLPPP **show** commands to specify that baselined statistics are to be shown.
- Example

```
host1#baseline ppp interface serial 2/0:1/1
```

- There is no **no** version.

**Sample
Displays With
and Without
Baseline**

The following command displays PPP interface (including MLPPP interface) statistics *without* baselining:

```
host1#show ppp interface statistics

PPP interface serial 2/0:4/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     572          684
  errors                      0            0
  discards                    0            0
PPP interface serial 2/0:5/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     572          684
  errors                      0            0
  discards                    0            0
PPP interface serial 2/1:4/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     572          684
  errors                      0            0
  discards                    0            0
PPP interface serial 2/1:5/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     572          684
  errors                      0            0
  discards                    0            0
4 ppp interfaces found

PPP interface mlppp group1 is up
PPP multilink member-interface serial 2/0:1/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     608          716
  errors                      0            0
  discards                    0            0
```

```
PPP multilink member-interface serial 2/0:2/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     608          716
  errors                      0            0
  discards                    0            0
PPP multilink member-interface serial 2/0:3/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     596          704
  errors                      0            0
  discards                    0            0

PPP interface mlppp group2 is up
PPP multilink member-interface serial 2/1:1/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     628          740
  errors                      0            0
  discards                    0            0
PPP multilink member-interface serial 2/1:2/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     628          740
  errors                      0            0
  discards                    0            0
PPP multilink member-interface serial 2/1:3/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0            0
  octets                     616          728
  errors                      0            0
  discards                    0            0

2 mlppp interfaces found
```

The following command displays PPP interface (including MLPPP interface) statistics *with* baselining:

host1#show ppp interface statistics delta

PPP interface serial 2/0:4/1 is up

Time since last baseline 00:00:35

Interface statistics	in	out
packets	0	0
octets	75	82
errors	0	0
discards	0	0

PPP interface serial 2/0:5/1 is up

Time since last baseline 00:00:37

Interface statistics	in	out
packets	0	0
octets	87	90
errors	0	0
discards	0	0

PPP interface serial 2/1:4/1 is up

Time since last baseline 00:00:39

Interface statistics	in	out
packets	0	0
octets	101	112
errors	0	0
discards	0	0

PPP interface serial 2/1:5/1 is up

Time since last baseline 00:00:43

Interface statistics	in	out
packets	0	0
octets	94	99
errors	0	0
discards	0	0

4 ppp interfaces found

PPP interface mlppp group1 is up

PPP multilink member-interface serial 2/0:1/1 is up

Time since last baseline 00:00:17

Interface statistics	in	out
packets	0	0
octets	28	26
errors	0	0
discards	0	0

```
PPP multilink member-interface serial 2/0:2/1 is up
Time since last baseline 00:10:22
Interface statistics          in          out
  packets                    0           0
  octets                     102         104
  errors                      0           0
  discards                    0           0
PPP multilink member-interface serial 2/0:3/1 is up
Time since last baseline 00:00:19
Interface statistics          in          out
  packets                    0           0
  octets                     112         126
  errors                      0           0
  discards                    0           0

PPP interface mlppp group2 is up
PPP multilink member-interface serial 2/1:1/1 is up
Time since last baseline 00:00:23
Interface statistics          in          out
  packets                    0           0
  octets                     125         132
  errors                      0           0
  discards                    0           0
PPP multilink member-interface serial 2/1:2/1 is up
Time since last baseline 00:00:25
Interface statistics          in          out
  packets                    0           0
  octets                     135         138
  errors                      0           0
  discards                    0           0
PPP multilink member-interface serial 2/1:3/1 is up
Time since last baseline 00:00:30
Interface statistics          in          out
  packets                    0           0
  octets                     125         132
  errors                      0           0
  discards                    0           0

2 mlppp interfaces found
```

show ppp interface mlppp

- Use to display information about MLPPP interfaces.
- You can display a great variety of information with this complex command. See the **show ppp interface** command in *Chapter 13, Configuring Point-to-Point Protocol*, for more detailed information on the display options.
- Use the **show ppp interface** command to display information about all PPP interfaces, including MLPPP interfaces.

- Field descriptions
 - › Bundle name – name of the multilink bundle
 - › MLPPP interface – interface type, interface specifier, and administrative status (up or down) for an MLPPP interface
 - › Link interface administrative status – indicates whether the interface is administratively enabled (open), meaning that the **no ppp shutdown** command is operational or administratively disabled (closed), which means that the **ppp shutdown** command is operational
 - › Configured network protocol – indicates the network protocol configured on the interface
 - › Baseline status – indicates whether a statistics baseline has been set
 - › Interface statistics:
 - packets – number of packets received (in) and sent (out) on the interface
 - octets – number of octets received (in) and sent (out) on the interface
 - errors – number of errors received (in) and sent (out) on the interface
 - discards – number of packets discarded on receipt (in) or discarded before they were transmitted (out)



Note: For the LCP, IPCP, and OSINLCP negotiated options, the command displays a value of “none” if the option was not negotiated.

- › LCP protocol configuration:
 - max-receive-unit – controls negotiation of the local MRU option
 - use lower layer – MRU of the layer below PPP defines the MRU to be negotiated
 - disabled – MRU option is not to be negotiated
 - a numeric value – MRU value to be negotiated
 - authentication – controls negotiation of the local authentication option
 - none – do not negotiate
 - chap – negotiate CHAP
 - pap – negotiate PAP
 - chap/pap – negotiate CHAP and if it is rejected, negotiate PAP
 - pap/chap – negotiate PAP and if it is rejected, negotiate CHAP
 - magic-number – controls negotiation of the local magic number option
 - disabled – do not negotiate
 - enabled – negotiate
 - keepalive-timer – rate of LCP echo requests
 - restart-timer – retry frequency during LCP, IPCP, and OSINLCP negotiations
 - max-terminate – maximum number of terminate requests
 - max-configure – maximum number of configure requests
 - max-failure – maximum number of configure NAKs
- › LCP protocol status:

- link-status – indicates the overall status of LCP negotiations, including the following states: Initial (idle), Starting (ready to negotiate), Authenticate (authenticating), and Network (LCP is up)
- › LCP negotiated options:
 - max-receive-unit – negotiated maximum receive unit in octets for the local and remote (peer) side of the link
 - max-receive-reconstructed-unit – negotiated maximum receive reconstructed unit in octets for the local and remote (peer) side of the link
 - authentication – negotiated authentication method (none, pap, or chap) for the local and remote (peer) side of the link
 - magic-number – negotiated magic number for the local and remote (peer) side of the link
 - pfc – negotiated pfc (none or enabled) for the local and remote (peer) side of the link
 - acfc – negotiated acfc (none or enabled) for the local and remote (peer) side of the link



Note: *The command displays a value of “none” for any negotiated option parameters if the option was not negotiated.*

- › LCP Endpoint Discriminator options:
 - local discriminator class – endpoint discriminator type, format, and address space for the local system
 - local endpoint discriminator – endpoint discriminator value for the local system within the specified class
 - peer discriminator class – endpoint discriminator type, format, and address space for the remote system
 - peer endpoint discriminator – endpoint discriminator value for the remote system within the specified class
- › LCP protocol statistics:
 - in-keepalive-requests – number of received keepalive requests (LCP Echo Request) for life of the interface (since either system boot or interface creation, whichever is later)
 - out-keepalive-requests – number of transmitted keepalive requests for life of interface
 - in-keepalive-replies – number of received keepalive replies for life of the interface
 - out-keepalive-replies – number of transmitted keepalive replies for life of the interface
 - keepalive-failures – number of keepalive failures reported on the interface
- › IPCP protocol configuration:
 - configured – IPCP is configured on this interface (true or false)
 - administrative-status – IPCP administrative status (open or closed)
 - ip-address – address to be used for negotiation of local IP address option
 - dns-precedence – used to resolve conflicts during negotiation of DNS addresses

- local – local side takes precedence, and the **no ppp peer dns** command is operative
- peer – remote side takes precedence, and the **ppp peer dns** command is operative
- wins-precedence – used to resolve conflicts during negotiation of WINS addresses
- local – local side takes precedence, and the **no ppp peer wins** command is operative
- peer – remote side takes precedence, and the **ppp peer wins** command is operative
- › IPCP protocol status:
 - operational-status – IPCP operational status (up or down)
- › IPCP negotiated options:
 - ip-address – negotiated IP address for the local and remote (peer) side of the link
 - primary-dns-address – negotiated primary DNS address for the local and remote (peer) side of the link
 - secondary-dns-address – negotiated secondary DNS address for the local and remote (peer) side of the link
 - primary-wins-address – negotiated primary WINS address for the local and remote (peer) side of the link
 - secondary-wins-address – negotiated secondary WINS address for the local and remote (peer) side of the link
- › OSINLCP protocol configuration:
 - configured – OSINLCP is configured on this interface (true or false)
 - administrative-status – OSINLCP administrative status (open or closed)
- › OSINLCP protocol status:
 - operational-status – OSINLCP operational status (up or down)
 - terminate-reason – reason for termination of OSINLCP service
- › OSINLCP negotiated options:
 - npdu-alignment – negotiated npdu alignment for the local and remote (peer) side of the link
- Example 1 displays information about the MLPPP member links configured in bundle *group1*:



Note: The command displays a value of “none” for any negotiated option parameters if the option was not negotiated.

```
host1#show ppp interface mlppp group1 members
PPP interface mlppp group1 is up
  PPP multilink member-interface serial 2/0:1/1 is up
  PPP multilink member-interface serial 2/0:2/1 is up
  PPP multilink member-interface serial 2/0:3/1 is up
```

- Example 2 displays information about all MLPPP member links configured for all bundles:

```
host1#show ppp interface mlppp members
PPP interface mlppp group1 is up
  PPP multilink member-interface serial 2/0:1/1 is up
  PPP multilink member-interface serial 2/0:2/1 is up
  PPP multilink member-interface serial 2/0:3/1 is up
PPP interface mlppp group2 is up
  PPP multilink member-interface serial 2/1:1/1 is up
  PPP multilink member-interface serial 2/1:2/1 is up
  PPP multilink member-interface serial 2/1:3/1 is up
PPP interface mlppp group3
No member-interfaces found
```

- Example 3 displays configuration information about MLPPP member links configured in bundle *group1*:

```
host1#show ppp interface mlppp group1 config
PPP interface mlppp group1 is up
Network interface administrative status is open
Configured network protocol is IPCP
PPP multilink member-interface serial 2/0:1/1 is up
Link interface administrative status is open
PPP multilink member-interface serial 2/0:2/1 is up
Link interface administrative status is open
PPP multilink member-interface serial 2/0:3/1 is up
Link interface administrative status is open
1 mlppp interfaces found
```

- Example 4 displays statistics about all configured MLPPP member links configured in bundle *group1*:

```
host1#show ppp interface mlppp group1 statistics
PPP interface mlppp group1 is up
PPP multilink member-interface serial 2/0:1/1 is up
No baseline has been set
Interface statistics
  packets          in          out
  octets           1408       1876
  errors            0           0
  discards          0           0
PPP multilink member-interface serial 2/0:2/1 is up
No baseline has been set
Interface statistics
  packets          in          out
  octets           1408       1876
  errors            0           0
  discards          0           0
```

```

PPP multilink member-interface serial 2/0:3/1 is up
No baseline has been set
Interface statistics          in          out
  packets                    0           0
  octets                     1408        1876
  errors                      0           0
  discards                    0           0
1 mlppp interfaces found

```

- Example 5 displays status information about the specified MLPPP bundle:

```

host1#show ppp interface mlppp group1 status
PPP interface mlppp group1 is up
1 mlppp interfaces found

```

- Example 6 shows complete configuration, statistics, and status information about the specified MLPPP bundle:

```

host1#show ppp interface mlppp group1 full
PPP interface mlppp group1 is up
Network interface administrative status is open
Configured network protocol is IPCP
IPCP protocol configuration
  configured                true
  administrative-status     open
  ip-address                 1.2.3.4
  dns-precedence            local
  wins-precedence           local
IPCP protocol status
  operational-status        up
IPCP negotiated options
  ip-address                 1.2.3.4      6.7.8.9
  primary-dns-address       none         none
  secondary-dns-address     none         none
  primary-wins-address      none         none
  secondary-wins-address    none         none
OSINLCP protocol configuration
  configured                false
  administrative-status     open
OSINLCP protocol status
  operational-status        down
  terminate-reason          not configured

```

PPP multilink member-interface serial 2/0:1/1 is up
Link interface administrative status is open
No baseline has been set

Interface statistics	in	out
packets	0	0
octets	1488	1972
errors	0	0
discards	0	0

LCP protocol configuration

max-receive-unit	use lower layer
authentication	none
magic-number	enabled
keepalive-timer	30 seconds
restart-timer	3 seconds
max-terminate	2
max-configure	10
max-failure	5

LCP protocol status

link-status	network
-------------	---------

LCP negotiated options	local	peer
max-receive-unit	1590	1590
max-receive-reconstructed-unit	1590	1590
authentication	none	none
magic-number	0x6c079eb0	0x2c5a5798
pfc	none	none
acfc	none	none

LCP Endpoint Discriminator options

local discriminator class	Locally Assigned Address
local endpoint discriminator	0x31393933313030303800001b000001
peer discriminator class	Locally Assigned Address
peer endpoint discriminator	0x31393933313030303800001b000002

LCP protocol statistics

in-keepalive-requests	70
out-keepalive-requests	70
in-keepalive-replies	70
out-keepalive-replies	70
keepalive-failures	0

PPP multilink member-interface serial 2/0:2/1 is up
Link interface administrative status is open
No baseline has been set

Interface statistics	in	out
packets	0	0
octets	1508	1996
errors	0	0
discards	0	0

```

LCP protocol configuration
  max-receive-unit          use lower layer
  authentication            none
  magic-number              enabled
  keepalive-timer           30 seconds
  restart-timer              3 seconds
  max-terminate              2
  max-configure              10
  max-failure                5

LCP protocol status
  link-status                network

LCP negotiated options
  local                      local          peer
  max-receive-unit           1590            1590
  max-receive-reconstructed-unit 1590            1590
  authentication             none             none
  magic-number                0x7ada4a05       0x1bb178cd
  pfc                          none             none
  acfc                          none             none

LCP Endpoint Discriminator options
  local discriminator class    Locally Assigned Address
  local endpoint discriminator 0x31393933313030303800001b000001
  peer discriminator class     Locally Assigned Address
  peer endpoint discriminator  0x31393933313030303800001b000002

LCP protocol statistics
  in-keepalive-requests       71
  out-keepalive-requests       71
  in-keepalive-replies        71
  out-keepalive-replies        71
  keepalive-failures           0

PPP multilink member-interface serial 2/0:3/1 is up
Link interface administrative status is open
No baseline has been set

Interface statistics
  in          out
  packets     0          0
  octets      1568       2068
  errors      0          0
  discards    0          0

LCP protocol configuration
  max-receive-unit          use lower layer
  authentication            none
  magic-number              enabled
  keepalive-timer           30 seconds
  restart-timer              3 seconds
  max-terminate              2
  max-configure              10
  max-failure                5

```

```

LCP protocol status
  link-status                network
LCP negotiated options      local          peer
  max-receive-unit          1590          1590
  max-receive-reconstructed-unit 1590          1590
  authentication            none           none
  magic-number              0x31cc52e0    0x32ebdec6
  pfc                       none           none
  acfc                      none           none
LCP Endpoint Discriminator options
  local discriminator class    Locally Assigned Address
  local endpoint discriminator 0x31393933313030303800001b000001
  peer discriminator class     Locally Assigned Address
  peer endpoint discriminator 0x31393933313030303800001b000002
LCP protocol statistics
  in-keepalive-requests      74
  out-keepalive-requests     74
  in-keepalive-replies       74
  out-keepalive-replies      74
  keepalive-failures         0
1 mlppp interfaces found

```

show ppp interface summary

- Displays a summary of all multilinked and nonmultilinked interfaces configured on the system.
- Field descriptions
 - › Configuration status – indicates the configuration state of the MLPPP interfaces, IPCP protocol, or OSINLCP protocol:
 - configured – interface or protocol is configured
 - notConfigured – interface or protocol is not configured
 - › Administrative status – indicates the administrative state of the MLPPP interface, IPCP protocol, or OSINLCP protocol:
 - open – **no ppp shutdown** command is operative
 - closed – **ppp shutdown** command is operative
 - › Operational status – indicates the operational state of the MLPPP interface, IPCP protocol, or OSINLCP protocol:
 - up – interface or protocol is operational
 - down – interface or protocol is not operational because of a problem in the PPP layer
 - lowerDown – interface or protocol is not operational, because a lower layer in the protocol stack is down
 - passive – interface is waiting for the peer to send an *LCP confReq* message
 - notPresent – interface or protocol is not operational, because the hardware is unavailable

- Example

```
host1#show ppp interface summary
Configuration status      configured notConfigured
  Link Interface          6          n/a
  Network Interface       2          n/a
  Ip                       2          0
  Osi                      0          2
Administrative status     open       closed
  Link Interface          6          0
  Network Interface       2          0
  Ip                       2          0
  Osi                      2          0
Operational status       up         down
  Link Interface          6          0
  Network Interface       2          0
  Ip                       2          0
  Osi                      0          2
Operational status       lowerDown passive  notPresent
  Link Interface          0          0          0
```