CHAPTER 5

Managing PNNI Routes

This chapter introduces Private Network-to-Network Interface (PNNI) routing and switching, and describes commands you can use to manage PNNI operation and routes.

PNNI Routing

The PNNI protocol includes a source-rooting protocol. In a source-rooting protocol, the originating node is responsible for routing. Defined PNNI routes, composed of one or more Designated Transit Lists (DTLs), can only be changed by the node that generated that DTL.

It is useful to remember that a PNNI node routes in detail through it's peer group, but in general through the world. This becomes important if a hierarchal topology multiple peer group (MPG) becomes available.

Note This software release supports only the single peer group (SPG) architecture.

Originating nodes calculate a WAN's PNNI routing tables. If the called party address is locally attached, the call is then routed to the local port. If the called party address matches an address advertised through the PNNI network, the call is then routed to the remote destination.

To determine the routing path to the destination node, the originating node first searches pre-computed tables. If that search fails, the node bases routing paths on-demand criteria. The following sections describe these routing methods.

Routing Based on Precomputed Tables

The number of precomputed routing tables depends on the combined number of class-of-service (CoS) PTSEs that a node generates and receives from the network. The minimum number of tables is zero, and the maximum is 10. After the calculating node generates or receives CoS based traffic metrics, the tables split as shown in Table 5-1, up to a maximum of 10.

Table 5-1 Routing Tables

Traffic Metrics	QoS-Based Routing Paths
Administrative Weight (AW)	CBR, rtVBR, nrtVBR, ABR, UBR
Cell Transfer Delay (CTD)	CBR, rtVBR, nrtVBR
Cell Delay Variation (CDV)	CBR, rtVBR

Each routing table is maintained as a shortest path tree (SPT) and each SPT is constructed based on the optimization of a particular traffic metric. An SPT maintains the shortest path tree to each reachable destination node located in the same PNNI routing domain as based on the traffic metric.

On Demand Routing

An on demand routing path is selected directly from the PNNI routing tables on the basis of the configured mode—either first fit or best fit.

- If first fit is configured, PNNI finds a single path that satisfies the call request as quickly as possible.
- If best fit is configured, PNNI finds a single path that satisfies the call request at the least cost.

Other characteristics are:

- Link verification and checks for path constraints
- Avoidance of blocked nodes and links in the event of crankbacks
- DTL limit checking

An originating node looks up the routing tables to determine the DTL for a call or connection.

The command **dsppnni-routing-policy** displays the routing policy. The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-routing-policy
   SPT epsilon.........          0     Load balance........    random
   SPT holddown time...          1     On demand routing...  best fit
   SPT path holddown time        2     AW Background Table          on
   CTD Background Table         on     CDV Background Table         on
Geneva.7.PXM.a >
```

PNNI Switching

As a switching protocol, PNNI supports Quality of Service.

This section explains the ATM service categories, metrics and attributes, and the signalling mechanism called crankback.

ATM Service Categories

The MGX 8850 switch supports the service categories shown in Table 5-2.

Table 5-2 Supported Service Categories for MGX 8850 switch

CBR	constant bit rate	Use to limit connections to a static amount of bandwidth that is continuously available until the connection is torn down. The amount of bandwidth is characterized by Peak Cell Rate (PCR) value.
rtVBR	real-time variable bit rate	Use for real-time applications that require tightly constrained delay and delay variation (voice/video applications). Category characterized in terms of a Peak Cell Rate (PCR), Sustainable Cell Rate (SCR), and Maximum Burst Size (MBS).
nrtVBR	non-real-time variable bit rate	Use for non-real-time applications with bursty traffic. Category is characterized in terms of a PCR, SCR, and MBS.
ABR	available bit rate	Use to allow ATM layer transfer characteristics provided by the network to change after the connection is established. Flow control mechanism is specified.
UBR	unspecified bit rate	Use for unspecified bit-rate ranges. This setting provides only maximum bit-rate configuration—no bit rate is guaranteed.

Table 5-3 Traffic Parameters Required for Various Classes Of Service

Class Of Service	AW	maxCR	AvCR	maxCTD	CDV	CLR_0	CLR_{0+1}	CRM	VF
CBR	required	optional	required	required	required	required	required	n/a	n/a
rtVBR	required	optional	required	required	required	required	required	optional	optional
nrtVBR	required	optional	required	required	n/a	required	required	optional	optional
ABR	required	required	required	n/a	n/a	n/a	n/a	n/a	n/a
UBR	required	required	n/a	n/a	n/a	n/a	n/a	n/a	n/a

ATM Metrics and Attributes

During call setup, if the configured line or trunk attributes do not support the QoS requested, PNNI excludes that line or trunk from consideration when it selects a path.

At any time, the following parameters can be configured on a per-node or per-link basis to improve network performance. The tunable parameters described in this section are:

- Administrative weight
- Available cell rate
- Bandwidth Overbooking
- Cell transfer delay
- Cell delay variation
- Link Selection
- Cell loss ratio for CLP_0 traffic CLR0+1 (CLR0+1)
- Cell loss ratio for CLP_{0+1} traffic (CLR0)

AW

The Administrative Weight (AW) for a path is the sum of the individual weights of the links on the path. The AW is a key element when selecting optimal routes. The assignment of administrative weights to links and nodes affects which paths PNNI selects in routing.

Tuning the AW on interfaces impacts the distribution of SPVCs and SVCs over the network.

You can use AW to exclude links from routing, such as a secondary link that is used only when the primary link is congested or failed.

AvCR

Available cell rate (AvCR) is the effective available capacity for CBR, rtVBR, and nrtVBR. For ABR, AvCR is the capacity available for minimum cell rate (MCR) reservation. AvCR is the most dynamic metric in PNNI; AvCR is the link-capacity unused by traffic which can be used by additional calls. You can configure AvCR to reflect the equivalent bandwidth that is available on the link or node. PNNI uses AvCR to decide if a link or node can carry a call, as measured in calls per second (cps).

Bandwidth Overbooking

The per-service-class based AvCR on each link is advertised by PNNI routing protocol after the overbooking factor is applied. Tuning bandwidth overbooking impacts the results of the G-CAC during the routing path selection process. Aggressive overbooking allows more SVCs and SPVCs to share the same set of network resources, though QoS can then be compromised. For example, user-compliant traffic may be discarded when congestion occurs.

Bandwidth overbooking may be configured on a per-interface or per-service-class basis.

CTD

The maximum Cell Transfer Delay (CTD) is used in for route-optimization as well as meeting QoS signaling requirements. Tuning the CTD on interfaces impacts distribution of SPVCs and SVCs over the network.

CTD includes processing and queueing delays plus propagation delay, as measured in cells per second (cps).

CDV

The Cell Delay Variation (CDV) is defined by service class on an interface. CDV is used for route-optimization as well as for meeting QoS signaling requirements. Tuning the CDV on interfaces impacts the distributions of SPVCs and SVCs over the network. CDV is measured peak-to-peak, in microseconds.

Link Selection

When multiple links connect two PNNI nodes, the link selection parameter prioritizes routing across one link when an SVC or SPVC is setup.

The link selection options are:

- AW—Selects the link with the least Administrative Weight (AW) in the egress direction. This is the default.
- AvCR—Selects the link with the largest Available Cell Rate (AvCR) in the egress direction.
- maxCR—Selects the link with the largest Max Cell Rate (maxCR) in the egress direction.
- loadbalance—Selects links randomly. This option is for load balancing.

Link selection may be used in the network design to layout the traffic behavior on parallel links between nodes or peer groups.

CLR0

Cell loss ratio for CLP_0 traffic. (CLR0) is the maximum cell loss ratio for CLP_0 traffic over a link or node.

CLR0+1

Cell loss ratio for CLP_{0+1} traffic. (CLR0+1) is the maximum cell loss ratio for CLP_{0+1} traffic over a link or node.

PNNI only advertises significant changes. The network overhead would be too high if PNNI advertised minor parameter changes.

Changes in CDV, MaxCTD, or AvCR are measured by proportional deltas from the last advertised value. A proportional multiplier threshold expressed as a percentage provides flexible control over the definition of significant change.

For some parameters, such as AW, any change in value is considered significant.

Crankback

Crankback is a PNNI signaling mechanism that triggers rerouting if call-setup encounters a failure, such as a broken line or resource unavailability. If call setup encounters such a failure, Crankback passes rerouting responsibility back to the last node which generated a designated transit list (DTL). The release carries a specific log of the problem. The rerouting node considers the logged problem and substitutes a DTL that avoids the blocked link or node. If the substituted DTL fails, PNNI initiates further crankback of the call to a node that has an alternate route to the destination.

Tranversion of any peer group requires a border node from that peer group to create a new DTL, and a node can change only a DTL that it created. Therefore, routing can change only within a peer group, unless call setup cranks back to the originating node.

In an SPG, crankback must always return rerouting responsibility to the source-node.

Displaying Node Configuration Information

The following sections describe commands that display PNNI configuration information.

dsppnni-node

Once a PNNI node is configured, enter the command **dsppnni-node** to show the WAN's nodal table. The node list is displayed in ascending order of each node's node index, all with one setting the node to the lowest PNNI hierarchy.

The significant information that will display is

- node index
- node name
- node level (56 for all nodes until multiple peer groups are supported)
- ATM address
- node id—The 22-byte PNNI logical identification
- restricted transit—a flag that can prevent PNNI routing from transmitting this node
- pg id
- branching restricted—a flag that can prevent cpu-intensive branching at this node
- non-transit for PGL election—a flag that indicates that node's level of eligibility as a PGL
- admin status—up/down
- operational status—up/down

The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-node
node index: 1                       node name: Geneva
   Level..............        56     Lowest..............      true
   Restricted transit..       off     Complex node........       off
   Branching restricted        on
   Admin status........        up     Operational status..        up
   Non-transit for PGL election..       off
   Node id..............56:160:47.0091810000000030ff0fef38.0030ff0fef38.01
   ATM address...........47.0091810000000030ff0fef38.0030ff0fef38.01
   Peer group id.........56:47.00.9181.0000.0000.0000.0000.00
Geneva.7.PXM.a >
```

dsppnsysaddr

The command **dsppnsysaddr** is more specific; it displays the following list of addresses from the System Address Table:

- ilmi
- uni
- static
- host

The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnsysaddr
47.0091.8100.0000.0030.ff0f.ef38.0000.010b.180b.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010b.1816.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010b.1820.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010b.1821.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010d.1820.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010d.1821.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010d.1822.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0000.010d.180b.00/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0030.ff0f.ef38.01/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.0030.ff0f.ef38.99/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0030.ff0f.ef38.1111.1101.0001.01/160
Type:     host     Port id:   17251106

47.0091.8100.0000.0050.0fff.e0b8/104
Type:   static     Port id:   17635339

39.6666.6666.6666.6666.6666.6666.6666.6666.6666/152
Type:      uni     Port id:   17504267

Geneva.7.PXM.a >
```

dsppnni-intf

The command **dsppnni-intf** displays the service category-based administrative weight and aggregation token parameters. The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-intf 11:2.2:22
Physical port id: 11: 2.2:22       Logical port id:   17504278
   Aggr token..........         0     AW-NRTVBR...........      5040
   AW-CBR..............      5040     AW-ABR..............      5040
   AW-RTVBR............      5040     AW-UBR..............      5040
Geneva.7.PXM.a >
```

dsppnni-link

The command **dsppnni-link** shows the PNNI link table.

If you specify:

- Both *node-index* and *port-id*, the command displays information about that specific *port-id* port.
- Only *node-index*, the command displays information about all PNNI link attached to the *node-index* node.
- Nothing, command displays all links attached to all PNNI nodes on this switching system

The final option allows you to overview all communication lines in the PNNI network.

The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-link

node index   : 1
Local port id:   17504278          Remote port id:   17176597
Local Phy Port Id: 11:2.2:22
   Type. lowestLevelHorizontalLink     Hello state....... twoWayInside
   Derive agg...........         0     Intf index...........  17504278
   SVC RCC index........         0     Hello pkt RX.........     17937
                                       Hello pkt TX.........     16284
   Remote node name.......Paris
   Remote node id.........56:160:47.00918100000000107b65f27c.00107b65f27c.01
   Upnode id..............0:0:00.000000000000000000000000.000000000000.00
   Upnode ATM addr........00.000000000000000000000000.000000000000.00
   Common peer group id...00:00.00.0000.0000.0000.0000.0000.00

node index   : 1
Local port id:   17504288          Remote port id:   17045536
Local Phy Port Id: 11:2.1:32
   Type. lowestLevelHorizontalLink     Hello state....... twoWayInside
   Derive agg...........         0     Intf index...........  17504288
   SVC RCC index........         0     Hello pkt RX.........     18145

Type <CR> to continue, Q<CR> to stop:
                                       Hello pkt TX.........     19582
   Remote node name.......SanJose
   Remote node id.........56:160:47.009181000000009409f1f1.00309409f1f1.01
   Upnode id..............0:0:00.000000000000000000000000.000000000000.00
   Upnode ATM addr........00.000000000000000000000000.000000000000.00
   Common peer group id...00:00.00.0000.0000.0000.0000.0000.00

node index   : 1
Local port id:   17504289          Remote port id:   17045537
Local Phy Port Id: 11:2.1:33
   Type. lowestLevelHorizontalLink     Hello state....... twoWayInside
   Derive agg...........         0     Intf index...........  17504289
   SVC RCC index........         0     Hello pkt RX.........     17501
                                       Hello pkt TX.........     18877
   Remote node name.......SanJose
   Remote node id.........56:160:47.009181000000009409f1f1.00309409f1f1.01
   Upnode id..............0:0:00.000000000000000000000000.000000000000.00
   Upnode ATM addr........00.000000000000000000000000.000000000000.00
   Common peer group id...00:00.00.0000.0000.0000.0000.0000.00
```

dsppnni-routing-policy

The command **dsppnni-routing-policy** displays the routing policies used for background routing tables generation. The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-routing-policy
   SPT epsilon.........          0     Load balance........    random
   SPT holddown time...          1     On demand routing...  best fit
   SPT path holddown time        2     AW Background Table          on
   CTD Background Table         on     CDV Background Table         on
Geneva.7.PXM.a >
```

dsppnni-svcc-rcc-timer

The command **dsppnni-svcc-rcc-timer** displays SVCC-based RCC variables. The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-svcc-rcc-timer
node index: 1
   Init time...........          4     Retry time..........         30
   Calling party integrity time...         35
   Called party integrity time....         50
Geneva.7.PXM.a >
```

dsppnni-timer

The command **dsppnni-timer** displays the routing policy parameters. The following example shows the report for this command:

```
Geneva.7.PXM.a > dsppnni-timer
node index: 1
   Hello holddown(100ms)...         10     PTSE holddown(100ms)...         10
   Hello int(sec)..........         15     PTSE refresh int(sec)..       1800
   Hello inactivity factor.          5     PTSE lifetime factor...        200
   Retransmit int(sec).....          5
   AvCR proportional PM....         50     CDV PM multiplier......         25
   AvCR minimum threshold..          3     CTD PM multiplier......         50
   Peer delayed ack int(100ms)...................         10
   Logical horizontal link inactivity time(sec)..        120
Geneva.7.PXM.a >
```

PNNI Configuration Commands

This section lists the nodal configuration commands for the MGX 8850 switch CLI. The command notation and argument parameters follow standard programming convention:

- Commands and their parameters are separated by a space.
- Variables are in *italics*.
- A vertical bar (|) represents the logical OR function.

All MGX 8850 switch CLI commands are explained in detail in the Cisco MGX 8850 Routing Switch Command Reference guide.

cnfpnni-node

Configure the following nodal attributes with the command **cnfpnni-node**:

-atmaddress	Node's ATM address.
-level	PNNI hierarchical level. This must remain identical on all SPG nodes.
-nodeid	Node's identifier. Once assigned, you may only change it while the node's administrative status is disabled (while the node is disabled).
-pgid	Node's peer group ID. Once assigned, you may only change it while the node's administrative status is disabled (while the node is disabled).
-enable	Node's administrative status, either enable or disable.
-transitRestricted	Specifies if node is a restricted transit node.
-complexNode	Specifies if the node is a complex node (complex nodes are not supported by MGX 8850, Release 2.0.10 software image).
-branchingRestricted	Specifies if node supports additional point-to-multipoint branches.
-pglNoTransit	Specifies participation in PGL elections by this node.
nodeName	Node's name.

cnfpnni-svcc-rcc-timer

Configure SVCC-based RCC variables with the command **cnfpnni-svcc-rcc-timer**. This defines a node's initial PNNI SVCC-based variables, as follows:

node-index	Node's index.
-inittime	Time (in seconds) that the node delays initiating establishment of an SVCC to a neighbor with a numerically lower ATM address, after determining that such an SVCC should be established.
-retrytime	Time (in seconds) that the node delays before attempting to re-establish an SVCC-based RCC after the RCC is unexpectedly torn down.
-callingintegritytime	Time (in seconds) that the node waits for a sent SVCC to become fully established before giving up and tearing it down.
-calledintegritytime	Time (in seconds) that the node waits for a received SVCC to become fully established before giving up and tearing it down.

cnfpnni-routing-policy

Configure the routing policies used for background routing tables generation with the command **cnfpnni-routing-policy**.

-epsilon Indicates the node's policy in determining equal-cost path during routes calculation.

-holddown Defines the node's minimum time interval between two consecutive calculations for generating routing tables.

-bnpathholddown Defines the minimum time interval between two consecutive calculations for generating border node path in a peer group for a complex node representation at the next higher level. (complex nodes are not supported by MGX 8850, Release 2.0.10 software image)

-loadBalance Defines the node's load balancing rule if alternative equal-lose routes exist for the call request.

-onDemand Defines the node's on-demand routing rule, either to:

firstfit = select a route that is the first it can find
bestfit = select the best route

Default = firstfit

-awBgTable Enable or disable administrative weight for the background routing table.
Default = **off**

-ctdBgTable Enable or disable c t d for the background routing table.
Default = **off**

-cdvBgTable Enable or disable c d v for the background routing table.
Default = **off**

cnfpnni-intf

Configure a PNNI interface service category-based administrative weight and aggregation token with the command **cnfpnni-intf**.

-token This is a 32-bit number used for link aggregation purpose. When an interface is added, the default is 0.

-aw This is a 24-bit number that configures administrative weight on this interface. It is applied to all QoS service classes if -awall is specified, otherwise it is only applied to the single service class. Default = 5040

maximum value = 24-bit unsigned integer.

-awall This is a 24-bit number that configures administrative weight on this interface. Default = 5040

maximum value = 24-bit unsigned integer.

-awcbr This is a 24-bit number that configures administrative weight used for cbr on this interface.
Default = 5040

maximum value = 24-bit unsigned integer.

-awrtvbr This is a 24-bit number that configures administrative weight used for rtvbr on this interface.
Default = 5040

maximum value = 24-bit unsigned integer.

-nrtvbr This is a 24-bit number that configures administrative weight used for nrtvbr on this interface.
Default = 5040

maximum value = 24-bit unsigned integer.

-awabr This is a 24-bit number that configures administrative weight used for abr on this interface.
Default = 5040

maximum value = 24-bit unsigned integer.

-awubr This is a 24-bit number that configures administrative weight used for ubr on this interface.
Default = 5040

maximum value = 24-bit unsigned integer.

cnfpnni-timer

Configure the PNNI timers with the command **cnfpnni-timer**. You can define the initial PNNI timer values and significant change thresholds of a PNNI logical node.

nodeindex	Logical node's node index.
-ptseholddown	The number is used as a multiplier of the Hello interval of the peer neighbor: the product is the max time length that the neighbor is considered to be alive without the reception of its Hello packets. Range: (0.1 through 10) second Default = 1
-helloholddown	Value for the Hello hold down timer that limits the rate at which it sends Hellos.
-hellointerval	Initial value for the Hello timer.
-helloinactivityfactor	Inactivity time factor on a horizontal link between two logical nodes.
-ptserefreshinterval	Time allowed for the PTSE to re-originate.
-ptselifetimefactor	Value for the lifetime multiplier, expressed as a percentage. The product of it and the **ptserefreshinterval** is sets the remaining lifetime of a self-originated PTSE.
-retransmitinterval	Period between retransmissions of unacknowledged DS, PTSE request, and PTSP.
-ptsedelayedackinterval	Minimum time allowed between transmissions of delayed PTSE acknowledgment packets.
-avcrpm	Proportional multiplier used in the algorithms that determines significant change for AvCR parameters.
-avcrmt	Minimum threshold used in the algorithms that determine significant change for AvCR parameters.
-cdvpm	Proportional multiplier used in the algorithms that determine significant change for CDV parameters.
-ctdpm	Proportional multiplier used in the algorithms that determine significant change for CTD parameters.