CHAPTER 11

Configuring PNNI

This chapter describes the Private Network-Network Interface (PNNI) protocol implementation within the LightStream 1010 ATM switch. In order to place calls between ATM End Systems, signaling needs to consult an ATM routing protocol. LightStream 1010 provides the following routing protocols:

- Interim Inter-Switch Protocol (IISP)—a static routing protocol.
- PNNI— a dynamic routing protocol that provides quality of service (QOS) routes to signaling based on the QOS requirements specified in the call setup request.

Note See the chapter "Configuring ILMI" for complete ILMI description and configuration information.

The following major sections describe PNNI implementation:

- Overview—provides a description of general PNNI operation
- Enhanced PNNI Features—provides a description of additional PNNI features

The following major sections provide procedures for PNNI configuration:

- Global Switch Configuration
- Display ATM PNNI Configuration
- PNNI Routing Configuration
- PNNI Node Configuration
- PNNI Interface Configuration

For a complete description of the commands mentioned in this chapter, refer to the *LightStream 1010 ATM Switch Command Reference* publication.

Overview

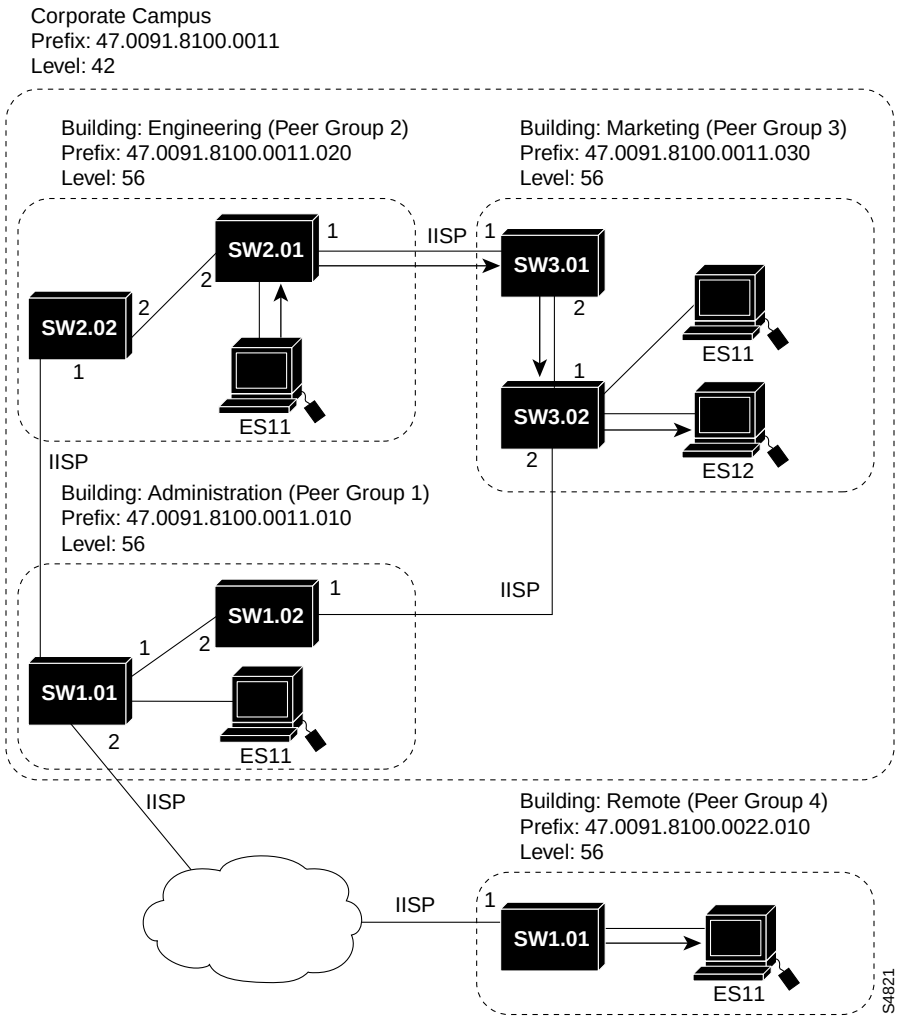
PNNI provides dynamic ATM routing with QOS support. The PNNI protocol is used as "the routing protocol" for the global ATM internetwork; and therefore has been specified as a hierarchical routing protocol. The number of hierarchical levels can vary from network to network.

Note The initial LightStream 1010 implementation of PNNI will support only a single level of hierarchy.

Figure 11-1 shows a network using PNNI and IISP protocols and is used in the following sections to describe PNNI and IISP routing and PNNI components. IISP routing is used to interconnect peer groups at the corporate campus backbone level, but the addresses have been assigned to allow future migration to hierarchical PNNI routing. Specifically, the corporate campus will eventually form a PNNI peer group at level 42.

Note IISP can be used to connect PNNI based private networks.

Figure 11-1 PNNI Network Example



A Peer Group (PG) is a collection of logical nodes that exchange information with other members of the group. This allows all members of the same peer group to maintain an identical view of the group. For example, Hello Packets, database synchronization, and flooding are carried out among members of the same peer group. The Engineering, Marketing, and Administration buildings are separate peer groups in Figure 11-1. For example, SW2.01 and SW2.02 are both members of the peer group 2.

Note Peer groups are similar to Open Shortest Path First (OSPF) routing protocol areas or to IP routing domains.

SW2.01 is a border node between peer group 2 and peer group 3. The border nodes must translate between PNNI and IISP and vice versa in order to splice the connections. The border nodes are also configured with reachability information to end systems (ESs) outside the PNNI network. The configured ES addresses are then advertised within the private network so that any internal node desiring to connect to the advertised ES routes to the border node. The signaling messages for IISP and PNNI are both supported at the border nodes.

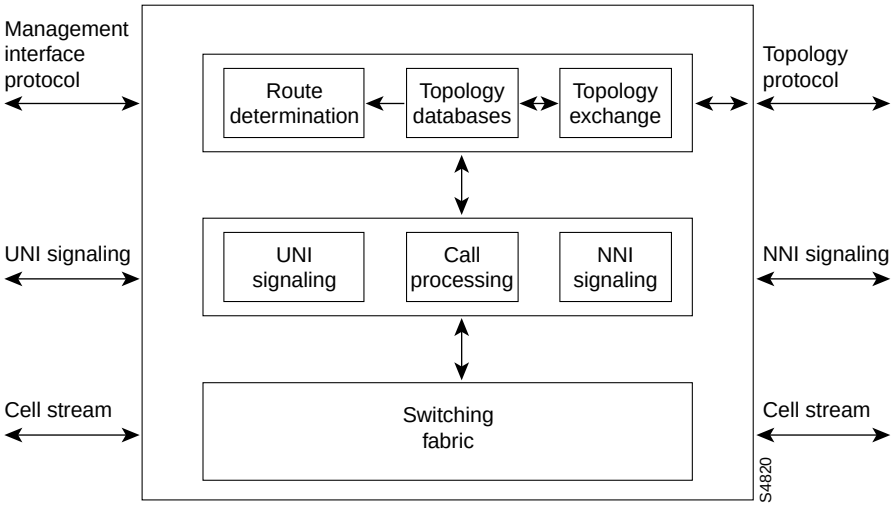
The level of a peer group, including all nodes within the peer group, indicates its position in the PNNI hierarchy. A level with a small numerical value implies greater topological aggregation and has a higher level in the PNNI hierarchy. A level with a higher numerical value implies less topological aggregation and has a lower level in the PNNI hierarchy.

The default assignment of nodes to peer groups is determined by their addresses. For example: the default lowest level peer group ID is determined by the level bit prefix node address where the level is configurable.

All lowest level nodes in a peer group should share the same level-bit address prefix and should have unique 13-byte address prefixes. See the section “Configure the ATM Address” for the command line interface (CLI) command used to configure the ATM address.

The VC routing and call processing system architecture are shown in Figure 11-2.

Figure 11-2 PNNI Processing System Architecture



This is a platform independent architecture and is valid for both campus and enterprise switches.

Signaling

When a connection request is received at a UNI or IISP interface, the Designated Transit List (DTL) or source route needs to be computed. Signaling requests the source route by sending a message to the PNNI router.

Dynamic Versus Static ATM Routing

Static routing protocols require route configuration. IISP is an example of a static routing protocol. Static routing protocols are unsuitable for larger networks because they require a significant amount of configuration.

Dynamic routing protocols adapt to changing network conditions by advertising reachability and topology status information changes. PNNI is a dynamic routing protocol. The LightStream 1010 PNNI implementation can interoperate with IISP to provide routing between multiple peer groups.

QOS Routing

Quality of Service (QOS) routing is the selection of routes or paths that satisfy a set of constraints for a requested connection. The user can specify QOS parameters for such connections as:

- Maximum cell transfer delay
- Peak-to-peak cell delay variation
- Cell loss ratio

Routing must find a path that satisfies the requested QOS for the duration of the connection.

Source Routing Versus Hop-by-Hop

There are basically two techniques to thread a path in a network.

- Hop-by-hop routing or
- Source routing

Hop-By-Hop Routing

Hop-by-hop routing is well known in datagram switching. Hop-by-hop routing is based on the computation of a table that has one entry for each destination node. The next entry in the table specifies what the next node on the path is to that destination. Routing towards the destination is done by forwarding the datagram (call request) to the next node based on the destination node address and the information in the next-hop routing table. Hop-by-hop routing requires the presence of the address of the destination node in the datagram.

When using the PNNI image of routing software the next-hop routes used by IISP are incorporated into the PNNI routing tables.

Source Routing

Source routing has the entire path specified by the source node. The path information is included in the call setup message, and signaling follows the path accordingly.

The PNNI protocol is a source routing protocol and has the following advantages over a hop-by-hop routing protocol:

- avoidance of routing loops
- faster call setups because of minimal processing at intermediate nodes
- better adaptive routing

A source route in PNNI consists of Designated Transit List (DTL) stacks, each including a sequence of nodes and links at a level of the PNNI hierarchy.

Note The initial LightStream 1010 ATM switch implementation of PNNI supports only one level of hierarchy so each source route consists of only one DTL.

Controlling Loops

Hop-by-hop routing controls loops by ensuring that all switches see a consistent topology view when computing next hop routing tables. The next hop routing tables have to be computed based on the same metric. In every distributed system there are transient conditions, such as a link failure, when the next-hop routing tables are inconsistent. This leads to looping. This is not a problem in datagram routing because the datagrams contain a mechanism that does not allow indefinite packet looping in the network.

Source routing is by definition loop free. Using source routing allows every switch to compute the source routes independently using its own selected mechanism. Transient conditions are not crucial to PNNI. In the worst case the call is cranked back to the source and an alternate path selected, but no looping ever occurs. See the section “Crankback Mechanism.”

Computing QOS Paths

Source routing provides the best control over the path selected in the network. The path never diverges from what the source route specifies, regardless of the route selection criteria. PNNI uses the crankback mechanism to correct failures by systematically routing calls to the destination. See the section “Crankback Mechanism.”

Topology Information in PNNI

PNNI is a Topology State algorithm. It advertises information about the status of links and nodes in the network. The advertised information contains multiple metrics and attributes for links and nodes for each ATM service category. Both topological information and address reachability are advertised. PNNI supports a hierarchical organization of the topology database.

The Hello Protocol

The Hello protocol is used to discover the identity of the adjacent neighbor node. The PNNI Hello protocol was modeled on the Open Shortest Path First (OSPF) protocol with appropriate extensions to support a hierarchical organization of the topological database. Discovering the identity of the neighbor is done via an exchange of hello packets containing appropriate information. If the

switches discover they are members of the same peer group, they form an inside link. If they are members of different peer groups, additional information about the hierarchy is exchanged and an outside link is created.

Database Synchronization

When the Hello protocol has declared the link as functional, the adjacent switches exchange a summary of their database contents. This mechanism is similar to the OSPF database synchronization procedures. The synchronization is governed by a master and slave relationship of switches. Nodes exchange database summary packets which contain header information of all PNNI Topology State Elements (PTSEs) in a node database. After such an exchange differences in the topological databases are updated. When completed, both nodes have consistent topological databases.

PNNI Topology Description and Distribution

PNNI Topology State Packets (PTSP) containing one or more PTSEs are used to disseminate information in the ATM network. PTSPs contain reachability, link and node status information necessary for PNNI to calculate QOS paths in an ATM network.

Reachability Information in PNNI

PNNI allows summarization of multiple ATM addresses into a single summary address prefix. Address summarization and the hierarchical organization of the topology enables PNNI to scale to very large networks.

Reachability information is used as the first step in routing a PNNI signaling request for a virtual connection. The call set up packet will be directed to a node advertising a prefix which matches the leading portion of the destination address. The longest matching reachable address prefix is always used.

Internal Reachable ATM Addresses

This information group describe internal reachable ATM destinations. Internal means known to PNNI to be local. For a node representing a single switch, an internally reachable address represents a summary of end systems attached to the switch, for example, discovered via ILMI address registration. At higher levels of the hierarchy, it summarizes information provided by members of the peer group.

Note Internal static routes can be configured manually to end systems that do not support ILMI. These routes will automatically be advertised as internal reachable addresses (subject to address summarization).

Exterior Reachable ATM Addresses

Exterior reachable ATM addresses are similar to internal reachable addresses and describe reachability to a set of ATM destinations. Using an exterior advertisement implies that the reachability information came from elsewhere. This includes cases such as information from other routing domains in which the switch participates or configuration about what is reachable over a specific link. A link connecting to an IISP network is an example of an exterior reachable address.

Supported Metrics and Attributes

Being a topology state routing protocol, PNNI advertises detailed information about the status of the links and nodes. The status of the topological entities (links and nodes) is described via metrics and attributes. Metrics are combined along a path. The simplest example of a metric is the administrative weight. The administrative weight of a path is the sum of the weights of links and nodes along the path.

Attributes are treated by PNNI in a different way. If an attribute value for a parameter violates the QOS constraint, then PNNI excludes that topological entity from consideration while making a path selection.

Supported metrics and attributes include the following:

- Administrative Weight (AW)—Indicates the relative preference of a link or node assigned by the private network operator.
- Available Cell Rate (AvCR)—Reflects the amount of equivalent bandwidth that is available on the link or node.
- Maximum Cell Transfer Delay (MaxCTD)—The (1–α) quantile of the elapsed time for transmission of cells across a link or node. This includes processing and queueing delays plus propagation delay.
- Cell Loss Ratio (CLR)—The ratio of the number of lost cells to the total number of cells transmitted across the link or node.
- Peak-to-Peak Cell Delay Variation (CDV)—The (1–α) quantile of the cell transfer delay minus the fixed delay experienced by all cells crossing the link or node.
- Maximum Cell Rate (MaxCR)—The maximum capacity usable by connections belonging to the specific service category.

Metrics and attributes supported by PNNI are listed in Table 11-1.

Table 11-1 PNNI Metrics and Attributes Supported

Parameter	Metric/ Attribute	Static/ Dynamic	Unit	Granularity	Range	Ecoding
Administrative Weight	Metric	Static	Unitless	N/A	1 - (2^{32}-1)	32 bit integer
Available cell rate	Attribute	Dynamic	cells per second	1 cell per second		32 bit integer
Maximum cell transfer delay	Metric	Static	microseconds	1 microsecond	1 microsecond - 168 seconds	32 bit integer
Cell delay variation	Metric	Static	microseconds	1 microsecond	1 microsecond - 168 seconds	32 bit integer
Cell loss ratio	Attribute	Static	order of magnitude		10^{-1} - 10^{-15}	16 bit exponent
Maximum cell rate	Attribute	Static	cells per second	1 cell per second		32 bit integer

PNNI metrics and attributes are specified separately for each parameter in the following service categories:

- Constant bit rate (CBR)
- Variable bit rate (VBR)
  - Real time (RT)-VBR
  - Nonreal time (NRT)-VBR
- Available bit rate (ABR)
- Undefined bit rate (UBR)

Administrative Weight

Administrative Weight (AW) is the main metric used for computation of paths by PNNI. The assignment of administrative weights to links and nodes will influence the way PNNI selects paths in the private ATM network.

Administrative weight indicates the relative preference of a link assigned by the private network owner. For example, it may depend on link capacity or link length.

Administrative weight can also be used to exclude certain links from routing, such as a backup link that needs to be used only when the primary link is full. The administrative weight for a path is simply the sum of the individual weights of the links on the path.

The LightStream 1010 will select paths with the least administrative weight when such paths satisfy the requested QOS of a connection.

Available Cell Rate

Available Cell Rate (AvCR) is the most dynamic metric in PNNI. It reflects the amount of equivalent bandwidth that is available on the link for new connections. AvCR depends on the calls traversing the link and is viewed as the residual capacity left for use by additional calls. Not every change in AvCR will be advertised in the network by PNNI. Only significant changes as defined by the ATM Forum PNNI specification are advertised in the network. PNNI needs the knowledge of AvCR to decide whether a given link or node is suitable to carry a given call. The LightStream 1010 PNNI implementation supports both simple and complex Generic Call Admission Control (GCAC) to make this decision.

AvCR is maintained on a per service category basis. Three AvCRs are maintained, one each for CBR, RT-VBR, and NRT-VBR service categories.

Significant Change definitions

Not every change of parameter value is substantial enough to generate an advertisement. The network would be overwhelmed with PNNI advertisement packets if frequently changing parameters were to generate advertisements every time any change in their value occurred. Changes in CDV, MaxCTD or AvCR are measured in terms of a proportional difference from the last value advertised. A proportional multiplier threshold expressed as a percentage provides flexible control over the definition of significant change.

Note For other parameters such as administrative weight, any change in value is considered as significant.

For each parameter, PNNI defines what constitutes a significant change. See the section “Configure Significant Change Thresholds” for configuration information.

The Generic Call Admission Control Algorithm

Not all switches will have the same mechanism to perform call control for connection admission. PNNI has defined its own mechanisms to determine whether a call with requested Peak Cell Rate (PCR) and Sustainable Cell Rate (SCR) will be admitted on a selected link (node). These mechanisms screen links and nodes for consideration in path computation. Two mechanisms perform this screening function, depending on the number of parameters advertised by each entity:

- Simple GCAC
- Complex GCAC

Simple GCAC requires only AvCR to be advertised.

Complex GCAC provides a more accurate calculation at a price of increased processing complexity. It uses two additional parameters that can be optionally advertised by a PNNI entity. These are the following:

- Cell Rate Margin (CRM)
- Variance Factor (VF)

By default the LightStream 1010 PNNI uses simple GCAC. In addition, it operates using complex GCAC for those links and nodes that have advertised CRM and VF.

The ATM Forum PNNI specification defines GCAC for the following service categories:

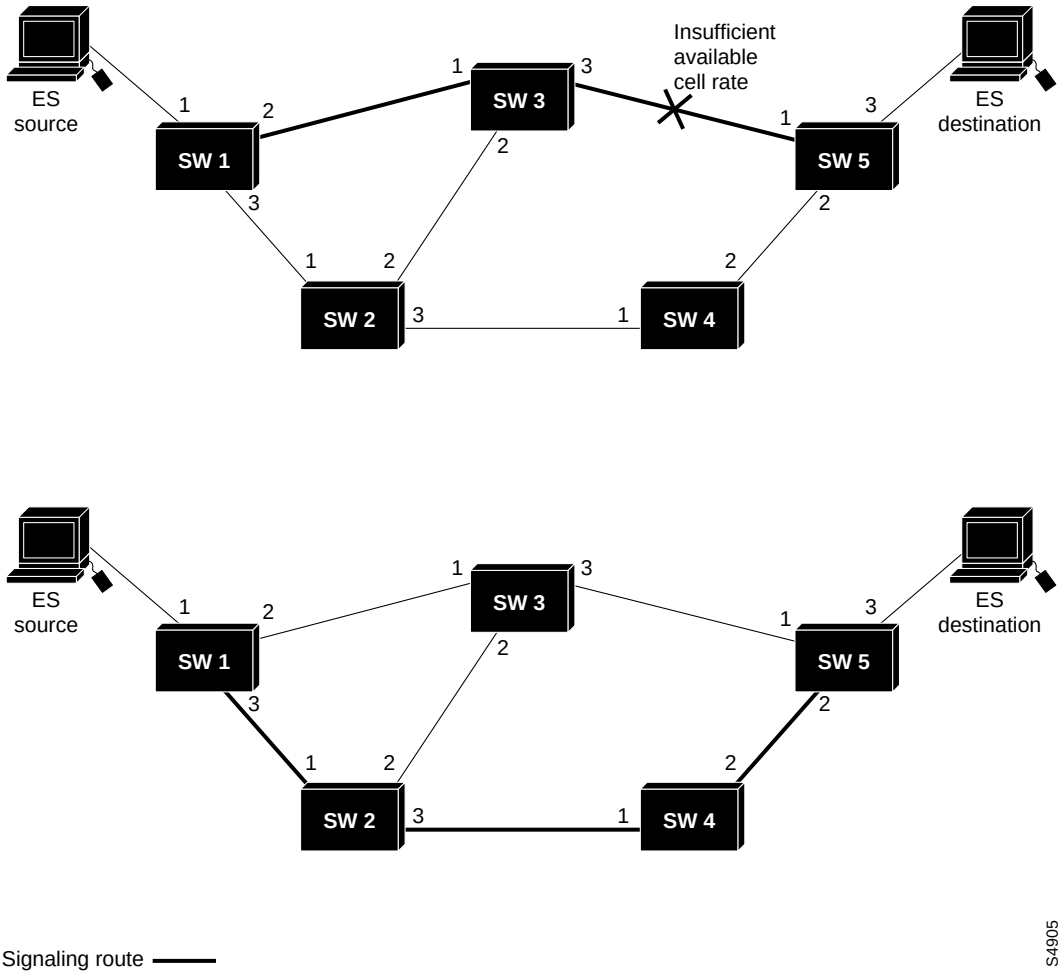
- CBR—This is based on PCR and AvCR. If AvCR is less than PCR the link is excluded; otherwise it is included.
- VBR—This is based on PCR, SCR, AvCR, and optionally CRM and VF.
- ABR—For ABR connections that have MCR of 0, there is no GCAC performed. For ABR connections with MCR greater than 0, links are only included if the AvCR is greater than MCR and if the advertised MaxCR is greater than zero.
- UBR—For UBR connections, links are only included if the advertised MaxCR is greater than zero. A MaxCR of zero indicates that the link cannot accept additional UBR connections.

Crankback Mechanism

The crankback concept adapted in PNNI is based on similar mechanisms used in the circuit switching. Crankback folds back the call to the source node in the peer group that created the DTL and the source retries on an alternate path. Crankback pinpoints the link or node to be avoided in the next retrial. A single call can be cranked back to the source many times. After a number of retrials the crankback mechanism declares that it cannot provide the requested QOS path.

Figure 11-3 is an example of a signaling request encountering insufficient available cell rate at the link SW3p3->SW5p1.

Figure 11-3 Crankback Mechanism Example



Signaling includes a crankback information element (IE) in the call release message indicating the blocked link SW3p3->SW5 and sends it back upstream to the source switch. PNNI computes a new DTL that avoids the blocked link: (SW1p3-> SW2p3-> SW4p2->SW5).

Note Crankback is transparent. It is an automatic mechanism that increases the success probability of a call.

Enhanced PNNI Features

The LightStream 1010 ATM switch PNNI implementation supports the following enhanced PNNI features:

- Autoconfiguration and Support for Address Modification
- Tuning PNNI to Specific Network Conditions
- Load Balancing
- VP Tunneling

Autoconfiguration and Support for Address Modification

The LightStream 1010 ATM switch PNNI implementation supports autoconfiguration. When the switch initially comes up, an autoconfigured ATM address is assigned. The autoconfigured ATM address provides a unique 13-byte address prefix to each switch used for ILMI address registration and address summarization. All autoconfigured addresses share the same 7-byte address prefix so they belong to the same peer group at level 56. This feature allows you to interconnect multiple switches out of the box without any configuration necessary.

You can modify the ATM address using manual configuration commands. In PNNI, by default the node identifier originates from the ATM address assigned to the switch. The node identifier uniquely identifies the node in PNNI. A change of ATM switch address would normally result in a change of the node identifier, causing all links to go down and thus disallowing the possibility of smooth address migration in the peer group. See the sections “Configure the ATM Address” and “Configure PNNI Node” for ATM address modification procedures.

Tuning PNNI to Specific Network Conditions

The LightStream 1010 PNNI implementation allows you to tune to the network conditions using the Command Line Interface (CLI).

Load Balancing

Load balancing distributes the traffic throughout the network. As a result of load balancing techniques, you can transmit more traffic across the network. The LightStream 1010 ATM switch uses two types of load balancing:

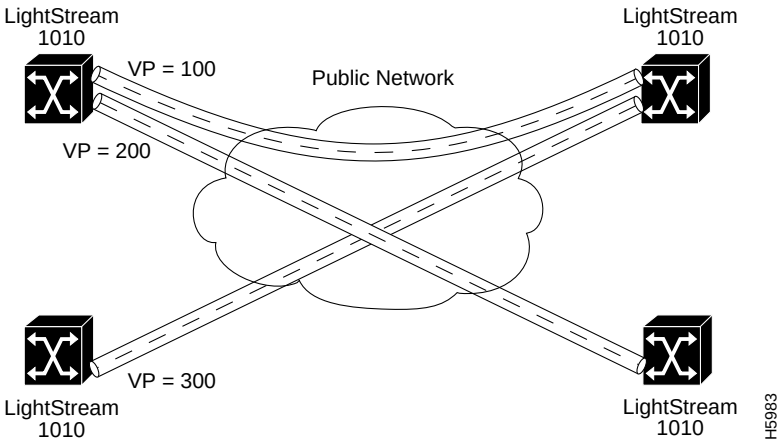
- Balancing between parallel links joining two adjacent switches
- Balancing calls to the same destination on a network-wide basis

For configuration information see the section “Configure ATM PNNI Link Selection.”

VP Tunneling

A typical application of VP tunneling using the workgroup and enterprise switch is shown in Figure 11-4. The switches form small private networks over a public cloud. They are interconnected over Permanent Virtual Paths (PVPs) which are essentially logical trunks.

Figure 11-4 Tunneling Example



The dashed lines indicate the PVPs which interconnect the ATM switches. Each of these VPs are logical trunks over which signaling (on channel VP=X, VC=5) and PNNI (on channel VP=X, VC=18) can operate normally. Switched Virtual Circuits (SVCs) can be routed and signaled across the VP tunnel as if both endpoints were connected by a physical link.

Global Switch Configuration

This section describes the following LightStream 1010 ATM switch PNNI global configuration:

- Configure the ATM Address
- Configure Static Routes

Configure the ATM Address

During the initial startup, the LightStream 1010 generates an ATM address using the defaults described in the section “ATM Address Configuration” in the chapter “Initially Configuring the LightStream 1010 ATM Switch.” The switch’s ATM address uses a hierarchical addressing model similar to the Open System Interconnect (OSI) network service access point (NSAP) addresses. PNNI uses this hierarchy to construct ATM peer groups. ILMI uses the first 13-bytes of this address as the switch prefix that it registers with end systems.

To configure a new ATM address that replaces the previous ATM address and is used to generate a new PNNI node ID and peer group ID, see the section “Configure PNNI Node.”

Multiple addresses can be configured for a single switch and this configuration can be used during ATM address migration. ILMI registers end systems with multiple prefixes during this period until an old address is removed. PNNI automatically summarizes all of the switch’s prefixes in its reachable address advertisement.

To configure an additional ATM address manually, use the following command using the **no** form of this command to disable.

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
Configure the ATM address for the switch.	**atm address** *atm_address*

1. This command is documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example adds the ATM address prefix 47.0091.8100.5670.000.0ca7.ce01 and the ellipses (...) add the default MAC address as the last six bytes.

```
Switch(config)#atm address 47.0091.8100.5670.0000.0ca7.ce01...
Switch(config)#
```

Display the ATM Address Configuration

Use the **show atm address** command to display the ATM address configuration.

To display the ATM address configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM address configuration.	**show atm address**

Example

This example displays the ATM address configuration using the **show atm address** command from user EXEC mode:

```
Switch#show atm address

Switch Address(es):
  47.00918100000000410B0A1081.00410B0A1081.00 active
  47.00918100000000603E5ADB01.00603E5ADB01.00

Soft VC Address(es):
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.0000.00 ATM0/0/0
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.0000.63 ATM0/0/0.99
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.0010.00 ATM0/0/1
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.0020.00 ATM0/0/2
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.0030.00 ATM0/0/3
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.1000.00 ATM0/1/0
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.1010.00 ATM0/1/1
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.1020.00 ATM0/1/2
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.1030.00 ATM0/1/3
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.8000.00 ATM1/0/0
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.8010.00 ATM1/0/1
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.8020.00 ATM1/0/2
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.8030.00 ATM1/0/3
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.9000.00 ATM1/1/0
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.9010.00 ATM1/1/1
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.9020.00 ATM1/1/2
  47.0091.8100.0000.0041.0b0a.1081.4000.0c80.9030.00 ATM1/1/3

ILMI Switch Prefix(es):
  47.0091.8100.0000.0041.0b0a.1081
  47.0091.8100.0000.0060.3e5a.db01
```

```
ILMI Configured Interface Prefix(es):

LECS Address(es):
Switch#
```

Configure Static Routes

Use the **atm route** command to configure a static route. A static route attached to an interface allows all ATM addresses matching the configured address prefix, to be reached through that interface.

Note Two PNNI peer groups may be connected using the IISP protocol. This requires a static route to be configured on the IISP interfaces to allow connections to be setup across the IISP link(s).

Following is an example of the **atm route** command configuring a static route to the 13-byte-switch-prefix, **47.00918100000000410B0A1081** to ATM interface 0/0/0.

```
Switch(config)#atm route 47.00918100000000410B0A1081 atm 0/0/0
Switch(config)#
```

Display the Static Route Configuration

Use the **show atm pnni prefix** command to display the ATM static route configuration.

To display the ATM static route configuration, perform the following task in user EXEC mode:

Task	Command
Display the static route configuration.	**show atm pnni prefix** [*address_prefix*|**local**]

Example

This example displays the ATM static route configuration using the **show atm pnni prefix** command from user EXEC mode:

```
Switch#show atm pnni prefix

Codes: P - installing Protocol (S - Static, P - PNNI, R - Routing control),
       T - Type (I - Internal prefix, E - Exterior prefix, SE -
                 Summary Exterior prefix, SI - Summary Internal prefix)

P  T  Node/Port         St  Prefix
- --  ---------------  --  --------------------------------------------------
S  E  1   ATM0/0/0      DN  default/0
S  E  1   ATM0/0/0      DN  47.0091.8100.0000.0000.0ca7.ce01/104
R SI  1   0             UP  47.0091.8100.0000.0041.0b0a.1081/104
S  E  1   ATM0/0/0      DN  47.0091.8100.0000.0041.0b0a.1081/104
R  I  1   ATM2/0/0      UP  47.0091.8100.0000.0041.0b0a.1081.0041.0b0a.1081/152
R  I  1   ATM2/0/0      UP  47.0091.8100.0000.0041.0b0a.1081.4000.0c/128
R SI  1   0             UP  47.0091.8100.0000.0060.3e5a.db01/104
R  I  1   ATM2/0/0      UP  47.0091.8100.0000.0060.3e5a.db01.0041.0b0a.1081/152
R  I  1   ATM2/0/0      UP  47.0091.8100.0000.0060.3e5a.db01.0060.3e5a.db01/152
R  I  1   ATM2/0/0      UP  47.0091.8100.0000.0060.3e5a.db01.4000.0c/128
S  I  1   ATM2/0/0      UP  47.0091.8100.0000.1111.1111.1111.1111.1111.1111/152
R SI  1   0             UP  47.0091.8100.5670.0000.0000.1122/104
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0000.0000.1122.0040.0b0a.1081/152
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0000.0000.1122.0041.0b0a.1081/152
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0000.0000.1122.4000.0c/128
S  E  1   ATM2/0/0      UP  47.0091.8100.5670.ca7c.e01/84
 --More--


Switch#
```

Display ATM PNNI Configuration

Use the **show atm pnni** command to display the ATM PNNI configuration.

To display the ATM PNNI router configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI router configuration.	**show atm pnni**

Examples

This example displays the ATM PNNI global configuration variables available using the **show atm pnni** command from user EXEC mode:

```
Switch#show atm pnni ?
  address      PNNI switch address(es)
  bg-routes    PNNI Routes From Background Route Table
  bg-status    PNNI Background SPF Status
  database     PTSE database information
  election     PNNI PGL election information
  identifiers  PNNI internal node number to node-id mapping
  interface    interface information
  neighbor     neighbor information
  node         PNNI node information
  prefix       PNNI prefix information
  rm-info      resource management information
  statistics   PNNI Statistics
  topology     PNNI topology database

Switch#
```

The next example displays the external ATM PNNI node configuration using the **show atm pnni node** command for node index number **1** from user EXEC mode:

```
Switch#show atm pnni node 1
PNNI node 1 is enabled and running
  Node name: eng_1
  System address 47.00918100000000410B0A1081.00410B0A1081.00
  Node ID 56:160:47.00918100000000410B0A1081.00410B0A1081.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 8, No. of neighbor 0

  Hello interval 15 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 5 sec
  PTSE refresh interval 90 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on
  Default administrative weight mode: uniform
  Next RM poll in 0 seconds
Switch#
```

PNNI Routing Configuration

This section describes the following LightStream 1010 ATM switch PNNI routing configuration:

- Enter ATM Router PNNI Configuration Mode
- Configure On-Demand and Background Path Updates
- Configure Precedence
- Configure Administrative Weight Mode
- Configure Maximum Administrative Weight Percentage
- Configure Resource Management Poll Interval
- Configure ATM PNNI Statistics Gathering
- Configure PNNI Node

Enter ATM Router PNNI Configuration Mode

To enter the ATM router PNNI configuration mode, perform the following task in global configuration mode:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example changes configuration mode to ATM router PNNI mode and displays the variables using the **?** help command:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#?
ATM router configuration commands:
  administrative-weight        Select mode of administrative weight assignment
  background-routes            Enable or Disable Background Routes
  bg                           Background SPF Related Parameters
  exit                         Exit from ATM routing protocol configuration
                               mode
  max-admin-weight-percentage  Maximum Administrative Weight Percentage
  no                           Negate or set default values of a command
  node                         Configure PNNI node
  precedence                   Define Prefix Priorities For Routing
  rm-poll-interval             How Often To Poll Resource Manager
  statistics                   Turn on PNNI statistics

Switch(config-atm-router)#
```

Configure On-Demand and Background Path Updates

Most calls are routed using precomputed routing trees. To satisfy QOS requirements, multiple background trees, are precomputed. The LightStream 1010 ATM switch supports the following two route selection modes:

- On-demand—a separate route computation is performed each time a SETUP or ADD PARTY message is received over a UNI or IISP interface. In this mode, the most recent topology information received by this node is always used for each setup request.
- Background-routes—Most calls can be routed using pre-computed routing trees. In this mode, multiple background trees are pre-computed for several service categories and QOS metrics. If no route can be found in the background trees, that satisfies the QOS requirements of a particular setup request, route selection returns to on-demand route computation.

The background-routes mode should be enabled in large networks, where it will most likely exhibit less stringent processing requirements and better scalability. Route computation is performed at most every poll-interval, when a significant change in the topology of the network is reported or when significant-threshold changes have occurred since the last route computation.

To configure the route selection mode to use background-routes, perform the following task in global configuration mode, using the **no** form of the **background-routes** command to return to on-demand mode and using the **no** form of the **bg** command to return to default values:To configure background routes, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#.`	**atm router pnni**
Configure background-routes parameters.	**bg** {**insignificant-threshold** *value*| **poll-interval** *seconds*}
Enable background routes.	**background-routes**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

insignificant-threshold - Insignificant threshold value from 1 to 100.

poll-interval - Background routes poll interval value from 1 to 60 seconds.

See the section “PNNI Topology Description and Distribution” for more information describing ATM PNNI database updates.

Example

The following example enables background-routes and configures the background routes poll interval to 30 seconds:

```
Switch(config)#atm router pnni
Switch(config-pnni-node)#background-routes
Switch(config-pnni-node)#bg poll-interval 30
```

Display the On-Demand and Background Path Updates Configuration

Use the **show atm pnni bg-status** and **show atm pnni bg-route** command to display the background route configuration.

To display the background route configuration, perform the following tasks in user EXEC mode:

Task	Command
Display the background route configuration.	**show atm pnni bg-status**
Display background route tables configuration.	**show atm pnni bg-route**

Example

The following example displays the ATM PNNI background route configuration:

```
Switch#show atm pnni bg-status

Background Route Computation is Enabled
Background Interval is set at 10 seconds
Background Insignificant Threshold is set at 32
Switch#
```

The following example displays the ATM PNNI background route tables for CBR:

```
Switch#show atm pnni bg-routes cbr

Background Routes From CBR/AW Table
-------------------------------------
2 Routes To Node 2
    1. Hops 1. n1p81801000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
    2. Hops 1. n1p81903000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5000  cdv 138  ctd 3154  min acr 147743  worst clr 10

Background Routes From CBR/CDV Table
-------------------------------------
2 Routes To Node 2
    1. Hops 1. n1p81801000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
    2. Hops 1. n1p81903000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5000  cdv 138  ctd 3154  min acr 147743  worst clr 10

Background Routes From CBR/CTD Table
-------------------------------------
2 Routes To Node 2
    1. Hops 1. n1p81801000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
    2. Hops 1. n1p81903000 -> n2
        ->: aw 5040  cdv 138  ctd 154  min acr 147743  worst clr 10
        <-: aw 5000  cdv 138  ctd 3154  min acr 147743  worst clr 10
Switch#
```

Configure Precedence

The LightStream 1010 ATM switch route selection algorithm chooses routes to particular destinations using the longest match reachable address prefixes known to the switch. When there are multiple longest match reachable address prefixes known to the switch, the route selection algorithm first attempts to find routes to reachable addresses with types of greatest precedence. Among multiple longest match reachable address prefixes of the same type, routes with the least total administrative weight are chosen first.

Local internal reachable addresses, whether learned via ILMI or as static routes, are given highest precedence; precedence value one. The precedence of other reachable address types is configurable.

To configure the ATM router PNNI precedence, perform the following task in global configuration mode using the **no** form of the command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure ATM router prompt, enter PNNI precedence and configure the PNNI node.	**precedence** [**pnni-remote-exterior** *value_2-4*| **pnni-remote-exterior-metrics** *value_2-4*| **pnni-remote-internal** *value_2-4*| **pnni-remote-internal-metrics** *value_2-4*| **static-local-exterior** *value_2-4*| **static-local-exterior-metrics** *value_2-4*| **static-local-internal-metrics** *value_2-4*]

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example configures all PNNI remote exterior routes with a precedence value of four:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#precedence pnni-remote-exterior 4
Switch(config-atm-router)#
```

Display ATM PNNI Precedence Configuration

Use the **show atm pnni precedence** command to display the ATM PNNI route determination precedence configuration.

To display the ATM PNNI route determination precedence configuration, perform the following task in user EXEC mode:

Task	Command
Display the node ATM PNNI route determination precedence configuration.	**show atm pnni precedence**

Example

The following example displays ATM PNNI route determination precedence configuration:

```
Switch#show atm pnni precedence
                                Working   Default
  Prefix Poa Type               Priority  Priority
  ----------------------------  --------  --------
  local-internal                   1         1
  static-local-internal-metrics    2         2
  static-local-exterior            3         3
  static-local-exterior-metrics    2         2
  pnni-remote-internal             2         2
  pnni-remote-internal-metrics     2         2
  pnni-remote-exterior             4         4
  pnni-remote-exterior-metrics     2         2

Switch#
```

Configure Administrative Weight Mode

You can configure administrative weight to indicate the relative desirability of using a link. In addition to the per interface **atm pnni administrative-weight** command, the ATM router PNNI **administrative weight** command can be used to change the default administrative weight assignment. For example, assigning equal administrative weights to all links in the network will minimize the number of hops used by each connection. For more information see the section "Administrative Weight."

To configure the ATM router PNNI administrative weight mode, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure router prompt, configure the administrative weight for all node connections.	**administrative-weight** {l**inespeed**|**uniform**}

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

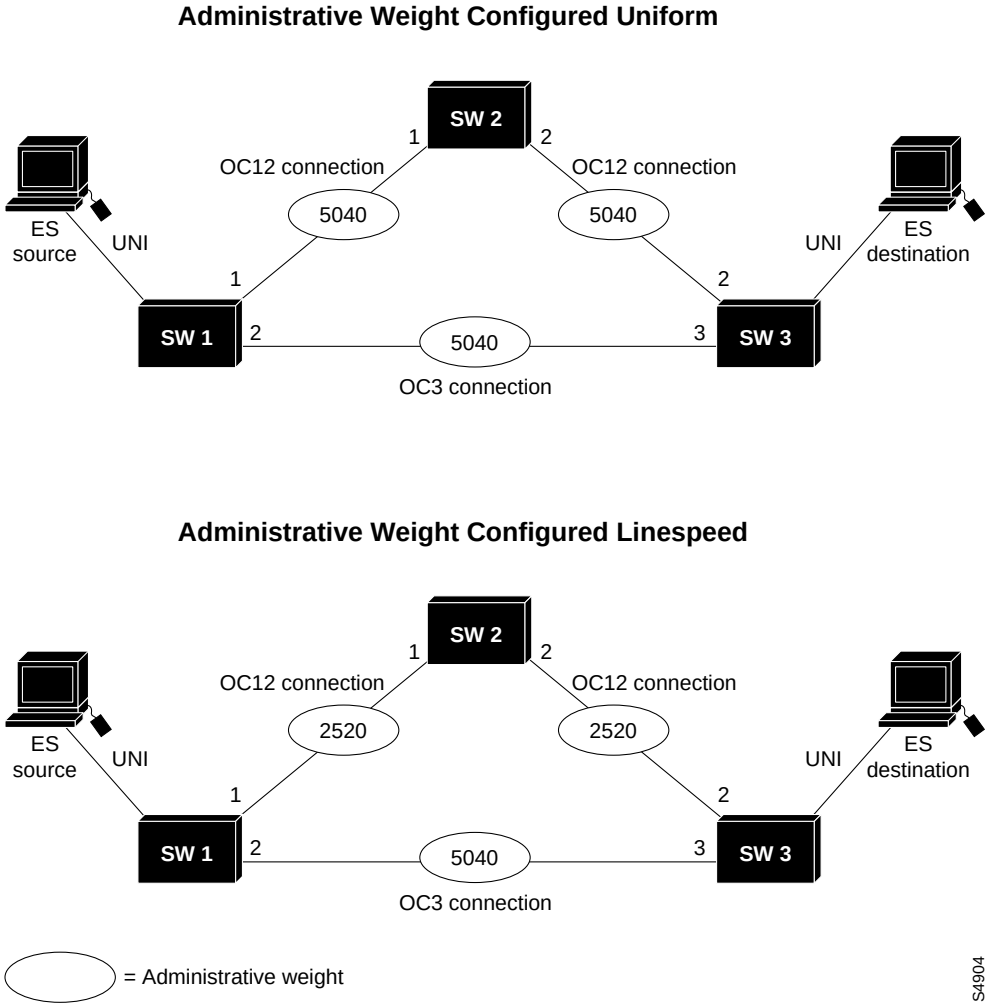
linespeed—Used to set default administrative weight to values determined by the interface line speed (maximum cell rate).

Note Higher linespeeds (maximum cell rates) have lower administrative weight and are selected first during routing.

uniform—Used to set all interface administrative weights that are not explicitly configured to the uniform value of 5040.

Figure 11-5 is an example of how administrative weight affects call routing.

Figure 11-5 Network Administrative Weight Example



In Figure 11-5, the top network is configured as uniform causing equal administrative weight to be assigned to each link. In the bottom network configuration the same network is configured as linespeed. The links between SW1 and SW2 (SW1p1->SW2p1) and between SW2 and SW3 (SW2p2->SW3p2) are both faster OC12 connections and have lower administrative weights. PNNI interprets the route over the two OC12 links as being administratively equivalent to a more direct route between SW1 and SW3 using the OC 3 connection.

Example

The following example configures administrative weight for the node as line speed:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#administrative-weight linespeed
Switch(config-atm-router)#
```

Display the Administrative Weight Mode Configuration

Use the **show atm pnni node** command to display the administrative weight mode configuration for the individual interfaces.

To display the administrative weight configuration, perform the following task in user EXEC mode:

Task	Command
Display the administrative weight configuration for the node.	**show atm pnni node**

Example

The following example displays the administrative weight (AW) configuration for the node:

```
Switch#show atm pnni node
PNNI node 1 is enabled and running
  Node name: switch
  System address 47.009181000000000000001212.121212121212.00
  Node ID 56:160:47.009181000000000000001212.121212121212.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 4, No. of neighbor 1

  Hello interval 15 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 10 sec
  PTSE refresh interval 90 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on, Supported PNNI versions: newest 1, oldest 1
  Default administrative weight mode: linespeed
  Max admin weight percentage: 300
  Next RM poll in 3 seconds
Switch#
```

Configure Maximum Administrative Weight Percentage

Administrative weight (AW) is the main metric used for computation of the paths by PNNI. The assignment of administrative weights to links and nodes impacts the way PNNI selects paths in the private ATM network. For more detailed information see the section “Administrative Weight.”

To configure the maximum administrative weight percentage, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
Configure the maximum administrative weight percentage.	**max-admin-weight-percentage** {*value 100 to 2000*}

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Note Configure the maximum administrative weight command only if background route computation is enabled. See the section “Configure On-Demand and Background Path Updates.”

Example

The following example configures the node maximum administration weight value as 300:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#max-admin-weight-percentage 300
Switch(config-atm-router)#
```

Display the Maximum Administrative Weight Percentage Configuration

Use the **show atm pnni node** command to display the node ATM PNNI maximum administrative weight configuration.

To display the node ATM PNNI maximum administrative weight percentage configuration, perform the following task in user EXEC mode:

Task	Command
Display the node ATM PNNI maximum administrative weight configuration.	**show atm pnni node**

Example

The following example displays maximum administrative weight percentage configuration:

```
Switch#show atm pnni node
PNNI node 1 is enabled and running
  Node name: eng_1
  System address 47.009181000000000000001212.121212121212.00
  Node ID 56:160:47.009181000000000000001212.121212121212.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 4, No. of neighbor 1

  Hello interval 15 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 10 sec
  PTSE refresh interval 90 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on, Supported PNNI versions: newest 1, oldest 1
  Default administrative weight mode: linespeed
  Max admin weight percentage: 300
  Next RM poll in 3 seconds
Switch#
```

Configure Resource Management Poll Interval

The resource management (RM) poll interval specifies how often PNNI polls RM to update the values of link metrics and attributes. Configuration of the RM poll interval allows you to control the trade-off between the processing load and the accuracy of PNNI information. A larger value will probably generate a smaller number of PTSE updates. A smaller value results in greater accuracy in tracking resource information.

To configure the resource management poll interval, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
Configure the Resource Management Poll Interval.	**rm-poll-interval** *seconds*

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example configures the RM poll interval to 10 seconds:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#rm-poll-interval 10
```

Display the Resource Management Poll Interval

To display the RM poll interval configuration, perform the following task in user EXEC mode:

Task	Command
Display the RM poll interval configuration.	**show atm pnni rm-info**

Example

The following example displays the RM poll interval configuration:

```
Switch#show atm pnni rm-info
acr pm 50,  acr mt 3, cdv pm 25, ctd pm 50, rm poll interval 5 sec
Interface insignificant change bounds:
ATM0/0/0 , port ID 80000000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519
ATM0/0/1 , port ID 80001000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519

<Information Deleted>

ATM1/1/3 , port ID 80903000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519
Switch#
```

Configure ATM PNNI Statistics Gathering

The following statistics on routing of ATM connections can be gathered:

- Number of source route requests
- Number of micro-seconds spent in dijkstra algorithm
- Number of crankback source route requests
- Number of next port requests
- Number of background route lookups
- Number of on-demand route computations

To enable ATM PNNI statistics, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
Enable ATM PNNI statistics gathering.	**statistics [call]**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example enables PNNI ATM statistics gathering:

```
Switch#config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#atm router pnni
Switch(config-atm-router)#statistics call
Switch(config-atm-router)#
```

Display the ATM PNNI Statistics

To display the ATM PNNI statistics, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI statistics.	**show atm pnni statistics [call]**

Example

The following example displays the ATM PNNI statistics:

```
Switch#show atm pnni statistics call

pnni call statistics since 22:19:29

                    total     cbr       rtvbr     nrtvbr    abr       ubr
source route reqs   1346      0         0         0         0         0
successful          1342      1342      0         0         0         0
unsuccessful        4         4         0         0         0         0
crankback reqs      0         0         0         0         0         0
successful          0         0         0         0         0         0
unsuccessful        0         0         0         0         0         0
on-demand attempts  0         0         0         0         0         0
successful          0         0         0         0         0         0
unsuccessful        0         0         0         0         0         0
background lookups  0         0         0         0         0         0
successful          0         0         0         0         0         0
unsuccessful        0         0         0         0         0         0
next port requests  0         0         0         0         0         0
successful          0         0         0         0         0         0
unsuccessful        0         0         0         0         0         0

                    total     average
usecs in queue      2513166   1867
usecs in dijkstra   0         0
usecs in routing    132703    98
Switch#
```

Configure PNNI Node

Each LightStream 1010 ATM switch is modeled as a single lowest-level PNNI node (locally identified as node 1). The node command is used to change the level of a node and to disable and enable a node. This causes the node ID and peer group ID of the node to be recalculated based on the level and the first ATM address.

Note The level of a node can only be modified when the node is disabled.

When the node command is entered, the switch changes to node configuration mode.

To change the ATM address of the switch, the level of the node and to recalculate the node ID and peer group ID based on the new ATM address and level, perform the following task in global configuration mode:

At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configuration mode prompt, configure the new ATM address for the switch.	**atm address** ***atm_address***
At the configuration mode prompt, remove the old ATM address from the switch.	**no atm address** ***atm_address***
At the configuration mode prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**

At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configuration mode prompt, configure the new ATM address for the switch.	**atm address** ***atm_address***
At the configure ATM router prompt, disable the PNNI node.	**node 1 disable**
Change the level of the PNNI node.	**node 1** *level level_indicator*
Enable the PNNI node, causing the node ID and peer group ID to be recalculated.	**node 1 enable**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example changes the ATM address of the switch from the autoconfigured address 47.0091.8100.0000.0041.0b0a.1081.0041.0b0a.1081.00 to the new address prefix 47.0091.8100.5670.0000.0000.1122.0041.0b0a.1081.00 changes the level of the node to 96, and causes the node ID and peer group ID to be recalculated:

```
Switch(config)#atm address 47.0091.8100.5670.0000.0000.1122...
Switch(config)#no atm address 47.0091.8100.0000.0041.0b0a.1081...
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1 disable
Switch(config-pnni-node)#node 1 level 96
Switch(config-pnni-node)#node 1 enable
```

Display PNNI Node Configuration

To display the ATM PNNI node configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI node configuration.	**show atm pnni node**

```
Switch#show atm pnni node
PNNI node 1 is enabled and running
  Node name: switch
  System address 47.009181000000000000001212.121212121212.00
  Node ID 56:160:47.009181000000000000001212.121212121212.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 4, No. of neighbor 1

  Hello interval 15 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 10 sec
  PTSE refresh interval 90 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on, Supported PNNI versions: newest 1, oldest 1
  Default administrative weight mode: linespeed
  Max admin weight percentage: 300
  Next RM poll in 3 seconds
Switch#
```

PNNI Node Configuration

This section describes configuration of the following LightStream 1010 ATM switch PNNI node attributes:

- Entering PNNI Node-Level Configuration
- Configure Node Name
- Configure PNNI Summary Address
- Configure Redistribution
- Configure Restricted Transit Nodes
- Configure Significant Change Thresholds
- Configure PNNI Hello, Database Synchronization and Flooding Parameters

Entering PNNI Node-Level Configuration

To configure the ATM router PNNI node, perform the following task in global configuration mode:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni {exit|no|node|precedence}**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#`.	**node** *node_index*

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

Following is an example of entering node level configuration mode and displaying the variables using the **?** help command:

```
Switch#
Switch#config terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#?
PNNI router node configuration commands:
  auto-summary        Automatically summarize switch address prefix
  exit                Exit from PNNI router node configuration mode
  name                Configure Node's Name
  no                  Negate or set default values of a command
  ptse                PTSE generation parameters
  redistribute        Route redistribution from another routing protocol
  summary-address     Summarize reachable addresses into PNNI
  timer               PNNI timer variables
  transit-restricted  Transit calls are not allowed

Switch(config-pnni-node)#
```

Configure Node Name

To configure the ATM router PNNI node, perform the following task in global configuration mode using the **no** form of the ATM router node configuration commands to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#.`	**atm router pnni {exit|no|node|precedence}**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#.`	**node** *node_index*
Configure the node name.	**name** *name_string*

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

Configure the name of the node as **eng_1** using the **name** command, as in the following example:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#name eng_1
Switch(config-pnni-node)#
```

Display the Node Name Configuration

Use the **show atm pnni node** command to display the ATM PNNI node name configuration.

To display the ATM PNNI node name configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI router configuration.	**show atm pnni node**

Examples

This example displays the ATM node name configuration using the **show atm pnni node** command from user EXEC mode:

```
Switch#show atm pnni node
PNNI node 1 is enabled and running
  Node name: eng_1
  System address 47.009181000000000000001212.121212121212.00
  Node ID 56:160:47.009181000000000000001212.121212121212.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 4, No. of neighbor 1

  Hello interval 15 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 10 sec
  PTSE refresh interval 90 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on, Supported PNNI versions: newest 1, oldest 1
  Default administrative weight mode: linespeed
  Max admin weight percentage: 300
  Next RM poll in 3 seconds
Switch#
```

Configure PNNI Summary Address

Address summarization allows scalability across multiple networks. By default the node has a summary address equal to the 13-byte address prefix of the ATM address of the switch. This address prefix is advertised into its peer group.

Multiple addresses can be configured for a single switch and this configuration can be used during ATM address migration. ILMI registers end systems with multiple prefixes during this period until an old address is removed. PNNI automatically creates 13-byte summary address prefixes from all of its ATM addresses.

Summary address prefixes can also be manually configured using the **summary-address** command. A node can have multiple summary address prefixes.

Note The command **no auto-summary** removes the default summary address(es). The **no auto-summary** command should be used whenever systems matching the first 13-bytes of this switch's ATM address(es) are attached to different switches. It can also be used for security reasons.

To configure address summarization, perform the following task in global configuration mode:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#`.	**node** *node_index*
Remove the default summary address(es).	**no auto-summary**
Configure the ATM PNNI summary address prefix.	**summary-address** *address_prefix*

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example removes the default summary address(es) and adds summary address **47.009181005670**:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#no auto-summary
Switch(config-pnni-node)#summary-address 47.009181005670
Switch(config-pnni-node)#
```

Display the ATM PNNI Summary Address Configuration

Use the **show atm pnni prefix** command to display the ATM PNNI summary address configuration.

To display the ATM PNNI summary address configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI summary address configuration.	**show atm pnni prefix**

Example

The following example displays the ATM PNNI summary address configuration:

```
Switch#show atm pnni prefix

Codes: P - installing Protocol (S - Static, P - Pnni, R - Routing control),
       T - Type (I - Internal prefix, E - Exterior prefix, SE -
                 Summary Exterior prefix, SI - Summary Internal prefix)

P  T  Node/Port         St  Prefix
- --  ---------------  --  --------------------------------------------------
S  E  1   ATM0/0/0      DN  default/0
P SI  1   0             UP  47.0091.8100.5670/56
S  E  1   ATM0/0/0      DN  47.0091.8100.0000.0000.0ca7.ce01/104
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0041.0b0a.1081.0041.0b0a.1081/152
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0041.0b0a.1081.4000.0c/128
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0060.3e5a.db01.0060.3e5a.db01/152
R  I  1   ATM2/0/0      UP  47.0091.8100.5670.0060.3e5a.db01.4000.0c/128

Switch#
```

Configure Redistribution

Redistribution instructs PNNI to distribute reachability information from non-PNNI sources throughout the PNNI routing domain. The LightStream 1010 ATM switch supports redistribution of static routes, such as those configured on IISP interfaces.

Note By default, redistribution of static routes is enabled.

To enable redistribution of static routes throughout the PNNI routing domain, perform the following task in global configuration mode using the **no** form of this command to stop redistribution:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#`.	**node** *node_index*
Enable redistribution of static routes.	**redistribution atm-static**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example enables redistribution of static routes:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#redistribute atm-static
Switch(config-pnni-node)#
```

Display the Redistribution Configuration

Use the **show running-config** command to display the redistribution configuration.

To display the node redistribution configuration, perform the following task in user EXEC mode:

Task	Command
Display the node redistribution configuration.	**show running-config**

Example

The following example displays the node redistribution configuration:

```
Switch#show running-config
Building configuration...

Current configuration:
!
version 11.1
no service pad
service exec-wait
service udp-small-servers
service tcp-small-servers
!
hostname Switch
!
clock summer-time pdt recurring 4 Sun Apr 2:00 last Sun Oct 2:00
boot buffersize 50000
boot system flash slot0:rhino/ls1010-wi-m_1.083.bin.Z
boot system flash ls1010-wi-m_1.083.bin.Z
boot system marek/ls1010-wp-m 255.255.255.255
boot config nvram:
boot bootldr bootflash:ls1010-wi-mz_1.087
```

```
!
ip host-routing
ip rcmd rcp-enable
ip rcmd rsh-enable
ip rcmd remote-host dplatz 171.69.1.129 dplatz enable
ip rcmd remote-host root 171.69.1.129 root enable
ip rcmd remote-username dplatz
ip rcmd source-interface Ethernet2/0/0
atm over-subscription-factor 16
atm service-category-limit cbr 3000
atm qos uni3-default  cbr max-cell-loss-ratio 12
atm lecs-address-default 47.0091.0000.0000.0000.0000.0000.0000.0000.0000.00
atm address 47.0091.8100.0000.0041.0b0a.1081.0041.0b0a.1081.00
atm address 47.0091.8100.0000.0060.3e5a.db01.0060.3e5a.db01.00
atm router pnni
 node 1 level 56 lowest
  ptse refresh-interval 60
  timer hello-interval  60
  no auto-summary
  redistribute atm-static
  max-admin-weight-percentage 300
  transit-restricted
  bg-routes
  spf poll-interval 30
  bg-route-interval 30
  administrative-weight linespeed
  statistics call
  name switch
  type 1
!
!
--More--
```

Configure Restricted Transit Nodes

Transit calls are calls originating from another ATM switch and passing through the switch. Some edge switches may want to eliminate this transit traffic and only allow traffic originating or terminating at this switch.

To configure whether a node allows transit calls, perform the following task in ATM PNNI node level configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#.`	**atm router pnni**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#.`	**node** *node_index*
Enable transit restricted on this node.	**transit-restricted**

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Example

The following example enables the transit restricted feature:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#transit-restricted
Switch(config-pnni-node)#
```

Display the Transit Restriction Configuration

Use the **show atm pnni topology** command to display the transit restriction configuration.

To display the ATM PNNI transit restriction configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM configuration.	**show atm pnni topology** *node node_name*

Example

The following example displays the ATM PNNI transit restriction configuration of a node named eng_1:

```
Switch#show atm pnni topology node eng_1

Node 1 (name: eng_1, type: unknown, ios-version: 11.1)
Node Id: 56:160:47.00918100000000410B0A1081.00410B0A1081.00
Service Classes Supported:NONE
Node Does Not Allow Transit Calls
Node has leadership priority 0

Switch#
```

Configure Significant Change Thresholds

PTSPs would overwhelm the network if they were transmitted every time any parameter in the network changed. To avoid this, PNNI uses significant change thresholds that control origination of PTSEs.

Note Any change in administrative weight and cell loss ratio is considered significant and triggers origination of a new PTSE instance.

To configure the PTSE significant change thresholds, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#`.	**node** *node_index*
Configure PTSE significant change percent number.	**ptse significant-change** {**acr-mt** *percentage*|**acr-pm** *multiplier*| **cdv-pm** *multiplier*|**ctd-pm** *multiplier*}

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

The significant change variables are:

- **acr-mt**—Available cell rate maximum threshold percentage
- **acr-pm**—Available cell rate proportional multiplier
- **cdv-pm**—Cell delay variation proportional multiplier
- **ctd-pm**—Maximum cell transfer delay proportional multiplier

For an example of other **ptse** command keywords, see the section "Configure PNNI Hello, Database Synchronization and Flooding Parameters."

Example

The following example configures a PTSE being sent only if the available cell rate changes 30 percent from the current metric:

```
Switch(config)#atm router pnni
Switch(config-atm-router)#node 1
Switch(config-pnni-node)#ptse significant-change acr-pm 30
Switch(config-pnni-node)#
```

Display the Significant Change Thresholds Configuration

Use the **show atm pnni rm-info** command to display the significant change threshold configuration.

To display the PTSE configuration, perform the following task in user EXEC mode:

Task	Command
Display the PTSE ID.	**show atm pnni rm-info**

Example

The following example displays the significant change threshold configuration:

```
Switch#show atm pnni rm-info
acr pm 30,  acr mt 30, cdv pm 25, ctd pm 50, rm poll interval 5 sec
Interface insignificant change bounds:
ATM0/0/0 , port ID 80000000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519
ATM0/0/1 , port ID 80001000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519

<Information Deleted>

ATM1/0/3 , port ID 80803000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8,
  UBR    : MCR 155519
ATM1/1/3 , port ID 80903000
  CBR    : MCR 155519, ACR 147743 [73871,155519], CTD 154 [77,231],CDV 138 [104, 172], CLR 10,
  VBR-RT : MCR 155519, ACR 147743 [73871,155519], CTD 707 [354,1060],CDV 691 [519,863], CLR 8,
  VBR-NRT: MCR 155519, ACR 147743 [73871,155519], CLR 8, UBR    : MCR 155519
Switch#
```

Configure PNNI Hello, Database Synchronization and Flooding Parameters

PNNI uses the Hello protocol to determine the status of neighbor nodes and PTSEs to disseminate topology database information in the ATM network. See the sections “The Hello Protocol,” “Database Synchronization,” and “Topology Information in PNNI” for more information.

To configure the Hello, Database Synchronization, and flooding parameters, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
At the configure prompt, enter ATM router PNNI mode from the terminal. The prompt will change to `Switch(config-atm-router)#`.	**atm router pnni**
At the configure ATM router prompt, enter node configuration mode. The prompt will change to `Switch(config-pnni-node)#`.	**node** *node_index*
Configure Hello database synchronization and flooding parameters.	**timer** {**ack-delay** *seconds*|**hello-holddown** *tenth_of_seconds*|**hello-interval** *seconds*|**inactivity-factor** *multiplier*|**retransmit-interval** seconds|**rm-poll-interval** *seconds*}
Configure PTSE significant change percent number.	**ptse** [**flood-delay**|**lifetime-factor**|**min-ptse-interval** |**refresh-interval**|**request**|**significant-change**]

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

flood-delay—Number of milliseconds before flooding is scheduled after receiving update

lifetime-factor—The refresh intervals maximum lifetime

min-ptse-interval—PTSE hold-down interval

refresh-interval—PTSE refresh interval

request—Maximum PTSE requested in one request packet

significant-change—The significant change variables are:

- **acr-mt**—Available cell rate maximum threshold percentage
- **acr-pm**—Available cell rate proportional multiplier
- **cdv-pm**—Cell delay variation proportional multiplier
- **ctd-pm**—Maximum cell transfer delay proportional multiplier

Note For an example of the **ptse significant-chang**e command, see the section "Configure Significant Change Thresholds."

Example

The following example configures the PTSE refresh interval at 10 seconds and the flood delay after an update at 20 milliseconds:

```
Switch(config-pnni-node)#ptse refresh-interval 10 flood-delay 20
Switch(config-pnni-node)#
```

The following example configures the retransmission of the Hello timer to 60 seconds:

```
Switch(config-pnni-node)#timer hello-interval 60
Switch(config-pnni-node)#
```

Display the PNNI Hello, Database Synchronization and Flooding Configuration

Use the **show atm pnni node** command to display the ATM PNNI Hello, database synchronization and flooding configuration.

To display the ATM PNNI Hello, database synchronization, and flooding configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI Hello, database synchronization and flooding configuration.	**show atm pnni node**

Example

The following example displays the ATM PNNI Hello, database synchronization, and flooding configuration:

```
Switch#show atm pnni node
PNNI node 1 is enabled and running
  Node name: eng_1
  System address 47.00918100000000410B0A1081.00410B0A1081.00
  Node ID 56:160:47.00918100000000410B0A1081.00410B0A1081.00
  Peer group ID 56:47.0091.8100.0000.0000.0000.0000
  Level 56, Priority 0, No. of interface 8, No. of neighbor 0

  Hello interval 60 sec, inactivity factor 5, Hello hold-down 10 tenths of sec
  Ack-delay 2 sec, retransmit interval 10 sec, rm-poll interval 5 sec
  PTSE refresh interval 10 sec, lifetime factor 7, minPTSEinterval 1000 msec
  Auto summarization: on
  Default administrative weight mode: linespeed
  Next RM poll in 3 seconds
Switch#
```

PNNI Interface Configuration

The following sections describe configuration of the LightStream 1010 ATM switch PNNI interfaces:

- Configure Administrative Weight Per Interface
- Configure ATM PNNI Link Selection

Configure Administrative Weight Per Interface

Administrative weight is the main metric used for computation of the paths by PNNI. The assignment of administrative weights to links and nodes impacts the way PNNI selects paths in the private ATM network. For more detailed information see the section “Administrative Weight.”

To configure the administrative weight for an individual interface, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
Specify an ATM interface and enter interface configuration mode.	**interface atm** *card/sub_card/port*
Configure the ATM administrative weight for this link.	**atm pnni admin-weight** *number traffic_class*

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

number—A value from 1 to 1000000.

traffic class—CBR, VBR-RT, VBR-NRT, ABR, UBR, or all.

Example

The following example configures ATM interface 0/0/0 with ATM PNNI administration weight of 7560 for traffic class ABR:

```
Switch(config)#interface atm 0/0/0
Switch(config-if)#atm pnni admin-weight 7560 abr
Switch(config-if)#
```

Display the Interface Administrative Weight Configuration

Use the **show atm pnni** command to display the ATM PNNI interface administrative weight configuration.

To display the ATM PNNI interface administrative weight configuration, perform the following task in user EXEC mode:

Task	Command
Display the interface ATM PNNI administrative weight configuration.	**show atm pnni** [**interface atm** *card/sub_card/port*] [**detail**]

Example

The following example displays the administrative weight for interface 0/0/0 configuration:

```
Switch#show atm pnni interface atm 0/0/0 detail

Port ATM0/0/0 is up  , Hello state 2way_in with node Switch

Next hello occurs in 2 seconds, Dead timer fires in 254 seconds
  CBR    : AW 5040, MCR 155519, ACR 147743, CTD 154, CDV 138, CLR 10
  VBR-RT : AW 5040, MCR 155519, ACR 147743, CTD 707, CDV 691, CLR 8
  VBR-NRT: AW 5040, MCR 155519, ACR 147743, CLR 8,
  UBR    : AW 5040, MCR 155519
Switch#
```

Configure ATM PNNI Link Selection

The Lightstream 1010 ATM Switch Link Selection feature allows you to choose the mode for selecting one specific link among several parallel links.

When multiple parallel links are configured inconsistently, the order of precedence of configured values is as follows:

1. admin-weight-minimize
2. blocking-minimize
3. transmit-speed-maximize
4. load-balance

For example, if any of the links is configured as admin-weight minimize, that is used for the entire link group.

To configure ATM PNNI link selection, perform the following task in global configuration mode using the **no** form of this command to assign the default value:

Task	Command
At the privileged EXEC prompt, enter configuration mode from the terminal.	**configure**[1] [**terminal**]
Specify an ATM interface and enter interface configuration mode.	**interface atm** *card/sub_card/port*
Configure ATM PNNI link selection for a specific link.	**atm pnni link-selection** {**admin-weight-minimize**|**blocking-minimize** | **load-balance**|**transmit-speed-maximize**}

1. These commands are documented in the *LightStream 1010 ATM Switch Command Reference* publication.

Syntax Description

admin-weight-minimize—Transmits call on the interface with lowest administrative weight.

blocking-minimize—Minimizes subsequent call blocking.

load-balance—Balances calls across all parallel links.

transmit-speed-maximize—Transmits call on highest speed parallel link.

Example

The following example configures ATM interface 0/0/0 to use the transmit-speed-maximize link selection mode:

```
Switch(config)#interface atm 0/0/0
Switch(config-if)#atm pnni link-selection transmit-speed-maximize
Switch(config-if)#
```

Display the PNNI Link Selection Configuration

Use the **show atm pnni neighbor** command to display the PNNI link selection configuration for all interfaces.

To display the ATM PNNI link selection configuration, perform the following task in user EXEC mode:

Task	Command
Display the ATM PNNI link selection configuration.	**show atm pnni neighbor**

Example

The following example displays detailed PNNI link selection configuration:

```
Switch#show atm pnni neighbor

Neighbor Name: engin_13
Link Selection Set To: minimize blocking of future calls
  Port          Remote port ID          Hello state
  ATM3/0/1      ATM3/0/3    (81803000)  2way_in
  ATM3/1/3      ATM3/0/2    (81802000)  2way_in (Flooding Port)

Switch#
```