ATM Logical Connections: VCC

- Logical Connections in ATM are referred to as **virtual channel connections (VCCs**). Virtual channel (VC) is a generic term used to describe unidirectional transport of ATM cells associated by a common unique identifier value.
- A VCC is set up between two end users through the network, and a variable-rate, full-duplex flow of fixed size cells is exchanged over the connection.

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ATM Logical Connections: VPC

The second concept introduced is the **Virtual Path Connection (VPC).** A Virtual Path Connection (VPC) can carry multiple Virtual Channel Connections (VCCs). The VPC has several advantages:

- Increased network performance.
- Reduced processing time.
- Shorter connection setup time.

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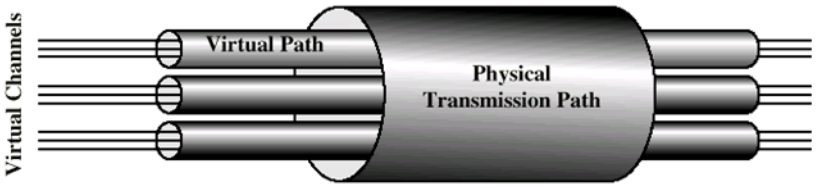
ATM Logical Connections VP/VCC



9

VP/VCC Setup

- VPC control mechanisms include calculating routes, allocating capacity, and storing connection state information.
- To set up VC, there must first be a VP to the required destination node with sufficient available capacity to support the virtual channel with appropriate QoS.

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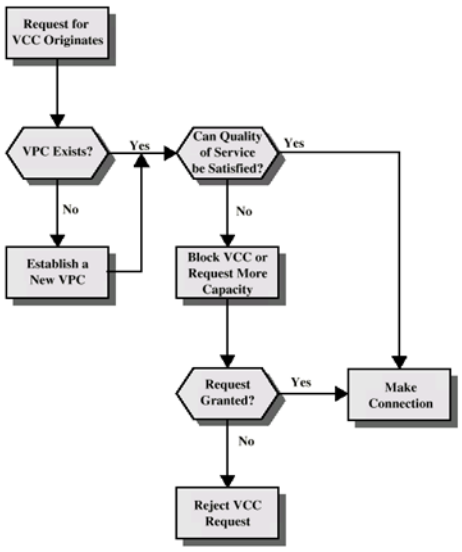
VP/VCC Setup



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VCC Uses

- Between end users
  - End to end user data
  - Control signals
- Between end user and network
  - Control signaling
- Between network entities
  - Network traffic management
  - Routing

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VP/VCC Characteristics

- **Quality of service**: parameters such as cell loss ratio and cell delay variation.
- **Cell sequence integrity**: A sequence of transmitted cell within a VCC is preserved.
- **Traffic parameter negotiation and usage monitor**: Traffic parameter can be negotiated between user and network. The input of cells is monitored by the network to ensure that the negotiated parameters are not violated.

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ATM Cells

- ATM defines two different cell formats: **UNI (User-Network Interface)** and **NNI (Network-Network Interface).**

- Fixed and Small size cell:
  - Small cells reduce queuing delay for high priority cells
  - Small cells can be switched more efficiently
  - Easier to implement switching of small cells in hardware

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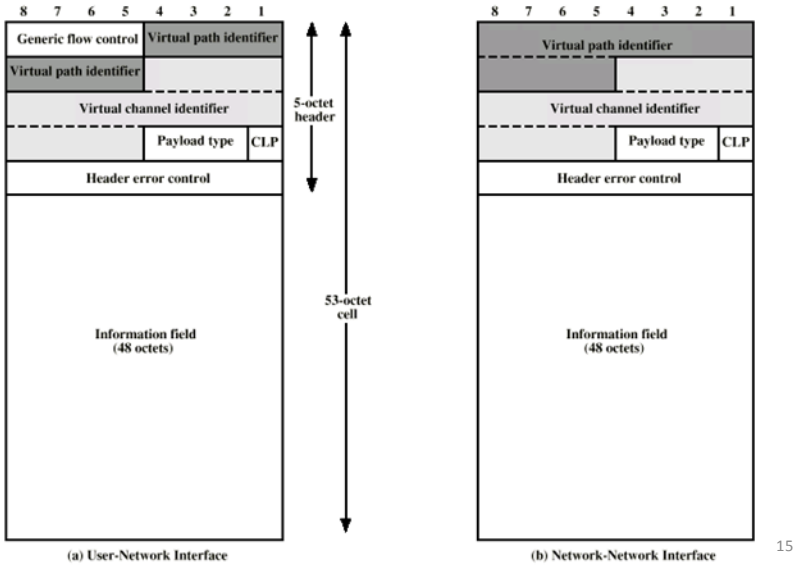
ATM Cell Format



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ATM Cell Format

- **Generic flow control**—could be used to assist the customer in controlling the flow of traffic for different QoS.
  - The GFC field was designed to give the User-Network Interface (UNI) 4 bits in which to negotiate multiplexing and flow control among the cells of various ATM connections. However, the use and exact values of the GFC field have not been standardized, and the field is always set to 0000.
- **Virtual path identifier (VPI)** – constitutes a routing field for the network. It is an 8-bits at the user-network interface and 12-bits at the network-network interface.
- **Virtual channel identifier (VCI)** – service access point, is used for routing to and from the end user.

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ATM Cell Format

- **Payload type (PT)** – is a 3-bit field indicates the type of information in payload field
  - The first bit indicates the type of ATM cell that follows. A first bit set to 0 indicates user data; a bit set to 1 indicates operations, administration & management (OA&M) data.
  - The second bit indicates whether the cell experienced congestion in its journey from source to destination.
  - The third bit indicates the last cell in a block for AAL in user ATM cells.
- **Cell loss priority (CLP)** is used to provide guidance to the network in the event of congestion.
  - 0 -- high priority, should not be discarded unless no other alternative is available.
  - 1 -- this cell can be discarded in case of congestion.

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Header Error Control (HEC)

- 8 bit error control field, calculated on remaining 32 bits of header
- The HEC uses the polynomial $x^8 + x^2 + x + 1$ to generate the code. As the input to the calculation is only 32 bits, it not only allows the code to be used to detect errors, but also to correct them

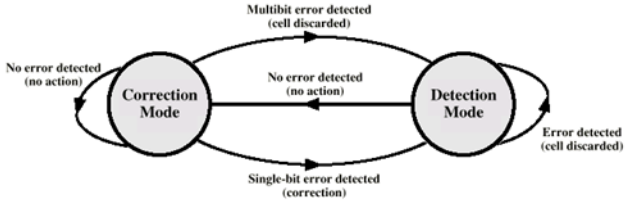

Figure 11.5 HEC Operation at Receiver

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HEC operation

1. The operations consist of two modes: correction mode and detection mode. Initially the receiver is at correction mode. When a cell arrives, HEC is calculated.
2. If no errors, the receiver remains in correction mode.
3. If an error is detected, and it is a single-bit error, the receiver will correct it and moves to detection mode.
4. If the error is a multi-bit error, the receiver just moves to the detection mode. The receiver remains in detection mode as long as errored cells are received.
5. When a good cell is received, the receiver switches back to correction mode.

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ATM Services

ATM network is designed to be able to transfer many different types of traffic simultaneously, including real-time flows such as voice, video, and burst TCP flows. The following service categories have been defined by the ATM Forum:

- Real-time service
  - Constant bit rate (CBR)
  - Real-time variable bit rate (rt-VBR)
- Non Real-time service
  - Non-real-time variable bit rate (nrt-VBR)
  - Available bit rate (ABR)
  - Unspecified bit rate (UBR)

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Real-Time Services

- Real-time applications typically involve a flow of information to the user that is intended to reproduce the flow at a source. have tight constraints on delay and delay variation (jitter).

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CBR

- The constant bit rate (CBR) is used by applications that require a fixed data rate that is continuously available during the connection lifetime and a relatively tight upper bound on transfer delay.
- Examples of CBR applications include:
  - Videoconferencing
  - Interactive audio (telephony)
  - Audio/video distribution (television, distance learning, pay-per view)
  - Audio/video retrieval (video-on-demand, audio library)

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rt-VBR

- The real-time variable bit rate (rt-VBR) is intended for time sensitive applications, i.e., those require tightly constrained delay and delay variation. rt-VBR applications transmit at a rate that varies with time
- e.g. compressed video
  - Produces varying sized image frames
  - Original (uncompressed) frame rate constant
  - So compressed data rate varies

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Non-real-time services

- Non-real-time services are intended for applications that have bursty traffic characteristics and do not have tight constraints on delay and delay variation.

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nrt-VBR

- With the non-real-time variable bit rate (nrt-VBR) service, the end system specifies some traffic characteristics such as:
  - Peak cell rate
  - Sustainable or average rate
  - Measure of how bursty traffic is
- The network can then provide substantial improved QoS in loss and delay.
- Example applications include airline reservations, banking transactions.

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UBR

- The unspecified bit rate (UBR) service is a best effort service.
- With UBR, cells are forwarded on a FIFO basis using the capacity not consumed by other services.
- Example applications include FTP, information distribution and retrieval, and remote terminal.

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ABR

- With the available bit rate (ABR) service, an application specifies a peak cell rate (PCR) and a minimum cell rate (MCR).
- The network allocates resources so that all ABR applications receive at least their MCR capacity. Any unused capacity is then shared among all ABR sources.
- e.g. LAN interconnection

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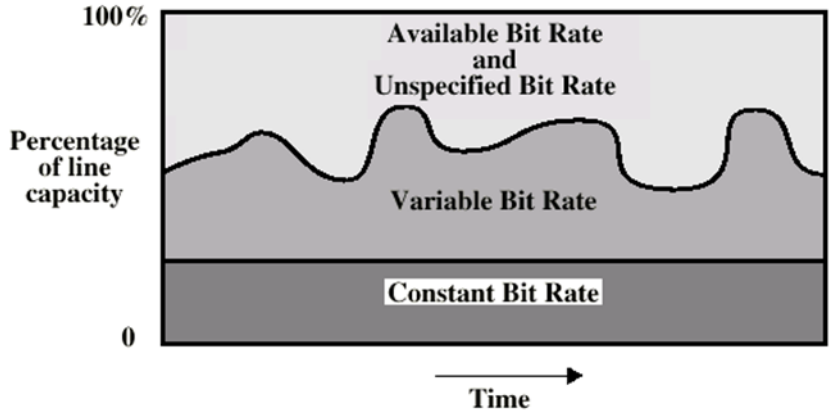
ATM Bit Rate Services



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Physical layer in ATM

Physical layer in ATM includes two sublayers:

- Physical Medium (PM) sublayer.
- Transmission Convergence (TC) Sublayer.

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Physical layer in ATM

Physical Medium (PM) sublayer

- Physical medium and transmission characteristics (e.g., multimode or single mode fiber)
- Insertion and extraction of timing information
- Specify bit timing, line coding.
  - ATM fiber interface makes use of the 4B/5B FDDI coding.

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Physical Layer Interfaces

- Three major categories of physical layer interfaces for ATM networks:
  - The existing Plesiochronous Digital Hierarchy (PDH): (over copper media)
    - DS-1 (1.544 Mbps)
    - DS-3 (44.736 Mbps)
    - E1 (2.048 Mbps)
    - E3 (34.368 Mbps)
    - E4 (139.264 Mbps)
  - The Synchronous Digital Hierarchy (SDH): (over fiber optic)
    - STS-3 (155.52 Mbps)
    - STS-12 (622.080 Mbps)
  - Physical media used on the local premises for ATM LANs

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Physical layer in ATM

Transmission Convergence (TC) Sublayer

- For transmission, receive cells from ATM layer
- Pack/map cells into appropriate transport format
  - Cell-based
  - PDH/SDH/SONET-based
- Deliver cells to PM sublayer for transmission
- Insert idle cells in order to provide a continuous flow of cells
  - Cell-rate decoupling maintains synchronization and inserts or suppresses idle (unassigned) ATM cells to adapt the rate of valid ATM cells to the payload capacity of the transmission system.
- HEC generation/verification
- For receiving, extract cells from bit or byte stream received from PM sublayer

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Cell Based Physical Layer

- No framing imposed
- Continuous stream of 53 octet cells
- Cell delineation and header error control
  - The cell delineation function maintains ATM cell boundaries, allowing devices to locate cells within a stream of bits.

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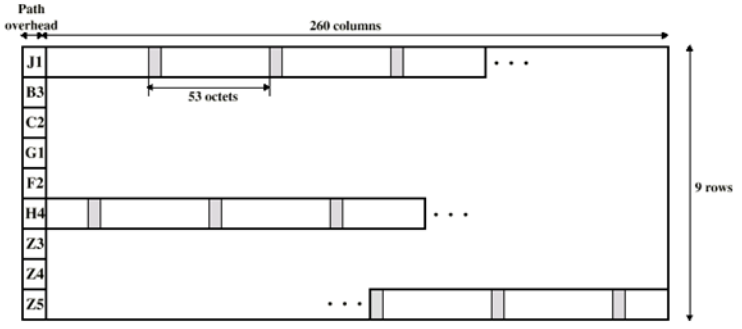
SDH Based Physical Layer

- Imposes structure on ATM stream, e.g. for 155.52Mbps Use STM-1 (STS-3) frame
- Can carry ATM and STM payloads
- SDH multiplexing techniques can combine several ATM streams



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ATM Adaptation Layer (AAL)

- The use of ATM creates the need for an adoption layer to support information transfer protocols not based on ATM.
  - Segmentation and re-assembly
  - Handle lost and misinserted cells
  - Flow control and timing

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AAL

AAL layer is organized in two logical sublayers:

- Convergence sublayer (CS)
  - Support for specific applications
  - AAL user attaches at SAP
- Segmentation and re-assembly sublayer (SAR)
  - Packages and unpacks info received from CS into cells

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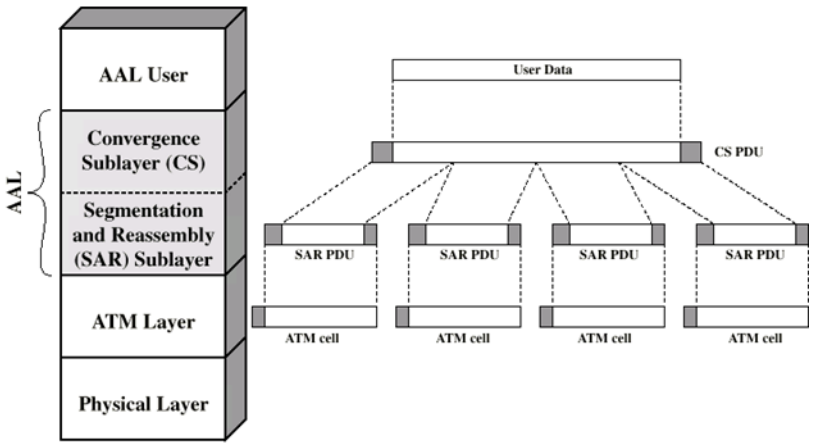
AAL


AAL User
Convergence Sublayer (CS)
Segmentation and Reassembly (SAR) Sublayer
ATM Layer
Physical Layer
AAL
User Data
CS PDU
SAR PDU
SAR PDU
SAR PDU
SAR PDU
ATM cell
ATM cell
ATM cell
ATM cell

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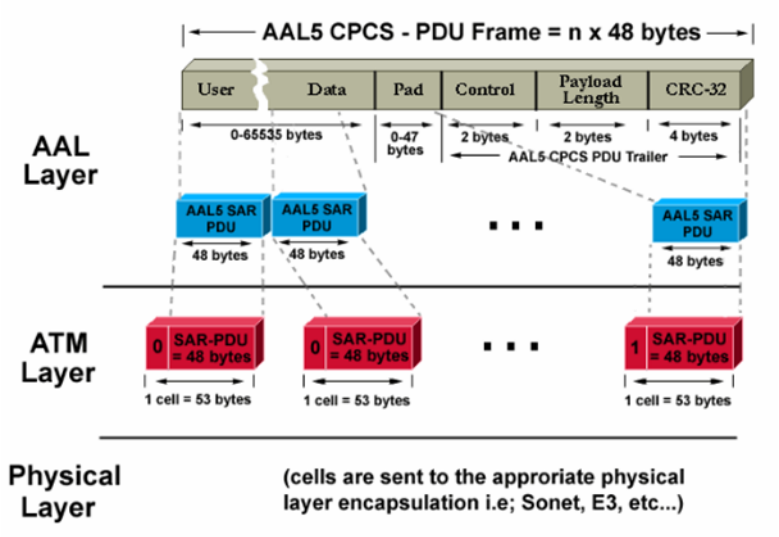
AAL


AAL5 CPCS - PDU Frame = n x 48 bytes
User
Data
Pad
Control
Payload Length
CRC-32
0-65535 bytes
0-47 bytes
2 bytes
2 bytes
4 bytes
AAL5 CPCS PDU Trailer
AAL Layer
AAL5 SAR PDU
AAL5 SAR PDU
AAL5 SAR PDU
48 bytes
48 bytes
48 bytes
ATM Layer
0 SAR-PDU = 48 bytes
0 SAR-PDU = 48 bytes
1 SAR-PDU = 48 bytes
1 cell = 53 bytes
1 cell = 53 bytes
1 cell = 53 bytes
Physical Layer
(cells are sent to the approriate physical layer encapsulation i.e; Sonet, E3, etc...)

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AAL Protocols

The classification is based on whether a timing relationship must be maintained between source and destination, whether the application requires a constant bit rate, and whether the transfer is connection oriented or connectionless.

- **AAL Type 1** supports constant bit rate (CBR), synchronous, connection oriented traffic. Examples include T1 (DS1), E1, and x64 kbit/s emulation.
- **AAL Type 2** supports time-dependent Variable Bit Rate (VBR-RT) of connection-oriented, synchronous traffic. Examples include Voice over ATM.
- **AAL Type 3/4** supports VBR, data traffic, with an additional 4-byte header in the information payload of the cell. Examples include Frame Relay and X.25.
- **AAL Type 5** is similar to AAL 3/4 with a simplified information header scheme. Examples of services that use AAL 5 are classic IP over ATM, Ethernet Over ATM, and LAN Emulation (LANE). AAL 5 is a widely used ATM adaptation layer protocol.

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ATM LANs

ATM LAN uses centralized Hubs/Switches connected to stations with star wiring. The station links may run at 155 Mbps, 51 Mbps, or 25 Mbps.

Advantages of ATM LANs:

- Support multiple, guaranteed classes of service. For example, a live video application may require a guaranteed 2-Mbps connection for acceptable performance while FTP can use “background” class of service.
- Facilitate the interworking between LAN and WAN technologies.

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ATM Routing

The ATM routing protocol is necessary to establish switched virtual circuits between ATM end users. There are two types of routing protocols for an ATM network:

1. Dynamic routing with Private Network-to-Network Interface (PNNI) protocol, which enables provides Quality of Service (QoS) routes based on QoS requirements specified in the call request.

1. Static routing, as configured with network management tools

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PNNI

- PNNI is a protocol that can be used to discover an ATM network topology, create a database of topology information, and route calls over the discovered topology.

- PNNI is commonly **referred to as a link state protocol**, which means that the protocol collects information about the current state of links and nodes in the network to build a network database.

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PNNI Network Database

To build the PNNI network database, each PNNI node must receive topology information from all the other devices in the network (Peer Group). To keep the database current, the node must receive regular updates from other nodes.

- Network database is a collection of PNNI Topology State Elements (**PTSEs**). Each PTSE describes a piece of topology information.
- A PNNI node originates one or more PTSEs which describe its own environment, and it also learns PTSEs originated and advertised from all the other PNNI nodes in the network.

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PNNI Network Database

- **Hello** protocol is used in PNNI to detect and maintain adjacency between PNNI nodes.
- The PNNI Hello protocol was modeled on the Open Shortest Path First (OSPF) protocol.
- When the PNNI nodes discover they are members of the same peer group, they exchange network databases through PTSE.
- The PNNI flooding advertising mechanism provides for reliable distribution of PTSEs throughout a peer group. The default periodic **flooding interval is 30 minutes.**

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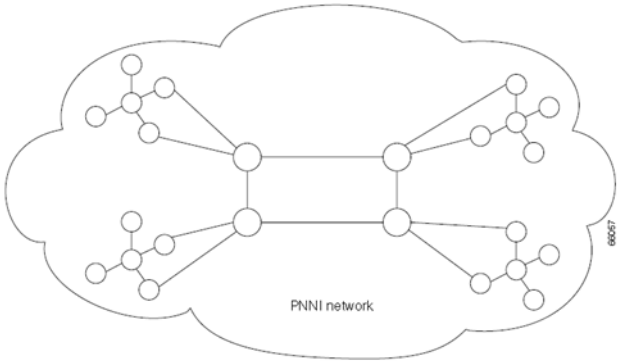
Single Grouping

- A single peer group topology is a PNNI network in which all nodes share PTSEs with all other nodes.



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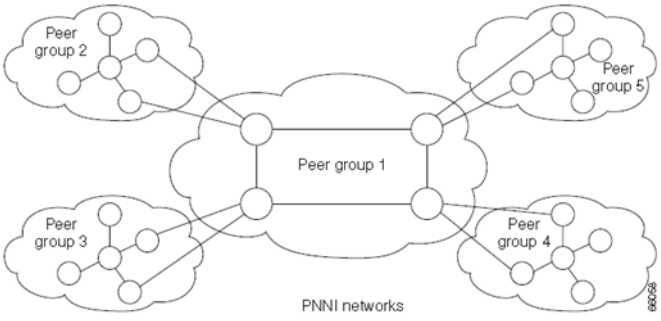
Hierarchical Grouping

- A hierarchical PNNI network is a topology that interconnects multiple PNNI peer groups to form a larger network. The peer group collects, stores and processes PTSEs for only those nodes in the same peer group.



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PNNI Operation

- When the ATM CPE requests an SVC, the SVC processing function uses the Route Agent to determine the route to the destination (ATM CPE 2). The destination ATM CPE is identified by its ATM address (20 Bytes). The call is either cleared or forwarded:
  - If no route can be found, the call is then cleared.
  - If a route is found, the first PNNI node forwards the call to the next PNNI node along the route, and local resources are then programmed on trunks and lines as the call progresses.

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PNNI Operation

- With each route request, the PNNI controller looks up the pre-calculated routing database for the given destination along with the requested service class and traffic metrics parameters.
- If a satisfactory route exists, the associated Designated Transit List (DTL) is returned as a response. **The DTL is a list of nodes, and optionally link IDs, that completely specify a path.**
- PNNI uses source-routing, where the source is responsible for the selection of the destination path. DTL is included in the connection setup.

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