An Overview of ATM

- ATM is Asynchronous Transfer Mode.
- ATM is originally the transfer mode for implementing Broadband ISDN (B-ISDN).
- In 1988, CCITT (from ITU) issued the first two recommendations relating to B-ISDN:
  - I.113 Vocabulary of Terms for Broadband Aspects of ISDN
  - I.121 Broadband Aspects of ISDN
- In 1911, the ATM Forum was created with the goal of accelerating the development of ATM standards.

An Overview of ATM

- Connection-oriented packet-switched network
- Used in both WAN and LAN settings
- Signaling (connection setup) Protocol:
  - Q.2931
- Packets are called *cells* (53 bytes)
  - 5-byte header + 48-byte payload
- Commonly transmitted over SONET
  - other physical layers possible
- Connections can be switched (SVC), or permanent (PVC).

Variable vs. Fixed-Length Packets

- No Optimal Length
  - if small: high header-to-data overhead
  - if large: low utilization for small messages
- Fixed-Length Easier to Switch in Hardware
  - simpler
  - enables parallelism

Big vs. Small Packets

- Small Improves Queue behavior
  - finer-grained pre-emption point for scheduling link
    - maximum packet = 4KB
    - link speed = 100Mbps
    - transmission time = 4096 x 8/100 = 327.68us
    - high priority packet may sit in the queue 327.68us
    - in contrast, 53 x 8/100 = 4.24us for ATM
  - near cut-through behavior
    - two 4KB packets arrive at same time
    - link idle for 327.68us while both arrive
    - at end of 327.68us, still have 8KB to transmit
    - in contrast, can transmit first cell after 4.24us
    - at end of 327.68us, just over 4KB left in queue

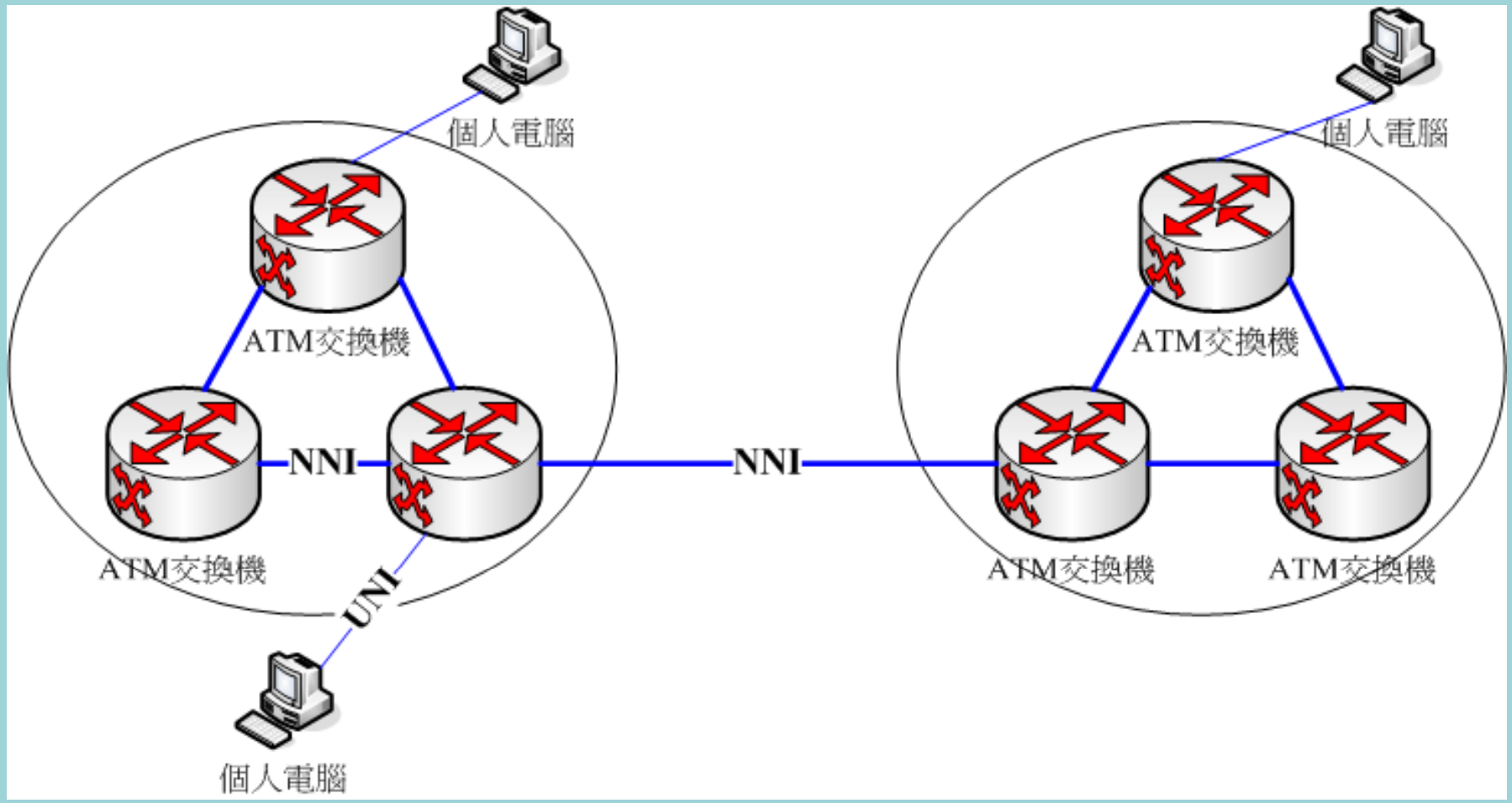
Big vs Small (cont)

- Small Improves Latency (for voice)
  - voice digitally encoded at 64KBps (8-bit samples at 8KHz)
  - need full cell's worth of samples before sending cell
  - example: 1000-byte cells implies 125ms per cell (too long)
  - smaller latency implies no need for echo cancellors
- ATM Compromise: 48 bytes = (32+64)/2

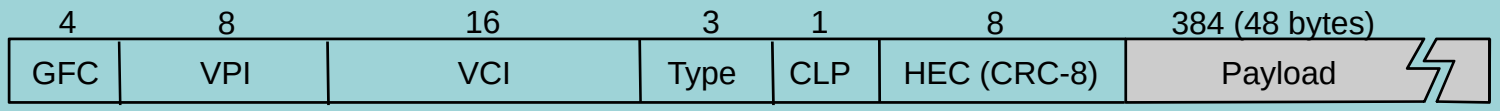
An Overview of ATM

- ATM operates on a best effort basis.
- ATM guarantees that cells will not be disordered.
- Two types of connections:
  - Point-to-point
  - Multipoint (Multicast)
- Four Types of Services:
  - CBR (Constant Bit Rate)
  - VBR (Variable Bit Rate)
  - ABR (Available Bit Rate) Flow Control, Rate-based, Credit- based
  - UBR (Unspecific Bit Rate) No Flow control.
- Aggregate Bandwidth vs. Shared Medium (FDDI, Fast Ethernet).

ATM Network Structure

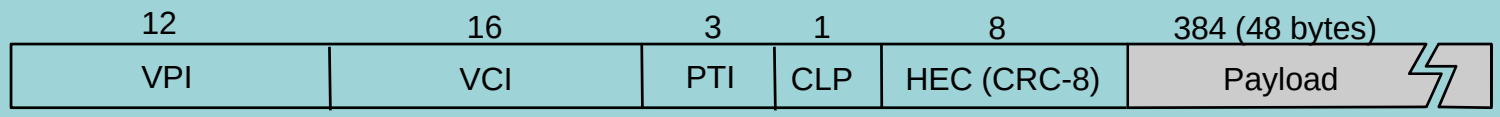


Cell Format



- User-Network Interface (UNI)
  - host-to-switch format
  - GFC: Generic Flow Control (still being defined)
  - VCI: Virtual Circuit Identifier
  - VPI: Virtual Path Identifier
  - Type: management, congestion control, AAL5 (later)
  - CLPL Cell Loss Priority
  - HEC: Header Error Check (CRC-8)

Cell Format

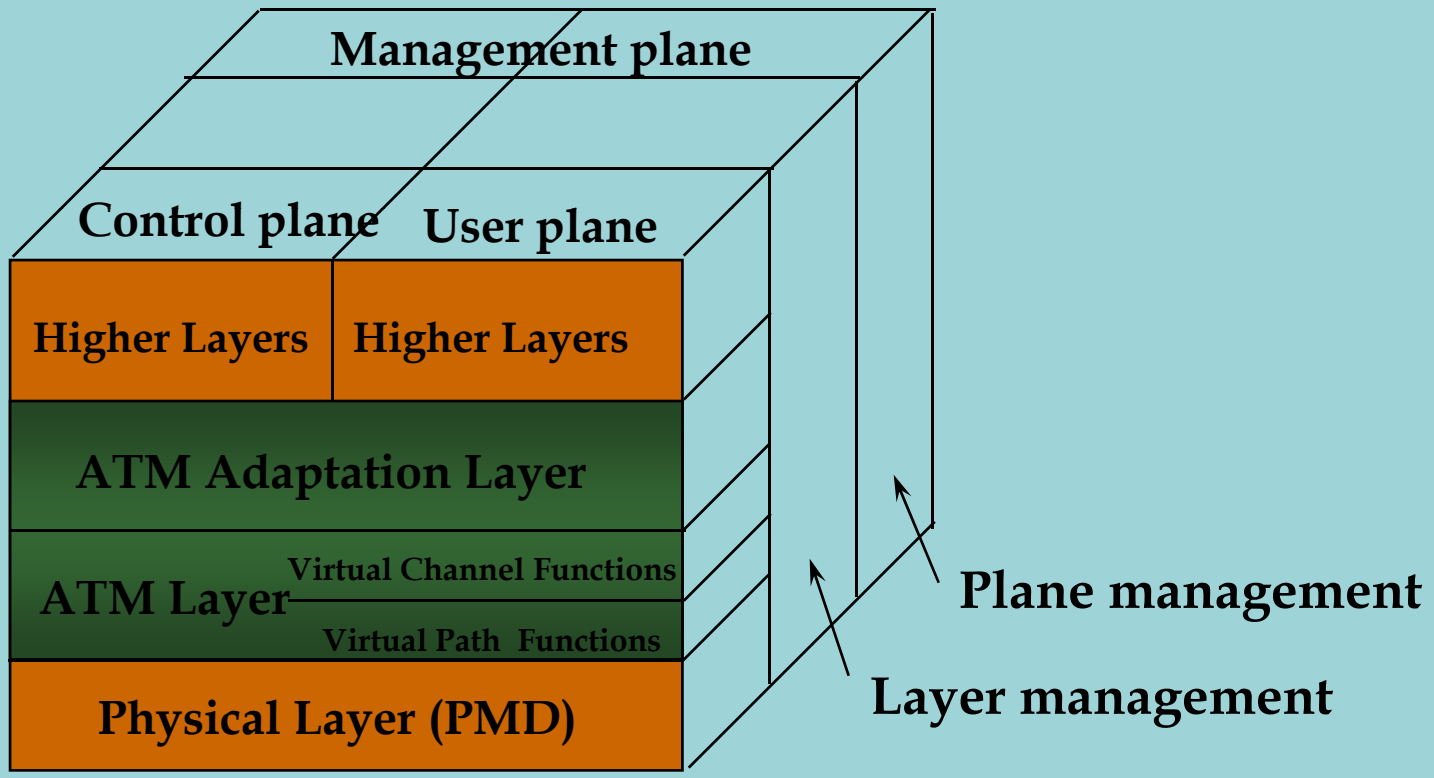


- Network-Network Interface (NNI)
  - switch-to-switch format
  - GFC becomes part of VPI field

ATM Characteristics

- No error protection or flow control on a link-by-link basis.
- ATM operates in a connection-oriented mode.
- The header functionality is reduced.
- The information field length is relatively small and fixed.

ATM Protocol Stack



Physical Layer Interface Specification

- SONET STS-3C
- SONET STS-12
- DS3
- STP for ATM LAN
- etc.

ATM Layer Service

- Transparent transfer of 48-octet data unit
- Deliver data in sequence on a connection
- Two levels of multiplexing
- Three types of connections
  - Point-to-point
  - Point-to-Multipoint
  - Multipoint-to-Multipoint
- Transport is best-effort
- Network QoS negotiation
- Traffic control and congestion control

ATM Layer Functions

- Cell multiplexing and switching
- Cell rate decoupling
- Cell discrimination based on pre-defined VPI/VCI
- Quality of Service (QoS)
- Payload type characterization
- Generic flow control
- Loss priority indication and Selective cell discarding
- Traffic shaping

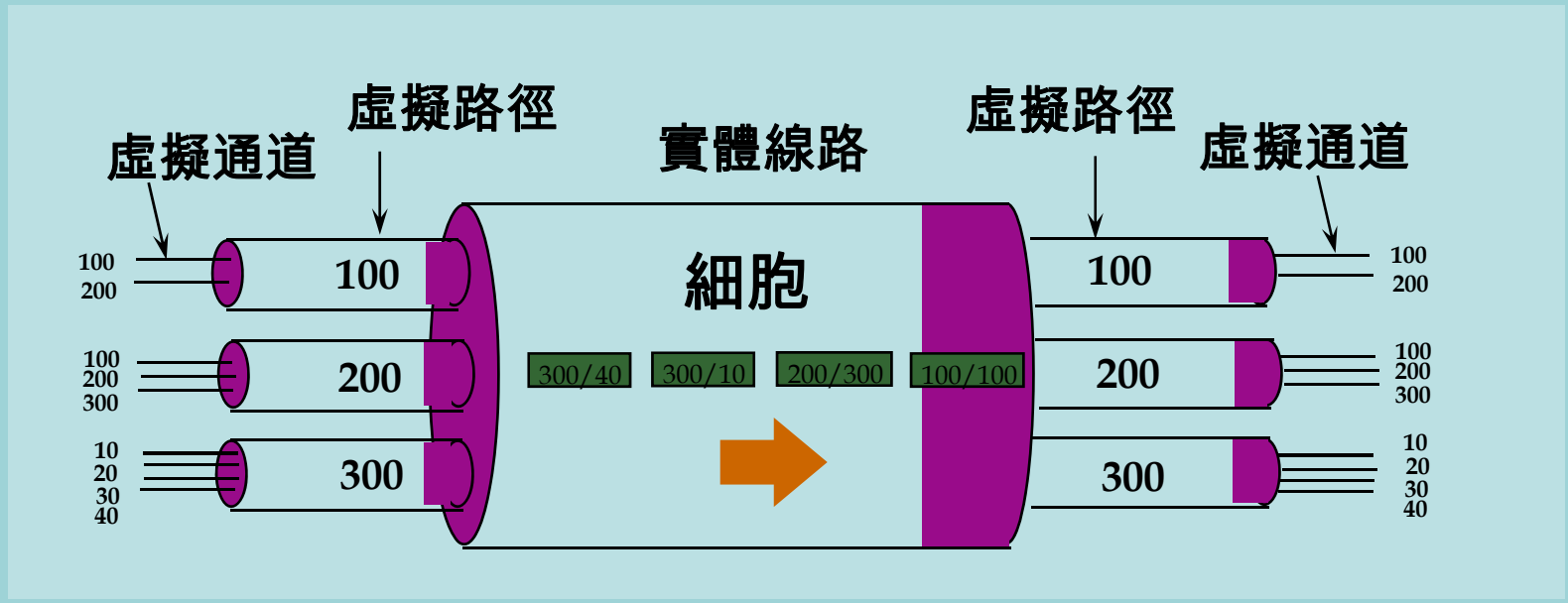
Pre-assigned VPI/VCI Values

- Unassigned Cell Indication (VPI = 0, VCI = 0)
- Meta signaling (VCI=1)
  - Meta signaling is the bootstrap procedure used to establish and release a signaling VC. Not used for PVC setup.
- General broadcasting signaling (VCI=2)
- OAM F4 flow indication -- segment and end-to-end (VCI=3 and VCI=4)
- Point-to-Point Signaling (VCI=5)
- Carriage of Interim Local Management Interface (ILMI) messages (VPI=0, VCI=16)

Cell Rate Decoupling and Cell Discrimination

- Cell Rate Decoupling
  - ATM sending entity adds unassigned cells to the assigned cell stream in order to adjust to the cell rate acquired by the payload capacity of the physical layer (R).
- Cell Discrimination
  - Meta signaling
  - General broadcast signaling
  - Point-to-point Signaling
  - Segment OAM F4 flow cell
  - End-to-end OAM F4 flow cell
  - ILMI message
  - User data

Virtual Channels, Virtual Paths, and the Physical Channel



Virtual Channels

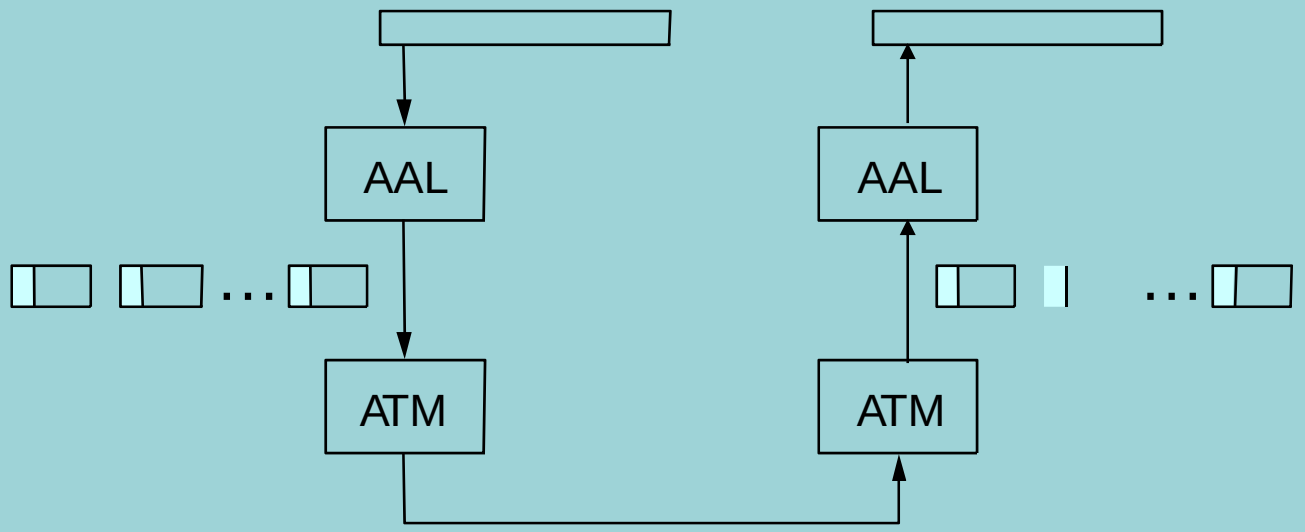
- The virtual channel (VC) is the fundamental unit of transport in a B-ISDN. Each ATM cell contains an explicit label in its header to identify the virtual channel.
  - a Virtual Channel Identifier (VCI)
  - a Virtual Path Identifier (VPI)
- A *virtual channel (VC)* is a communication channel that provides for the transport of ATM cells between two or more endpoints for information transfer.
- A Virtual Channel Identifier (VCI) identifiers a particular VC within a particular VP over a UNI or NNI.
- A specific value of VCI has no end-to-end meaning.

Virtual Paths

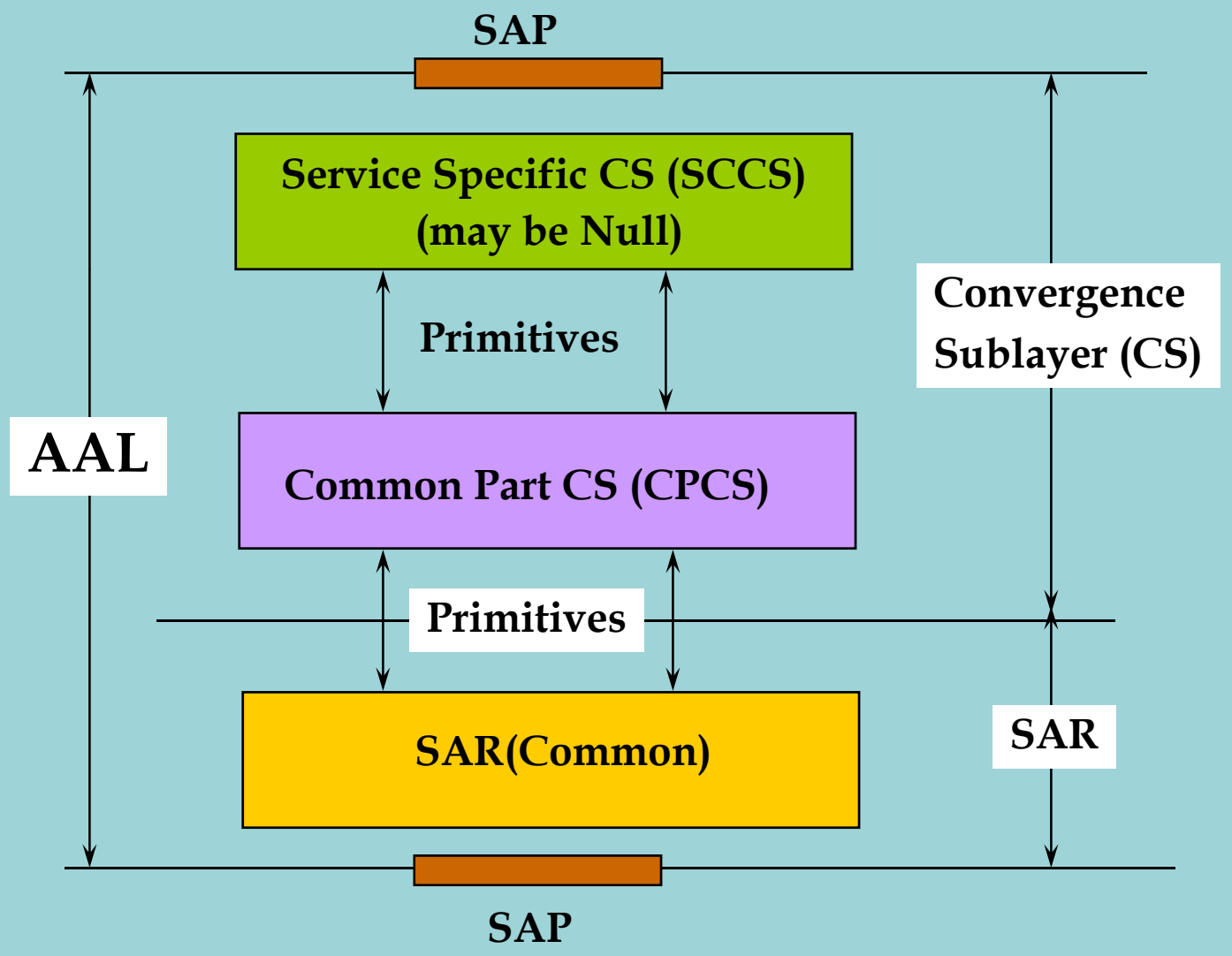
- A *Virtual Path (VP)* is a group of Virtual Channels that are carried on the same physical facility and share the same Virtual Path Identifier (VPI) value.
- The VP boundaries are delimited by Virtual Path Terminators (VPT).
- AT VPTs, both VPI and VCI are processed.
- Between VPTs associated with the same VP, only the VPI values are processed (and translated) at ATM network elements.
- The VCI values are processed only at VPTs, and are not translated at intermediate ATM network elements.

Segmentation and Reassembly

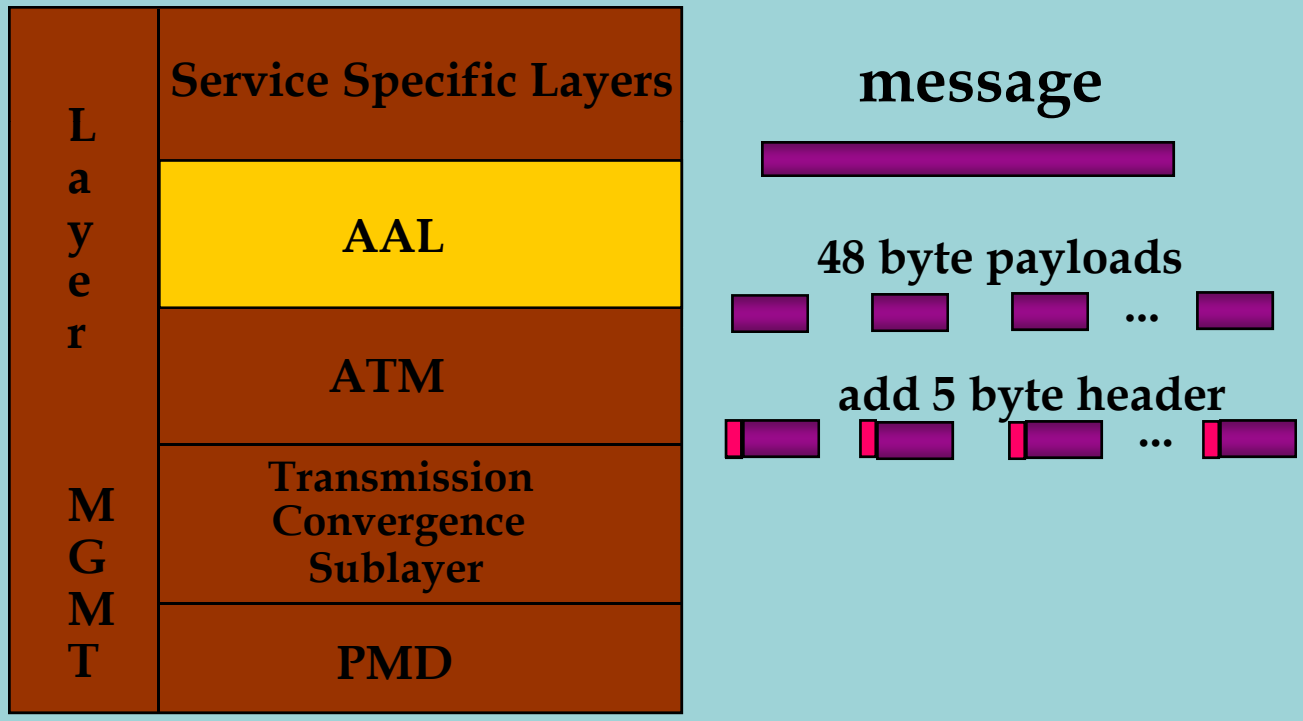
- ATM Adaptation Layer (AAL)
  - AAL 1 and 2 designed for applications that need guaranteed rate (e.g., voice, video)
  - AAL 3/4 designed for packet data
  - AAL 5 is an alternative standard for packet data



AAL Reference Structure



AAL


Layer
MGMT
Service Specific Layers
AAL
ATM
Transmission Convergence Sublayer
PMD
message
48 byte payloads
...
add 5 byte header
...

ATM Adaptation Layers (AAL)

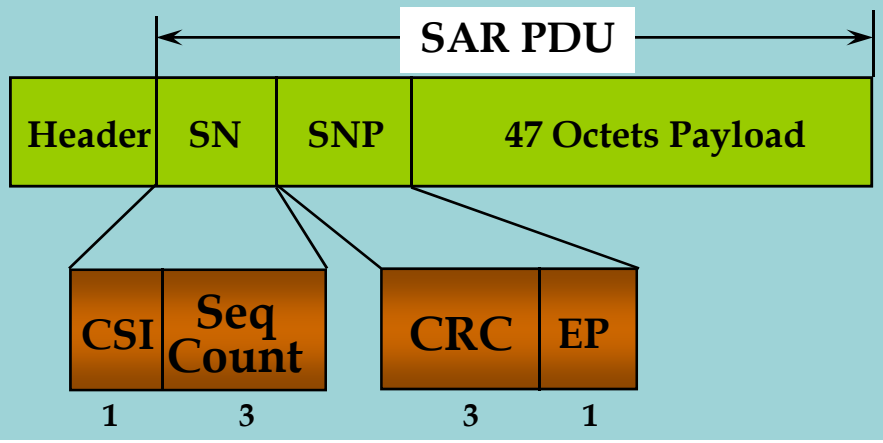
- In order to carry data units longer than 48 octets in ATM cells, an adaptation layer is needed.
- The *ATM adaptation layer* (AAL) provides for segmentation and reassembly of higher-layer data units and for detection of errors in transmission.
- Since the ATM layer simply carries cells without concern for their contents, a number of different AALs can be used across a single ATM interface.
- The AAL maps the user, control, or management protocol data units into the information field of the ATM cell and vice versa.

AAL Service Classification

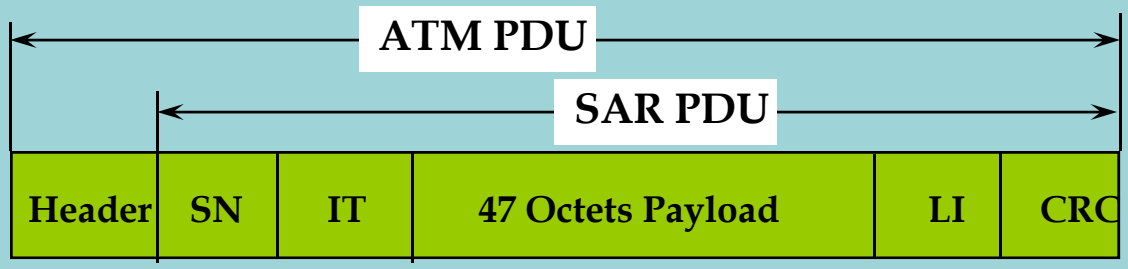
<table>
<tr><td rowspan="2">Attribute</td><td>Class A
Circuit Emulation</td><td>Class B
Packetized voice/video</td><td>Class C
Connection Oriented Data</td><td>Class D
Datagram</td><td>Signalling (Q.93B)</td></tr>
<tr><td>AAL1</td><td>AAL2</td><td>AAL 3</td><td>AAL 4</td><td rowspan="2">SAAL</td></tr>
<tr><td>Timing between source and destination</td><td colspan="2">Required</td><td colspan="2">Not required</td></tr>
<tr><td>Bit Rate</td><td>Constant</td><td colspan="3">Variable</td></tr>
<tr><td>Connection Mode</td><td colspan="3">Connection oriented</td><td>Connectionless</td></tr>
</table>

AAL 1 (Constant Bit Rate -CBR) Functions

- Emulation of DS1 and DS3 Circuits
- Distribution with forward error correction
- Handle cell delay for constant bit rate
- Transfer timing information between source and destination
- Transfer structure information (structure pointer)
- Provide indication of unrecoverable lost or errored information



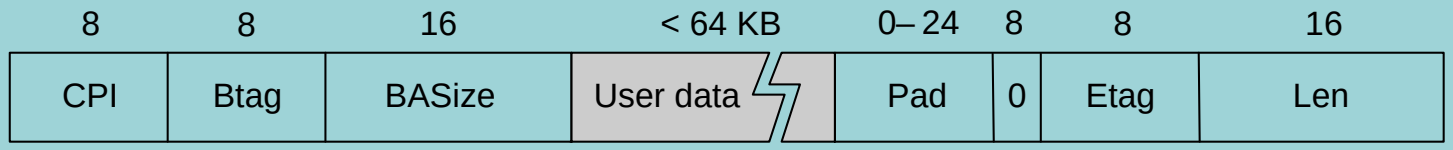
AAL 2 Protocol Data Unit (PDU)



- **SN: Sequence number**
- **IT: Information Type:BOM,COM,EOM,SSM**
- **Length Indicator**

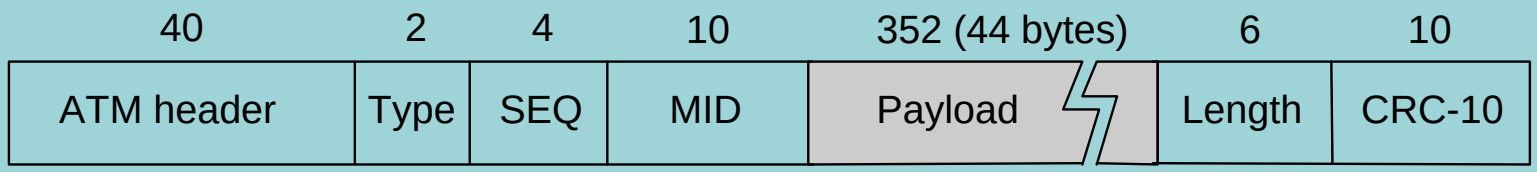
AAL 3/4

- Convergence Sublayer Protocol Data Unit (CS-PDU)



  - CPI: commerce part indicator (version field)
  - Btag/Etag:beginning and ending tag
  - BAsize: hint on amount of buffer space to allocate
  - Length: size of whole PDU

Cell Format



- Type
  - BOM: beginning of message
  - COM: continuation of message
  - EOM end of message
- SEQ: sequence of number
- MID: message id
- Length: number of bytes of PDU in this cell