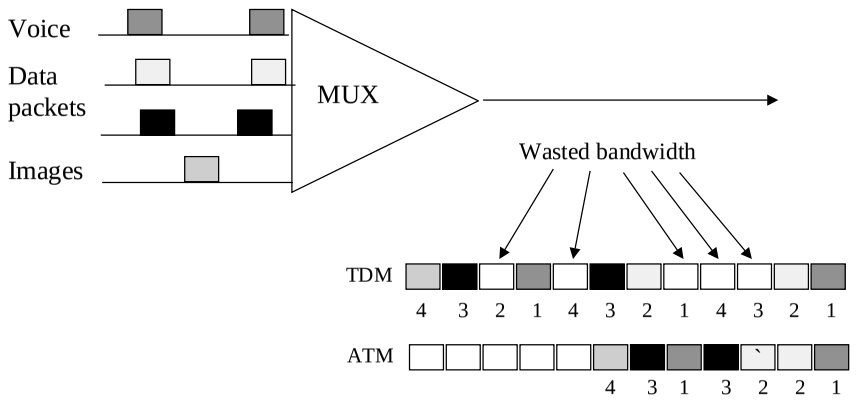
# ATM Networks

- Introduction
- ATM Cells
- Virtual-circuit switching



# ATM Multiplexing






# Cell Switching (ATM)

- Connection-oriented packet-switched network
- Used in both WAN and LAN settings
- Signaling (connection setup) Protocol: Q.2931
- Specified by ATM forum
- Packets are called *cells*
  - 5-byte header + 48-byte payload
- Commonly transmitted over SONET
  - other physical layers possible



# 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

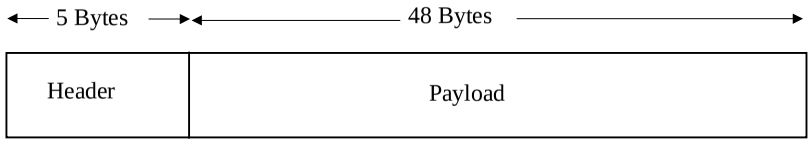


# Big vs Small (cont)

- 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



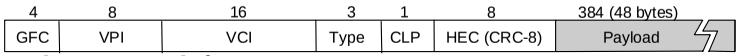
# The ATM Cell





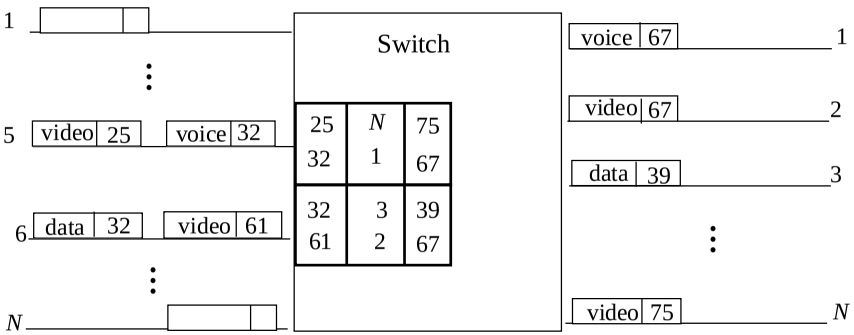

# Cell Format

- User-Network Interface (UNI)



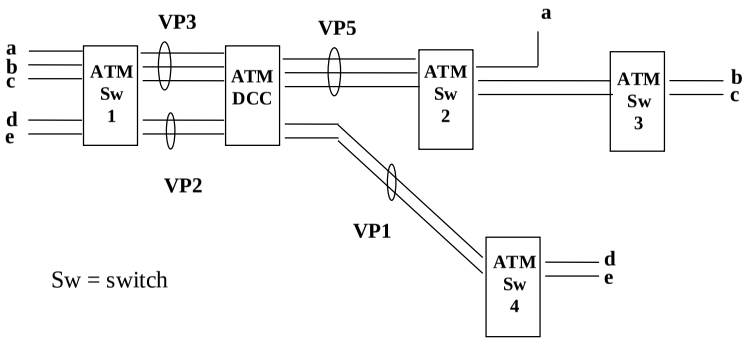

  - host-to-switch format
  - GFC: Generic Flow Control (still being defined)
  - VCI: Virtual Circuit Identifier
  - VPI: Virtual Path Identifier
  - Type: management, congestion control, AAL5 (later)
  - CLPL Cell Loss Priority
  - HEC: Header Error Check (CRC-8)
- Network-Network Interface (NNI)
  -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

# ATM Switching



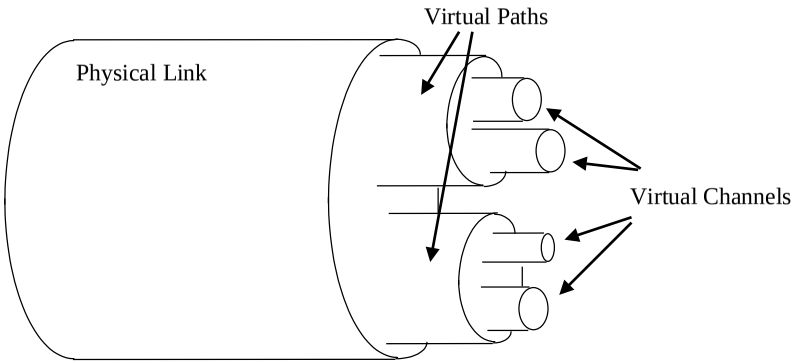



# Virtual Paths in an ATM Network



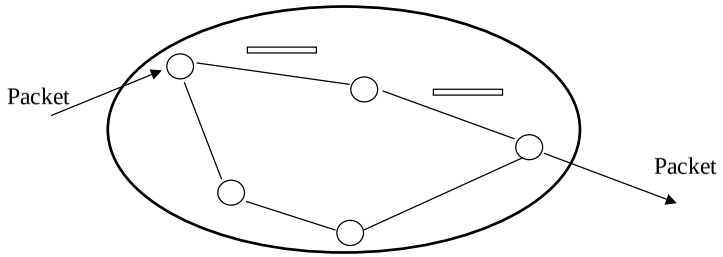



# ATM Virtual Connections

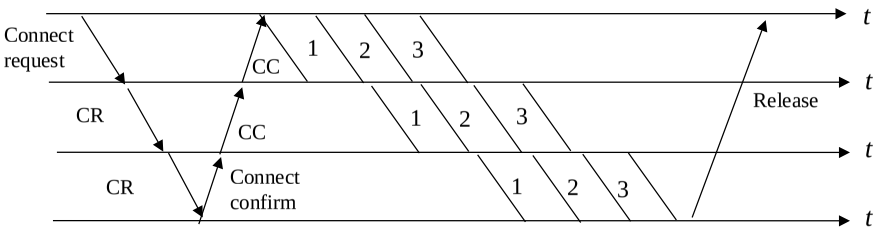





# Virtual circuit Switching

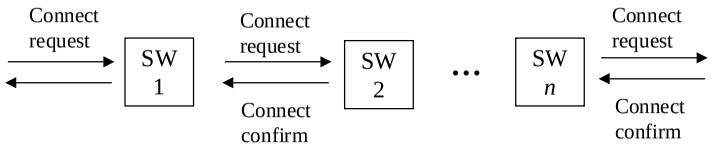


# VC Setup Delays






# VC Signaling





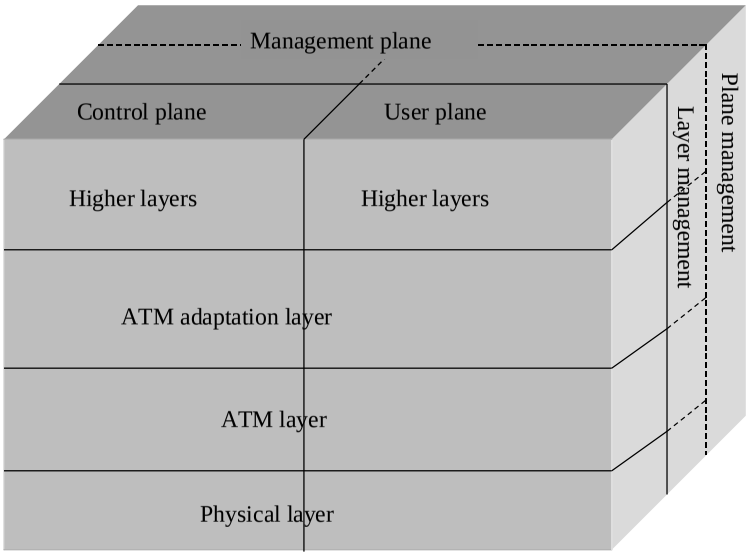

# VC Routing Table

Entry for packets with identifier 15 →

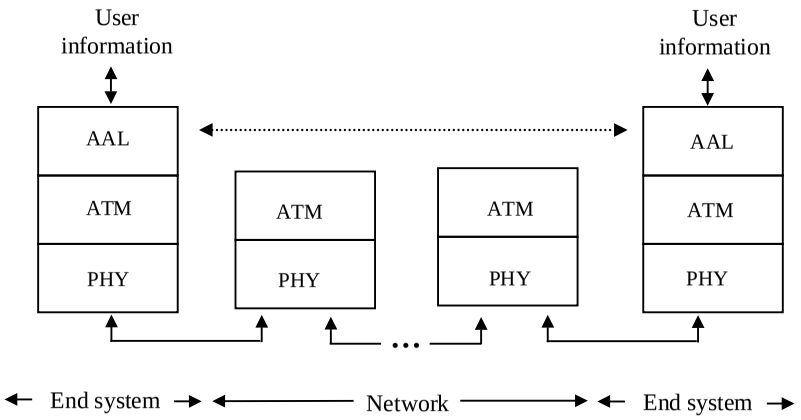
| Identifier | Output port | Next identifier |
|---|---|---|
| | | |
| 12 | 13 | 44 |
| | | |
| 15 | 15 | 23 |
| | | |
| 27 | 13 | 16 |
| | | |
| | | |
| 58 | 7 | 34 |
| | | |



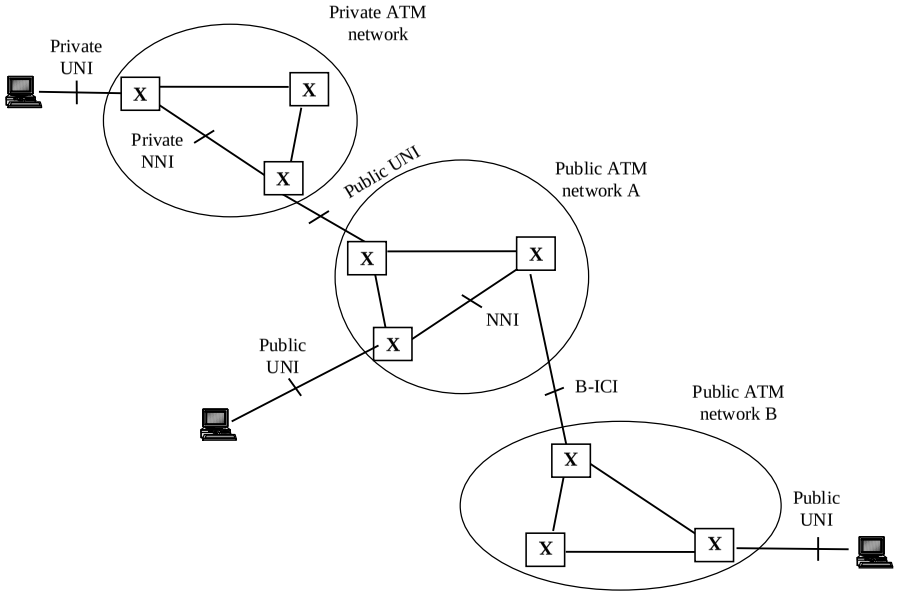
# Broadband ISDN reference model



# User Plane Layers






# ATM Network Interfaces



# ATM QOS Parameters

- Non-negotiable parameters: characteristics of networks
- Cell error ratio
- Cell misinsertion ratio: undetected header errors.
- Severely-errored cell block ratio: Bursty errors

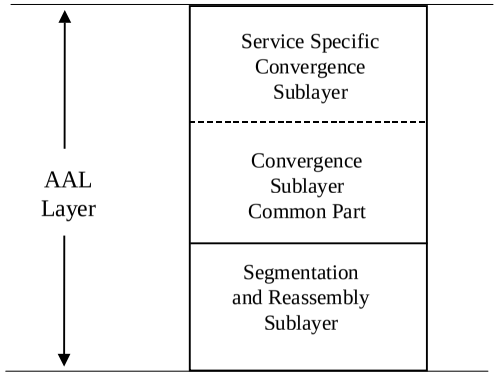
- Negotiable parameters: User can ask during setup
- Cell loss ratio
- Cell transfer delay
- Cell delay variation



# ATM Service Categories

- Constant bit rate (CBR): Rigorous timing requirements, voice, circuit emulation.
- Real-time Variable Bit Rate: VBR traffic such as video.
- Non-real-time VBR: Bursty data sources, no rigorous timing requirments
- Available bit rate (ABR): Sources that can adapt to available bandwidth in the network. Low cell loss ratio.
- Unspecified bit rate (UBR): No QOS guarantees.

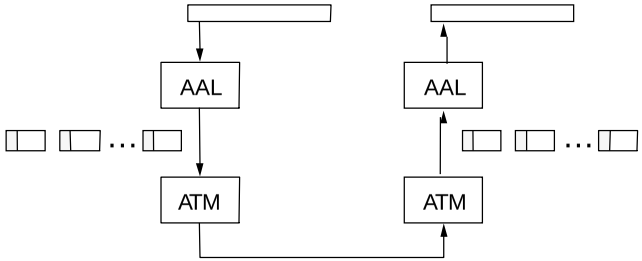
# AAL Sublayers





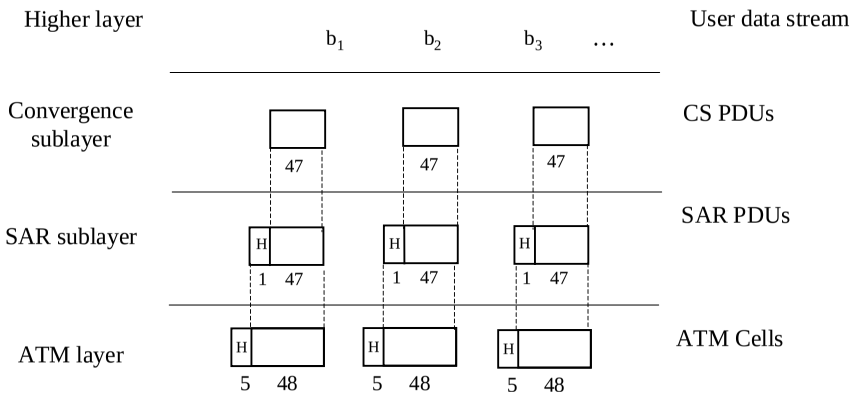

# Segmentation and Reassembly

- 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






# AAL1 Process

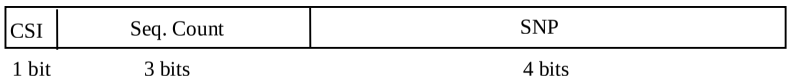



For Constant rate transfers, e.g., 64kbps PCM voice call

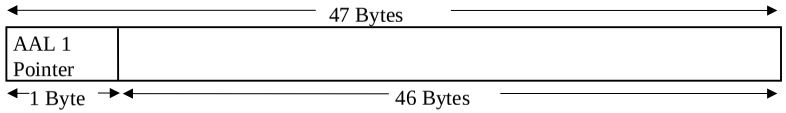


# AAL1 PDUs

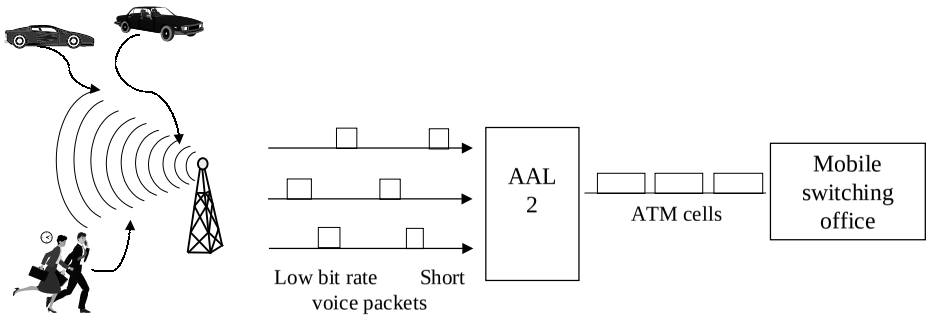
(a) SAR PDU header




(b) CS PDU with pointer in structured data transfer



# Application scenario for AAL2

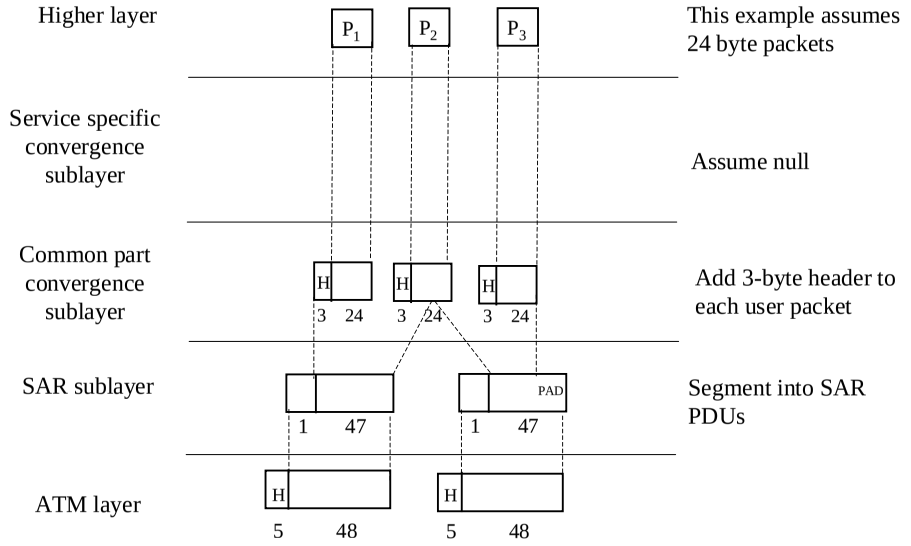



Originally, for variable bit rate (VBR) applications with end-to-end delay requirements, e.g., compressed video.

Now, BW-efficient transfer of low-bit-rate short-packet traffic with low-delay requirements. Allows multiplexing of multiple users on a single ATM connection, e.g., cell phone traffic, compressed audio.

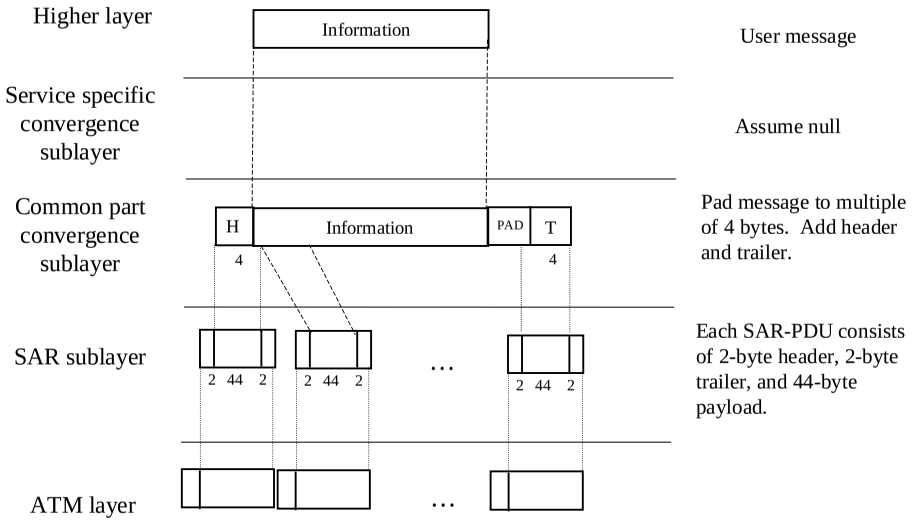


# AAL2 Process





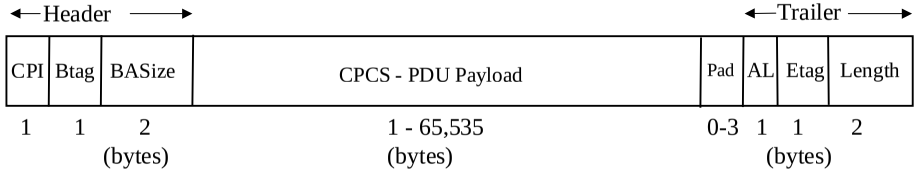

# AAL 3/4 Process



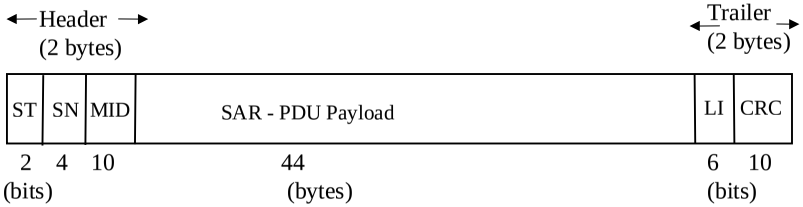

AAL3 for connection-oriented bursty data with low loss, no delay requirements. AAL4 for connection-less data transfers.



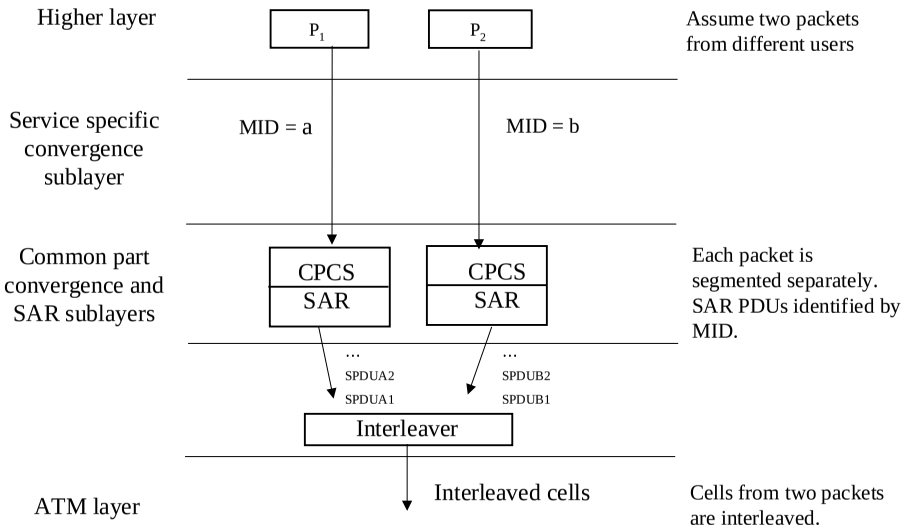
(a) CPCS-PDU format




(b) SAR PDU format




# AAL 3/4 CPCS and SAR formats

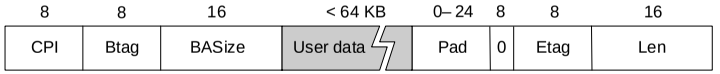



**Multiplexing in AAL 3/4**



# AAL 3/4

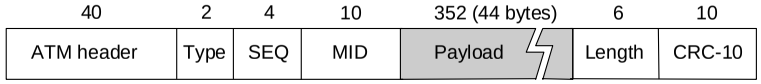
- Convergence Sublayer Protocol Data Unit (CS-PDU)




  - 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

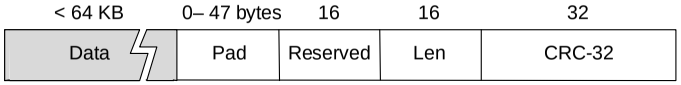



  - Type
    - BOM: beginning of message
    - COM: continuation of message
    - EOM end of message
  - SEQ: sequence of number
  - MID: message id
  - Length: number of bytes of PDU in this cell



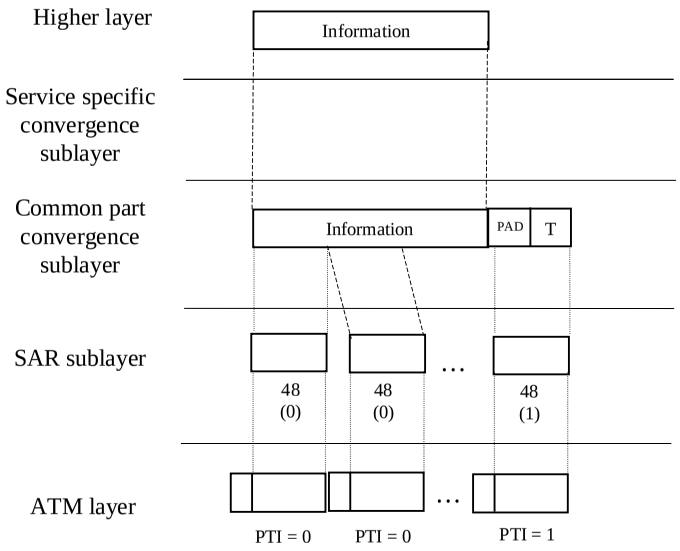
# AAL5

- CS-PDU Format




  - pad so trailer always falls at end of ATM cell
  - Length: size of PDU (data only)
  - CRC-32 (detects missing or misordered cells)
- Cell Format
  - end-of-PDU bit in Type field of ATM header
- A more efficient alternative to AAL3/4
  - message and stream modes
  - assured and nonassured delivery

# AAL 5 Process




Assume null



# AAL 5 PDU

| Information | Pad | UU | CPI | Length | CRC |
|---|---|---|---|---|---|
| 0 - 65,535 (bytes) | 0-47 | 1 | 1 (bytes) | 2 | 4 |