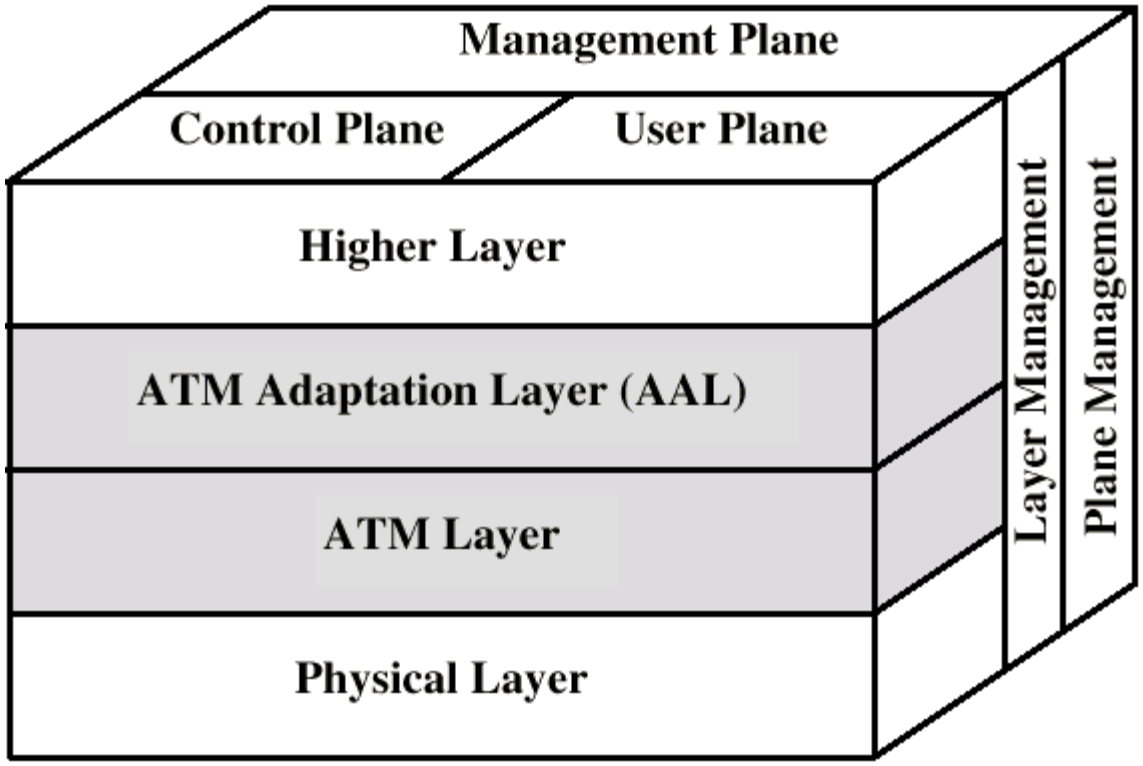
Asynchronous Transfer Mode

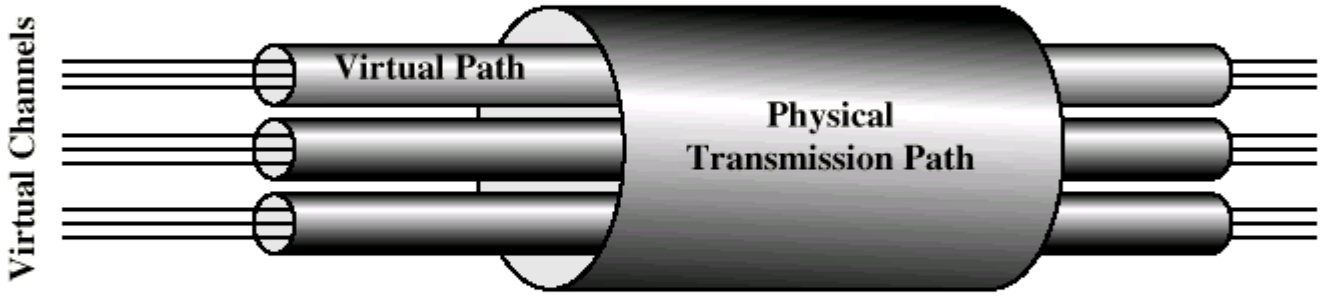
Protocol Architecture (diag)



Reference Model Planes

- User plane
  - —Provides for user information transfer
- Control plane
  - —Call and connection control
- Management plane
  - —Plane management
    - whole system functions
  - —Layer management
    - Resources and parameters in protocol entities

ATM Connection Relationships



ATM

—Virtual channels and virtual paths

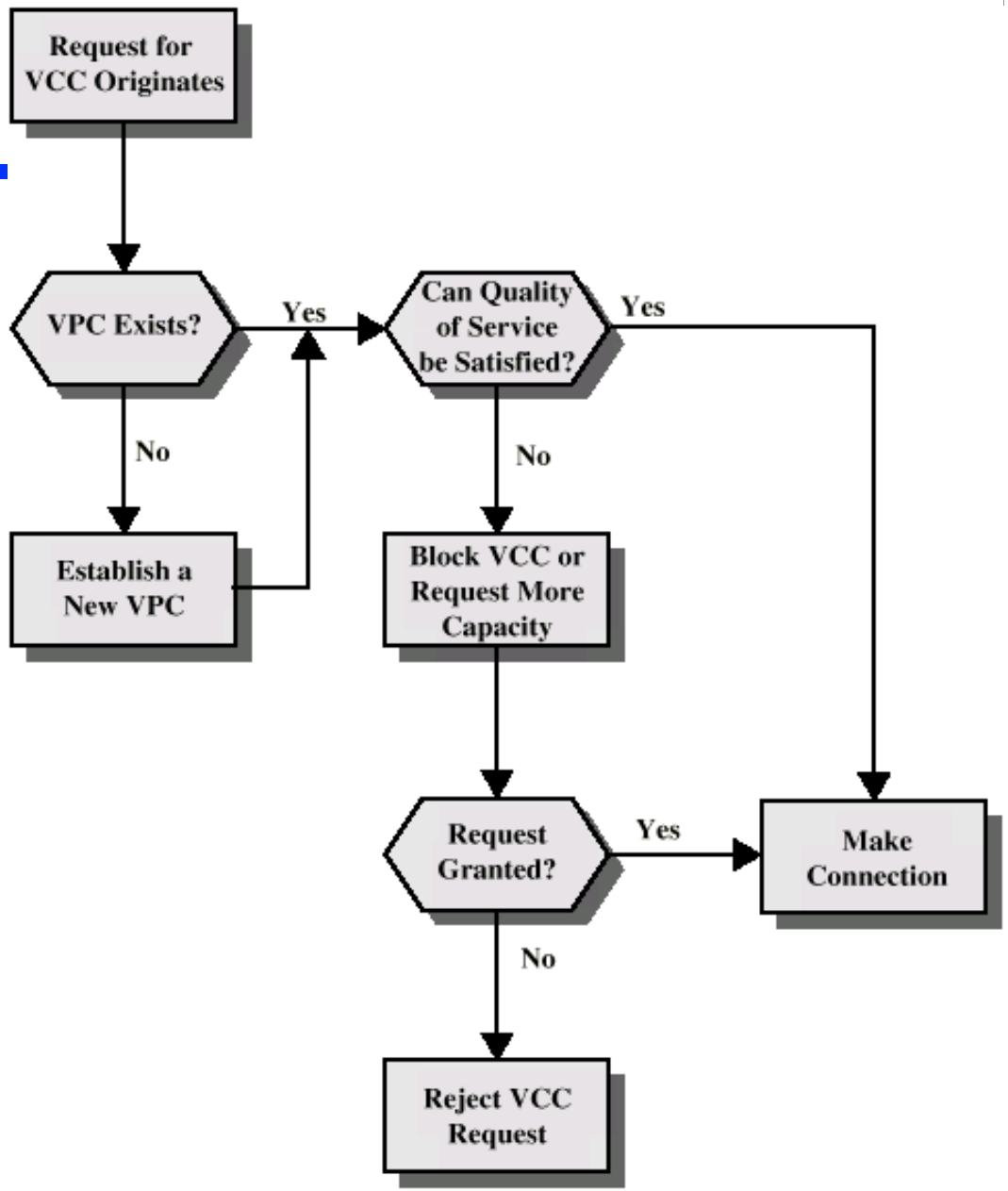
- **Virtual channel connections** (VCC): logical connections in ATM
  - a VCC is analogous to a virtual circuit in X.25
  - VCCs are the basic unit of switching in an ATM network
  - VCCs are also used for user-network exchange, i.e. control signaling, and for network-network exchange, i.e. network management and routing.
- **Virtual path connection** (VPC): a bundle of VCCs that have the same endpoints
  - i.e. all of the cells flowing over all the VCCs in a single VPC are switched together.

ATM

—Advantages of using virtual paths

- simplified network architecture:
  - transport function can be separated into those dealing with an individual virtual channel and those dealing with a group of virtual logical connections, i.e. the virtual path
- increased network performance and reliability
- reduced processing and short connection setup time
  - *once the virtual path is set up, much of the work is done*. When capacity in the virtual path is reserved in anticipation of later calls, new virtual channels can be established. This is done via simple control functions at the endpoints of the virtual path.
- flexible network services
  - virtual paths are visible to the user, i.e. user can define closed user groups or closed networks of virtual-channel bundles.

Call Establishment Using VPs



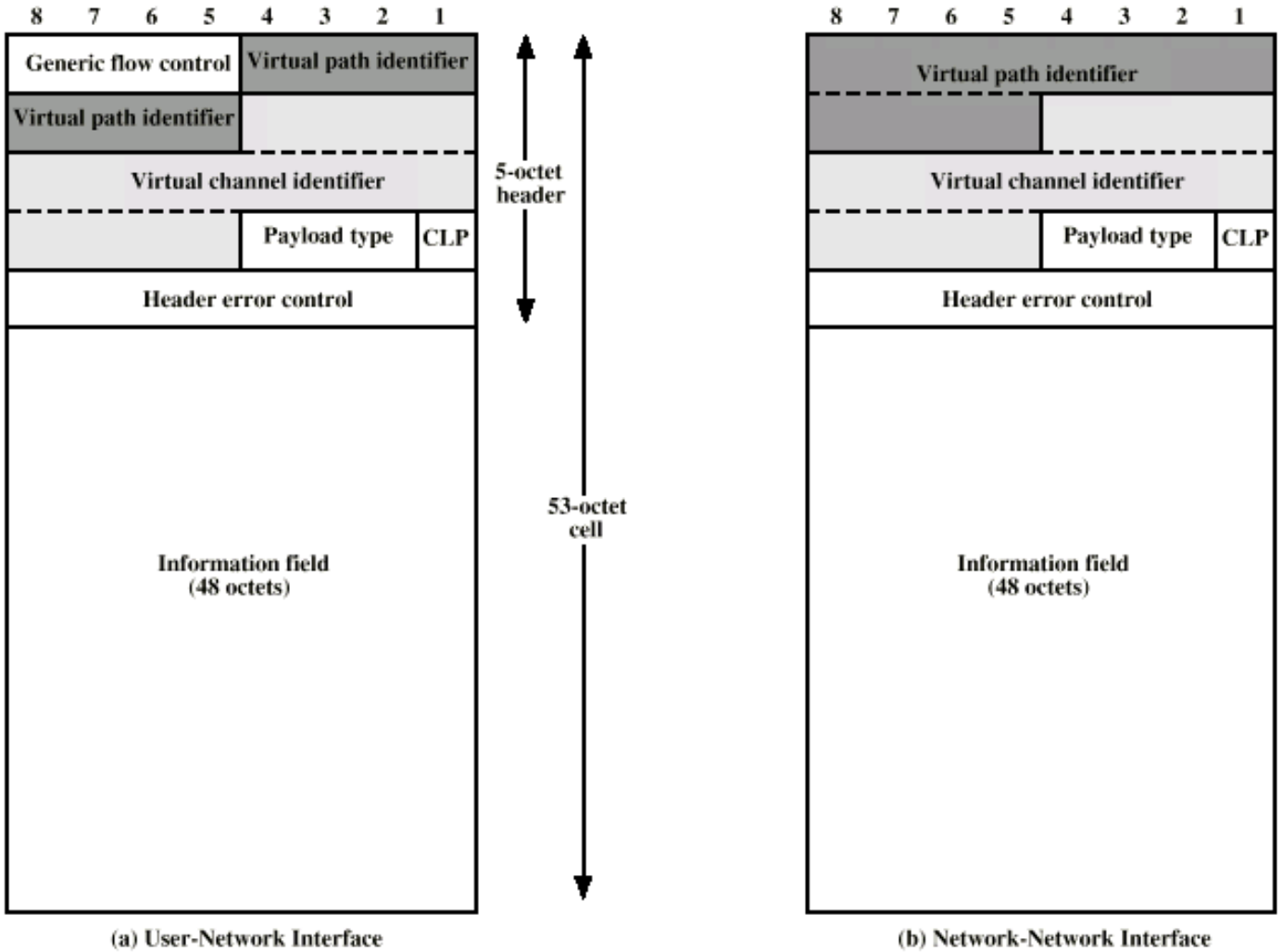
Virtual Channel Connection Uses

- Between end users
  - —End to end user data
  - —Control signals
  - —VPC provides overall capacity
    - VCC organization done by users
- Between end user and network
  - —Control signaling
- Between network entities
  - —Network traffic management
  - —Routing

ATM Cells

- Fixed size
- 5 octet header
- 48 octet information field
- 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

ATM Cell Format

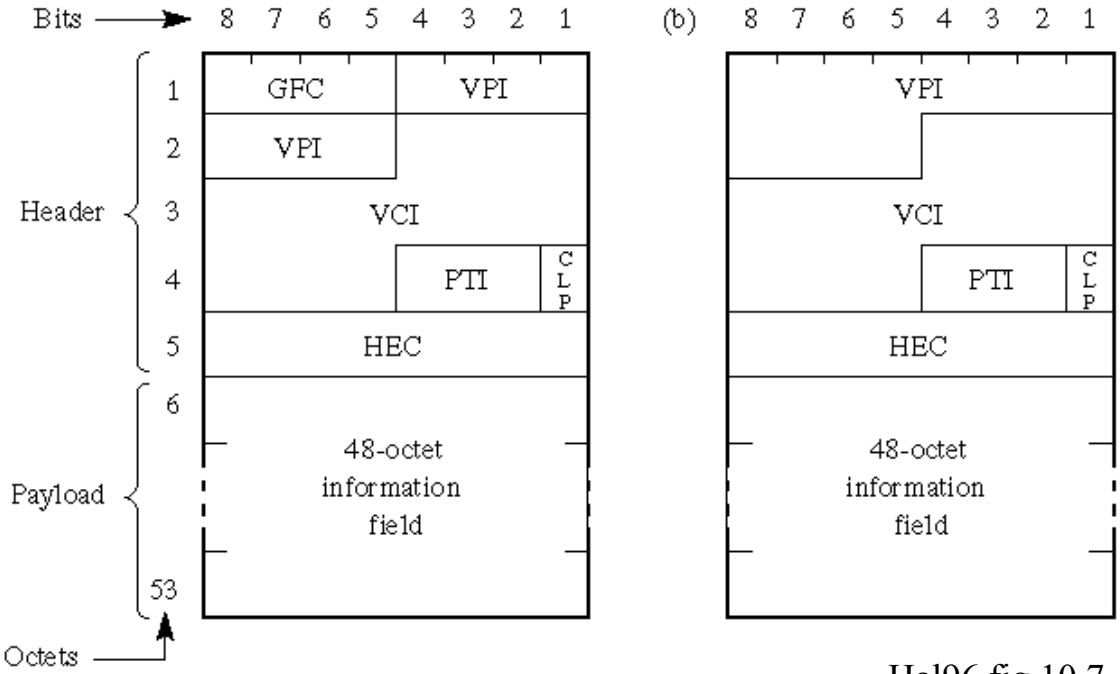


ATM

—ATM Cell Formats: user - network, network - network

PTI: 000 – user data, no congestion, SDU type 0
001 – user data, no congestion, SDU type 1
010 – user data, congestion, SDU type 0
011 – user data, congestion, SDU type 1
100 –
101 –
110 –
111 –

Network control



Hal96 fig.10.7

GFC = Generic flow control
VPI = Virtual path identifier
VCI = Virtual channel identifier
PTI = Payload type identifier
CLP = Cell loss priority
HEC = Header error checksum

SDU = service data unit

ATM

- ATM cell format
  - Generic flow control (GFC)
    - used in user-network interface only
    - enables local switch or remote concentrator unit to regulate the entry of cells by the user into the network
  - Virtual path identifier (VPI)
    - used for identification and routing purposes within the network
    - 8 or 12 bits for respective cells (user-network or network-network)
  - Virtual channel identifier (VCI)
    - 16 bit for channel identification and routing purposes
  - Payload type indicator (PTI)
    - different types of information can be carried in the cell
    - cells with user data have a 0 in the msb
  - Cell loss priority (CLP)
  - Header error checksum (HEC) 8 bit CRC on first 4 Bytes

Header Error Control

- 8 bit error control field
  - —HEC = Header Error Control
- Calculated on remaining 32 bits of header
- Polynomial is $X^8 + X^2 + X + 1$
- Allows some error correction

HEC Operation at Receiver

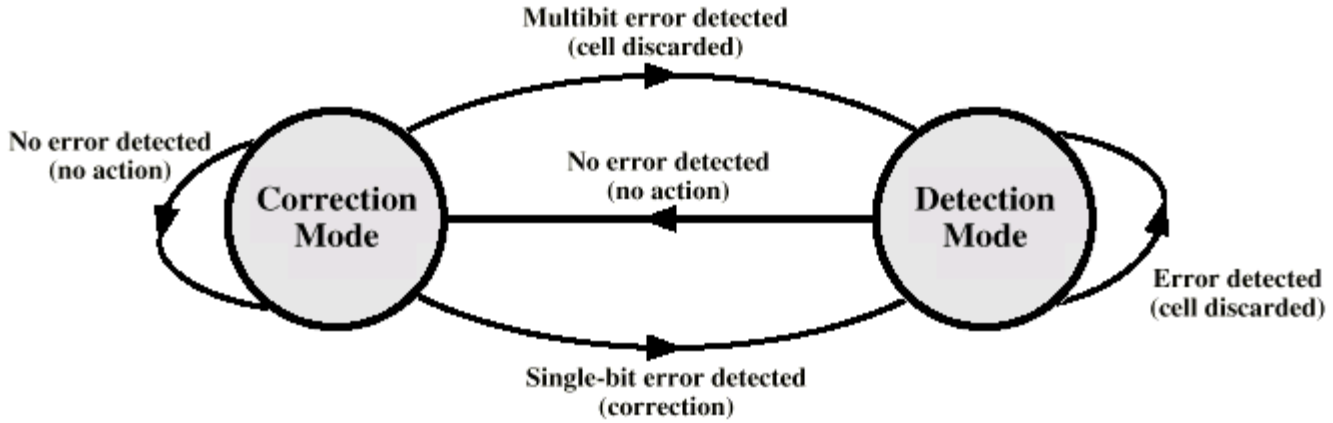
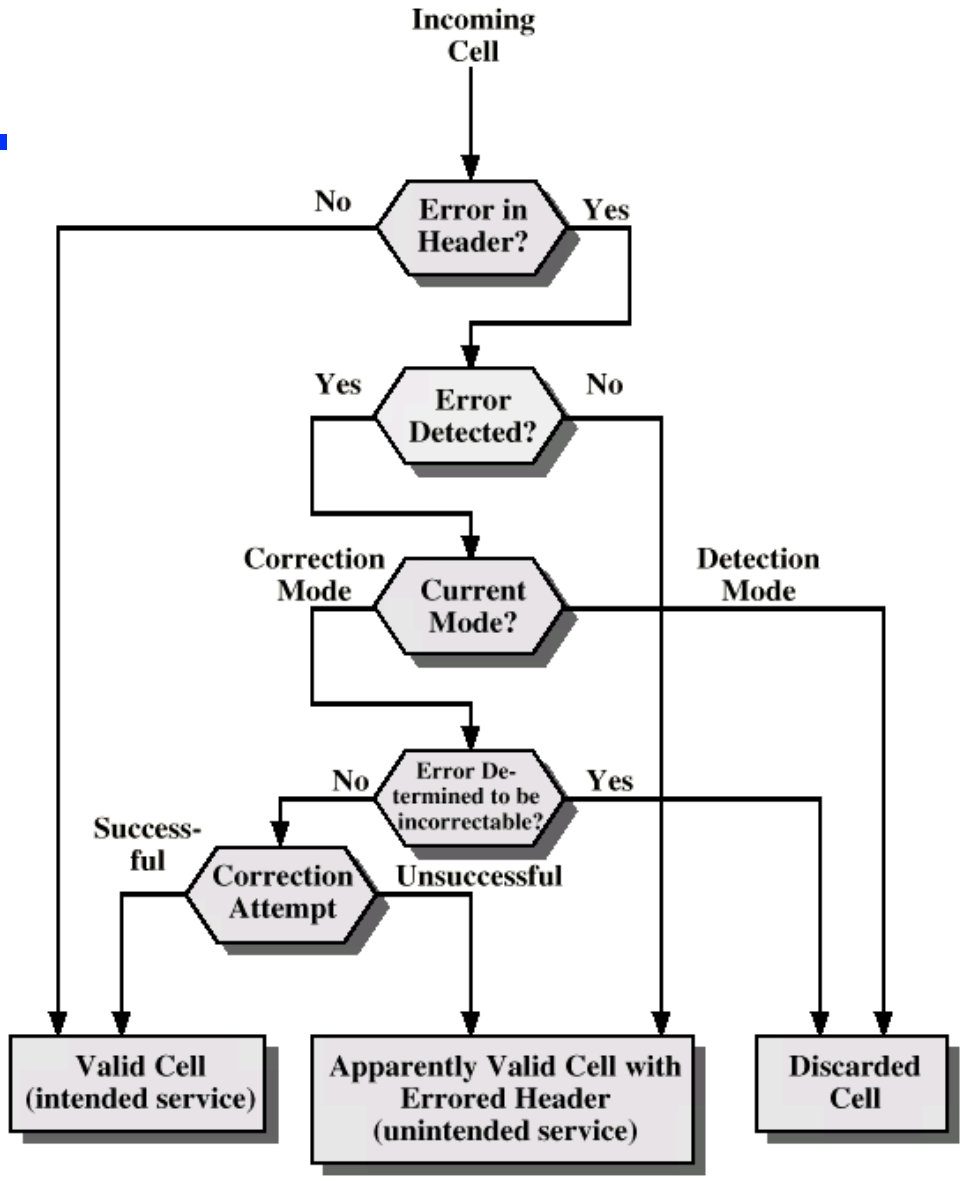


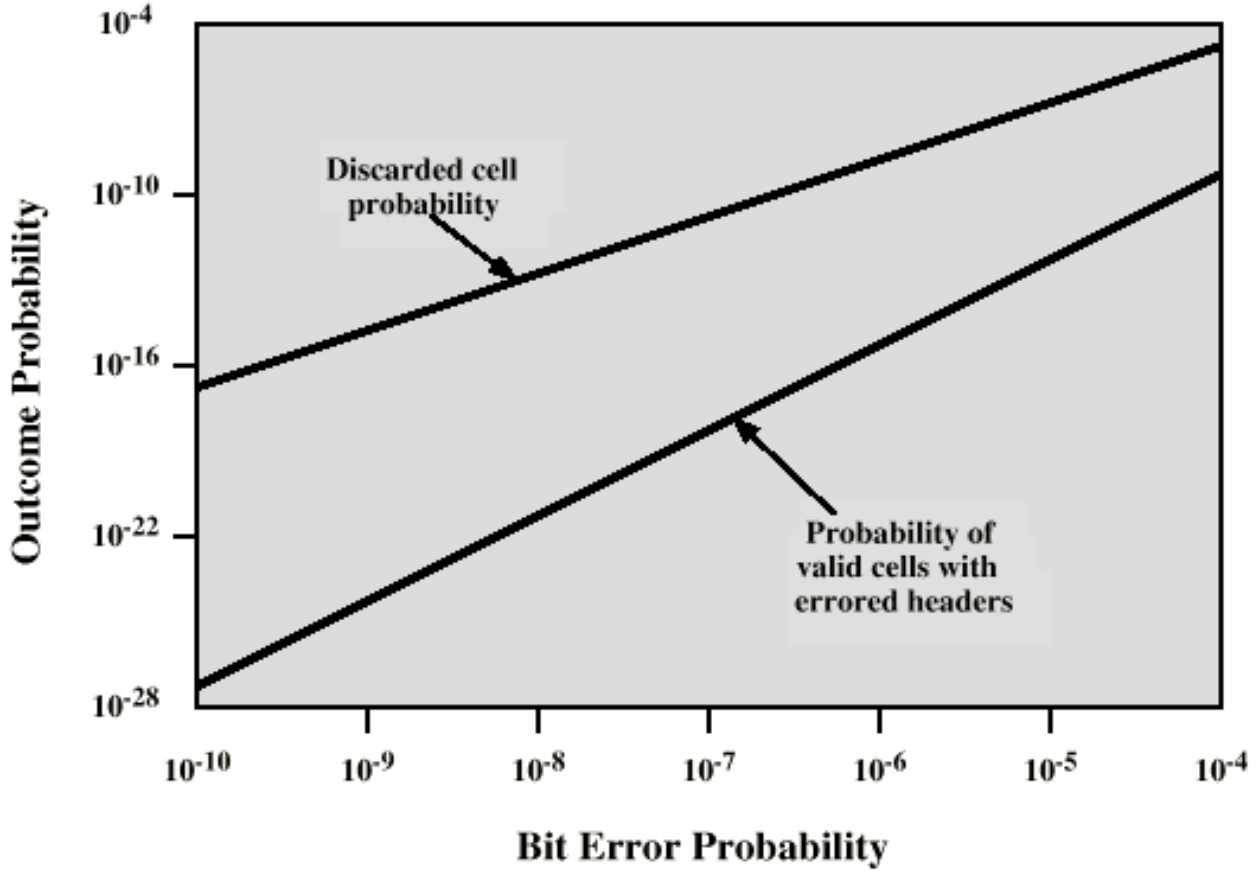
Figure 11.5 HEC Operation at Receiver

HEC: Header Error Control

Effect of Error in Cell Header



Impact of Random Bit Errors



Transmission of ATM Cells

- ...
- 622.08Mbps
- 155.52Mbps
- 51.84Mbps
- 25.6Mbps

- Cell Based physical layer
- SDH based physical layer

ATM

- On-demand connections
  - initiated by user device
  - send request for a *switched virtual connection* (SVC) to central control unit called *signaling control point* (SCP)
  - SCP manages transmission bandwidth and switched connections thought the network.
  - SCP receives *signaling messages* over separate permanent VCs.
- Permanent VC (PVC)
  - useful if number of servers is large
  - PVC is established between workstations & servers and central forwarding point called *connectionless server*.

ATM

- Call Processing
  - —Two types of traffic in ATM LAN
    - traffic between multiservice workstations and their associated servers
    - traffic between bridges/routers that are the interface to the legacy LANs
  - —Two types of calls for multiservice workstations
    - connection oriented
    - connectionless

ATM

—Connection Oriented

- Caller contacts Signaling Control Point (SCP) with destination address and data parameters.
- SCP forwards to dest.
- If dest. accepts, then SCP setup up Virtual Path Identifier/Virtual Channel Identifier (VPI/VCI) across network.

ATM

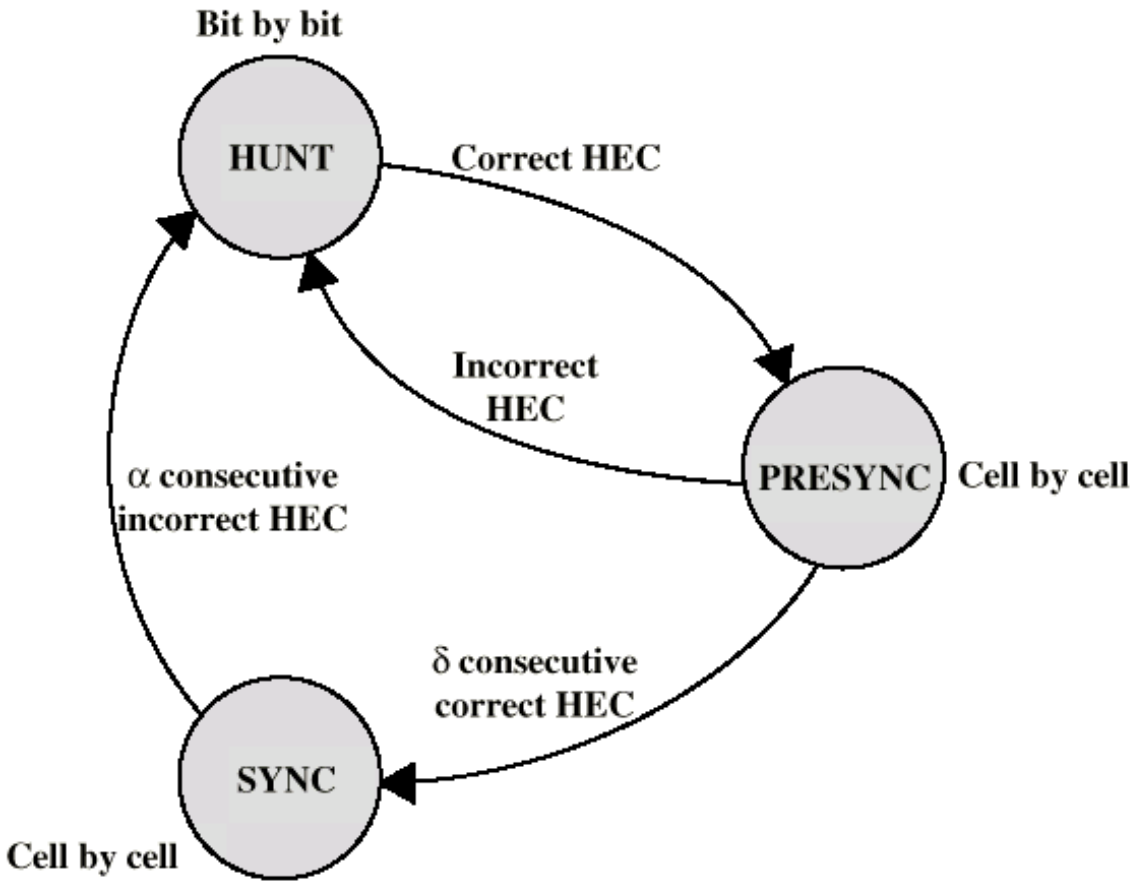
—Connectionless

- two methods to support interworking between ATM workstations and a workstation that is connected to a legacy LAN:
  - LAN Emulation (LE)
    - LE client (LEC), LE server (LES), LE configuration server (LECS), LE Broadcast and unknown address Server (BUS)
    - Use an LE ARP protocol to determine destination ATM address, establish connection and use until idle for timeout
  - IP over ATM
    - Use LE as a router

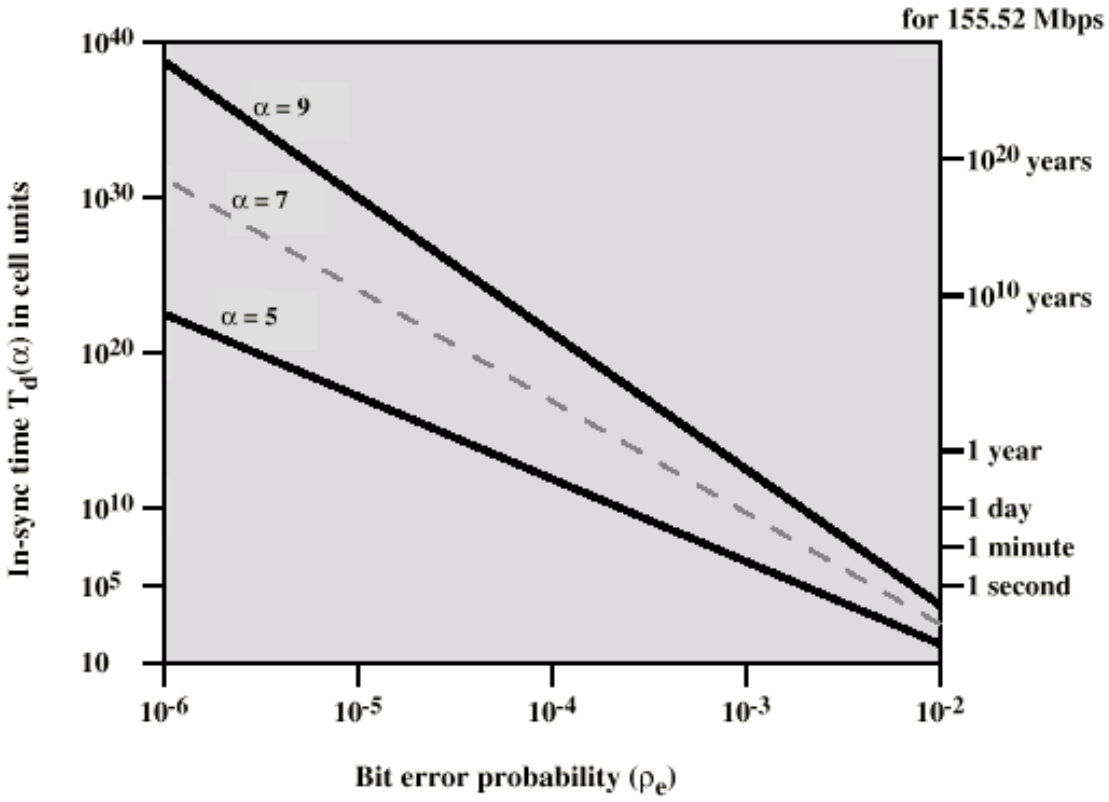
Cell Based Physical Layer

- No framing imposed
- Continuous stream of 53 octet cells
- Cell delineation based on header error control field

Cell Delineation State Diagram

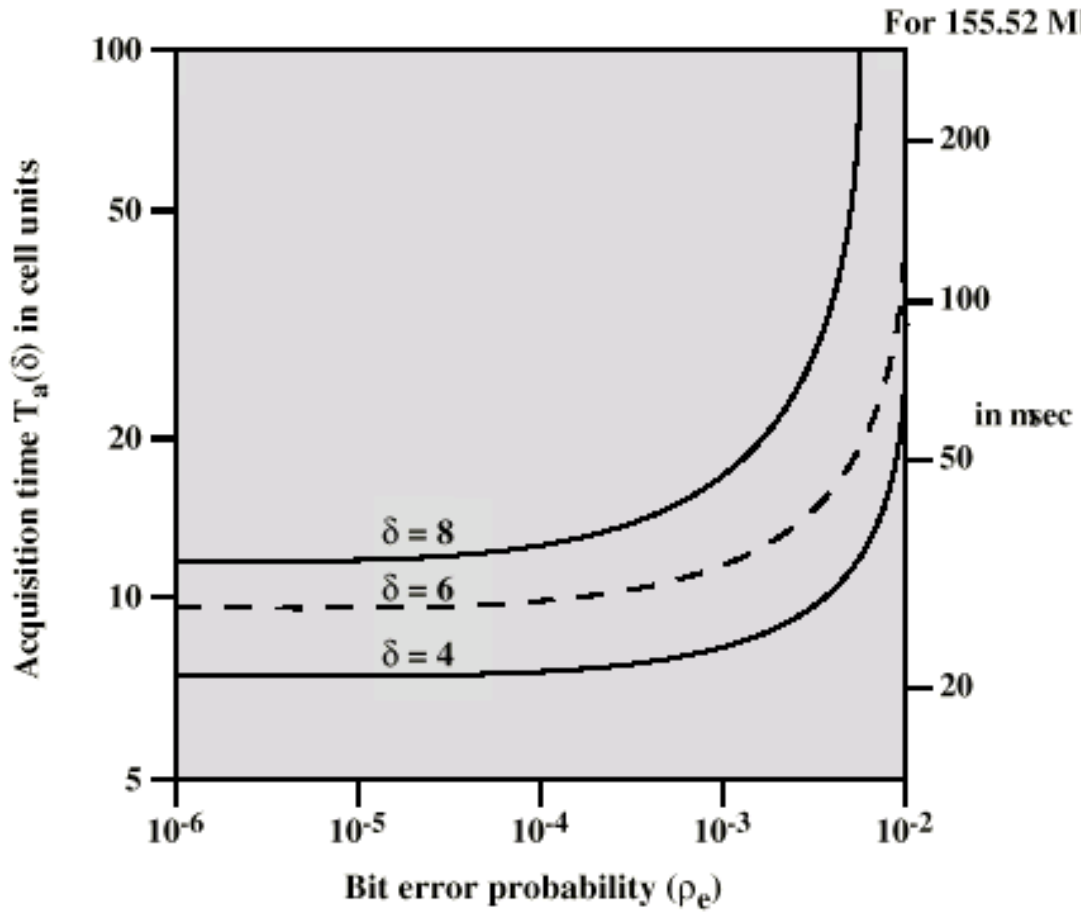


Impact of Random Bit Errors on Cell Delineation Performance



Average amount of time that receiver will maintain synchronization in the face of error

Acquisition Time v Bit Error Rate

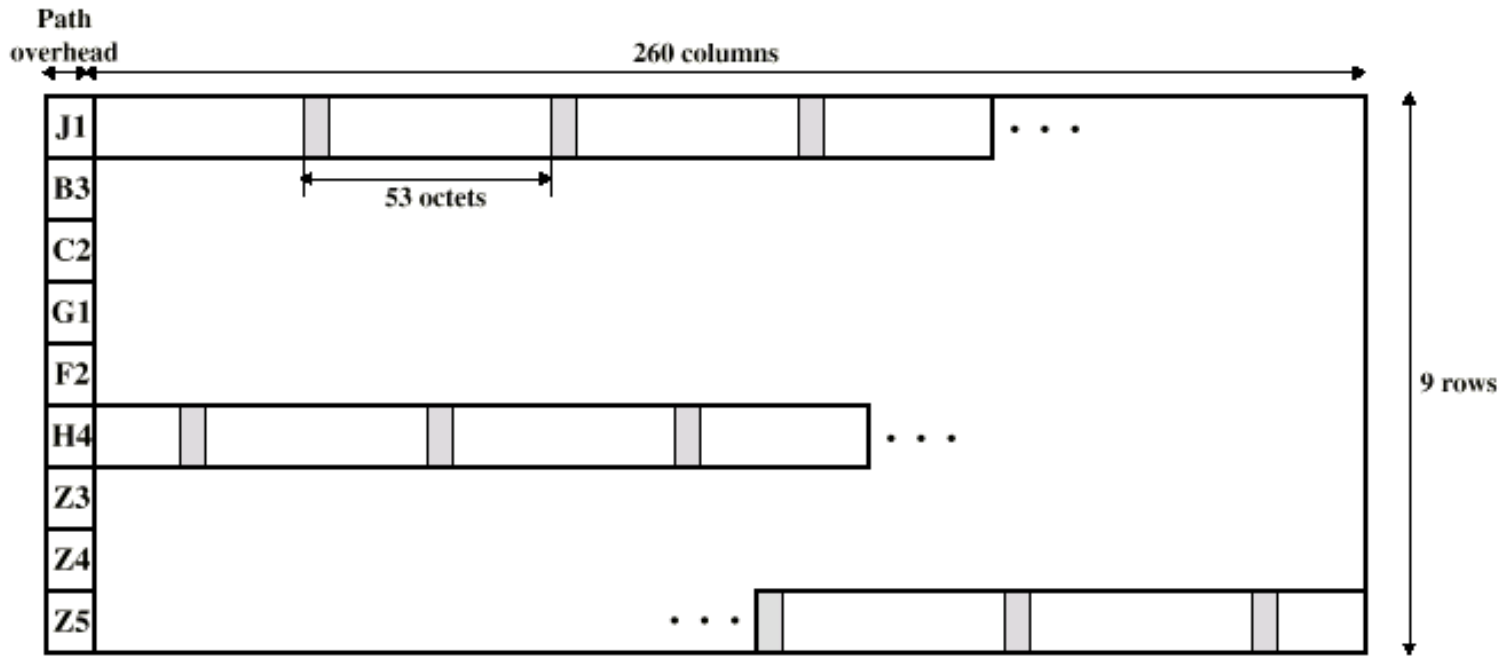


Average amount of time to acquire synchronization as a function of error rate

SDH Based Physical Layer

- ATM can be used over
  - SDH = *Synchronous Digital Hierarchy* or
  - SONET
- Imposes structure on ATM stream
  - e.g. for 155.52Mbps
  - Use STM-1 (STS-3) frame
- Can carry ATM and STM payloads
  - STM = *Synchronous transfer mode*
- Specific connections can be circuit switched using SDH channel
- SDH multiplexing techniques can combine several ATM streams

STM-1 Payload for SDH-Based ATM Cell Transmission



payload capacity is 260*9 = 2340 octets

since 2340 is not an integer multiple of 53, cells may cross payload boundary

ATM Service Categories

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

Real Time Services

- Amount of delay
- Variation of delay (jitter)

Constant Bit rate

- Fixed data rate continuously available
- Tight upper bound on delay
- Uncompressed audio and video
  - —Video conferencing
  - —Interactive audio
  - —A/V distribution and retrieval

rt-variable bit rate

- Time sensitive application
  - —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
- Can statistically multiplex connections

nrt-variable bit rate

- May be able to characterize expected traffic flow
- Improve QoS in loss and delay
- End system specifies:
  - Peak cell rate
  - Sustainable or average rate
  - Measure of how bursty traffic is
- e.g. Airline reservations, banking transactions

Unspecified bit rate

- May be additional capacity over and above that used by CBR and VBR traffic
  - —Not all resources dedicated
  - —Bursty nature of VBR
- For application that can tolerate some cell loss or variable delays
  - —e.g. TCP based traffic
- Cells forwarded on FIFO basis
- Best efforts service

Available bit rate

- Application specifies peak cell rate (PCR) and minimum cell rate (MCR)
- Resources allocated to give at least MCR
- Spare capacity shared among all ARB sources
- e.g. LAN interconnection

ATM Adaptation Layer

- Support for information transfer protocol not based on ATM
- PCM (voice)
  - —Assemble bits into cells
  - —Re-assemble into constant flow
- IP
  - —Map IP packets onto ATM cells
  - —Fragment IP packets
  - —Use LAPF over ATM to retain all IP infrastructure

Adaptation Layer Services

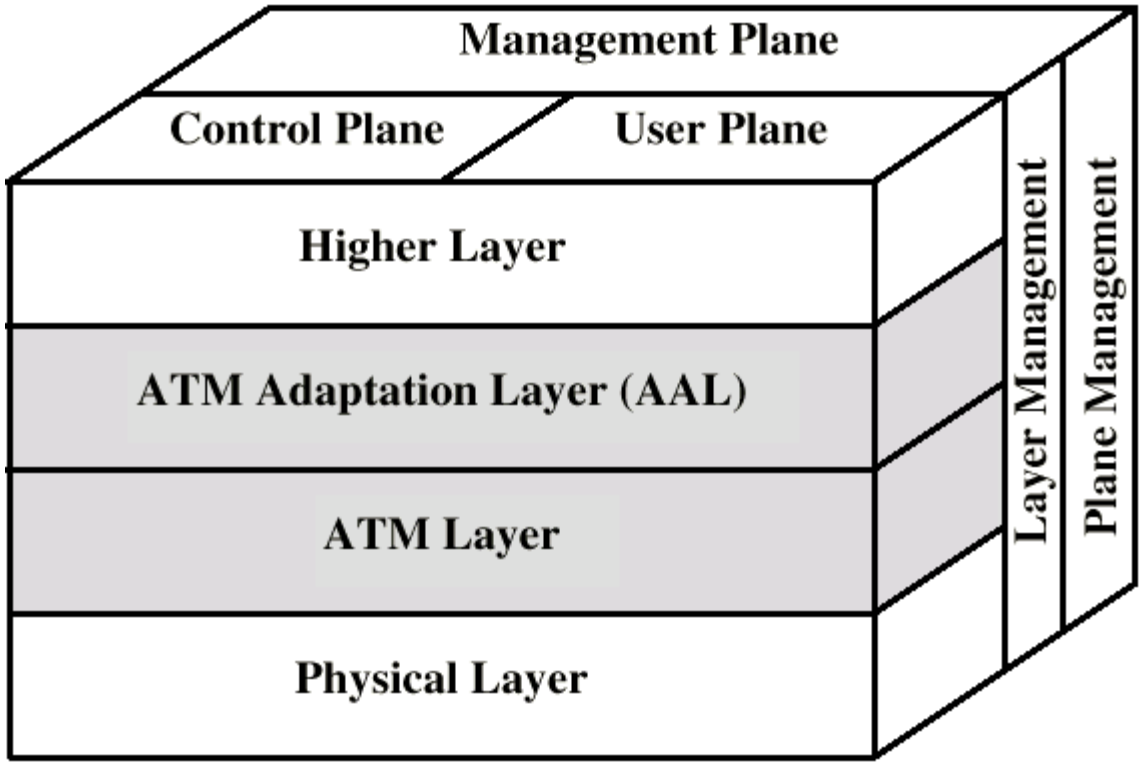
- Handle transmission errors
- Segmentation and re-assembly
- Handle lost and misinserted cells
- Flow control and timing

Supported Application types

- Circuit emulation
- VBR voice and video
- General data service
- IP over ATM
- Multiprotocol encapsulation over ATM (MPOA)
  - —IPX, AppleTalk, DECNET
- LAN emulation

ATM Protocol Layers

- Protocol Layers



ATM Protocol Layers

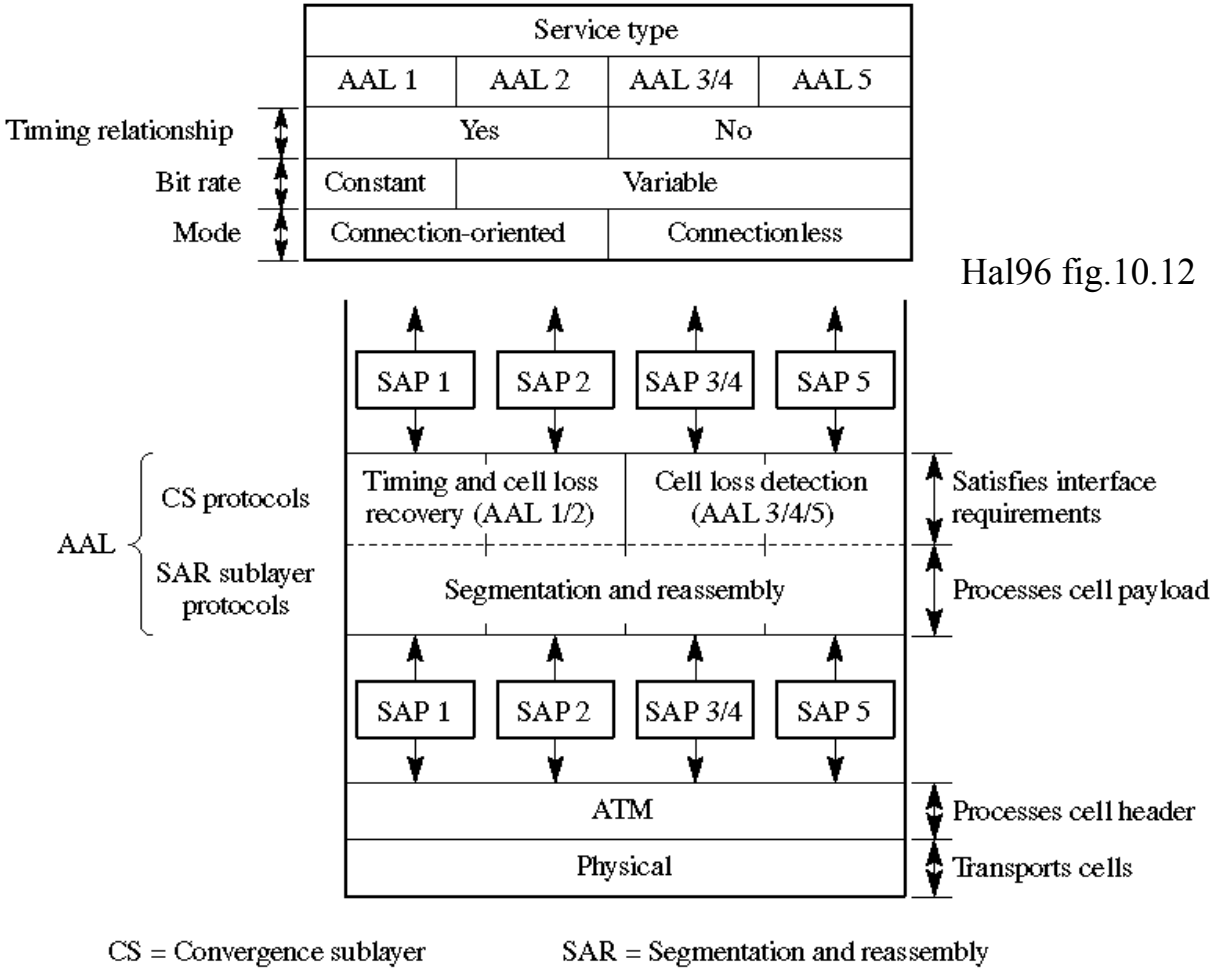
- AAL (ATM adaptation layer)
  - —Designed to interface between users and ATM.
  - —Responsible for marshaling/unmarshaling data into/out-of cells
  - —Different types needed, depending on service
    - AAL 1 (guaranteed bit rate, e.g. voice, connection oriented)
    - AAL 2 (variable bit rate, e.g. compressed video, connection oriented)
    - AAL 3/4 (connectionless)
    - AAL 5 (simple and efficient adaption layer SEAL)

ATM Protocol Layers

- ATM Layer
  - —Responsible for routing and bridging
  - —Includes buffering and switching
  - —VC setup and termination

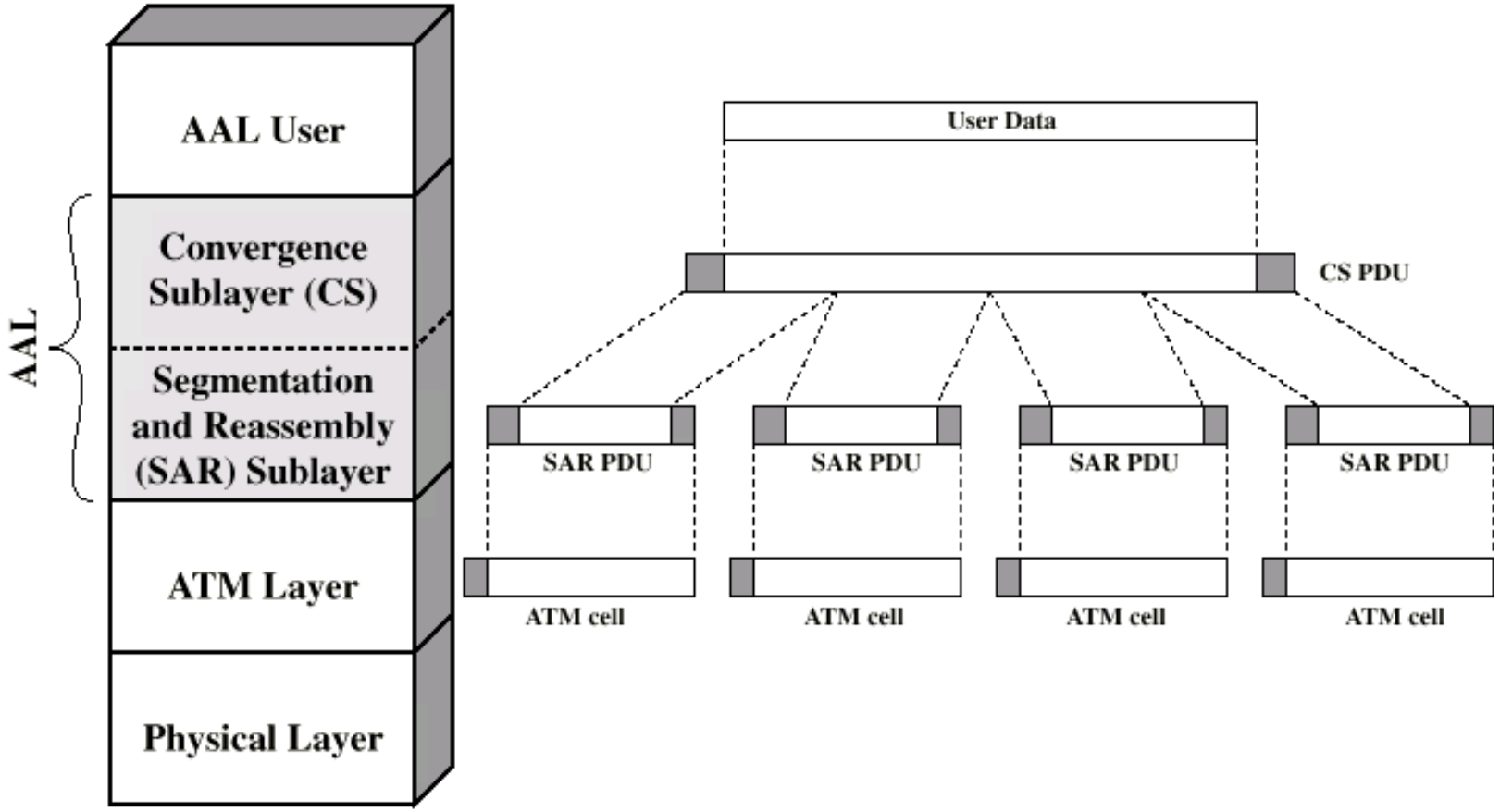
ATM

ATM adaptation layer

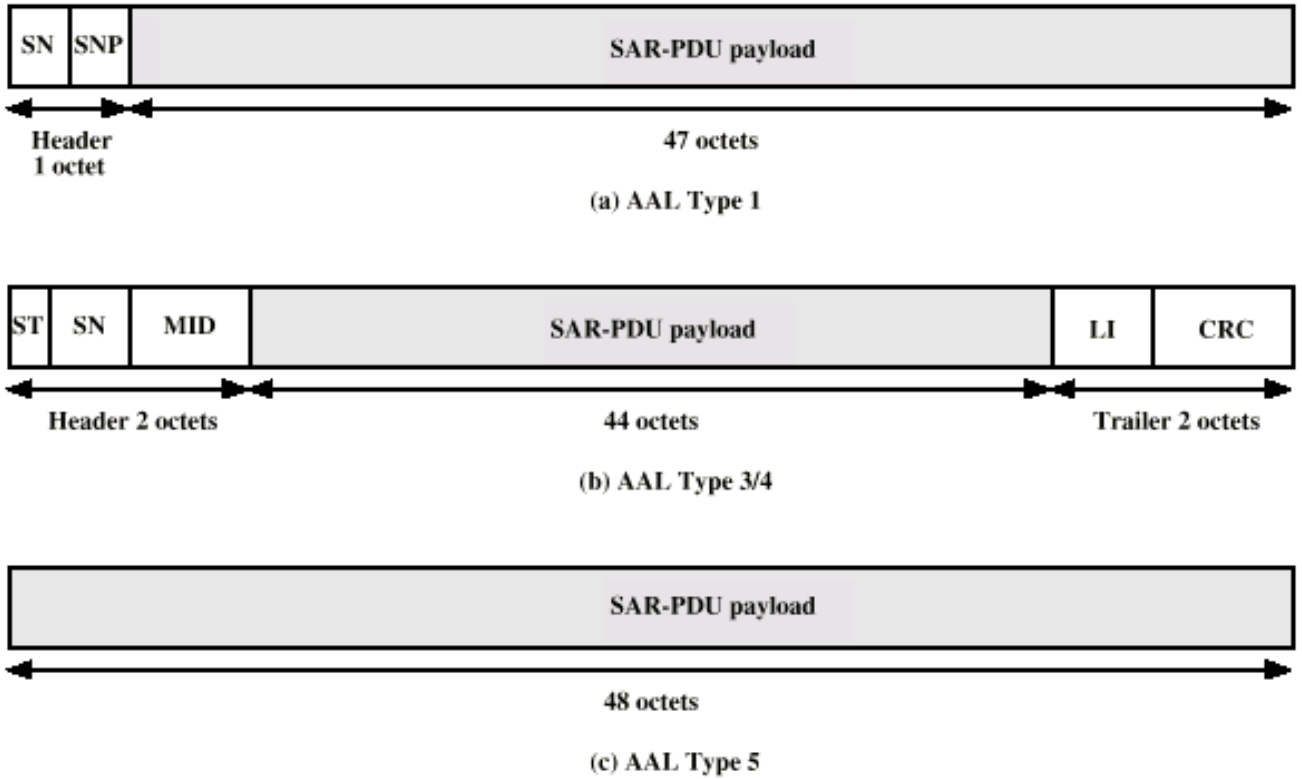


Hal96 fig.10.12

AAL Protocols



Segmentation and Reassembly PDU



SN = sequence number (4 bits)
SNP = sequence number protection (4 bits)
ST = segment type (2 bits)
MID = multiplexing identification (10 bits)
LI = length indication (6 bits)
CRC = cyclic redundancy check (10 bits)

AAL Type 1

- Constant bit rate (CBR) source
- SAR packs and unpacks bits
- Block accompanied by sequence number

AAL Type 2

- VBR
- Analog applications

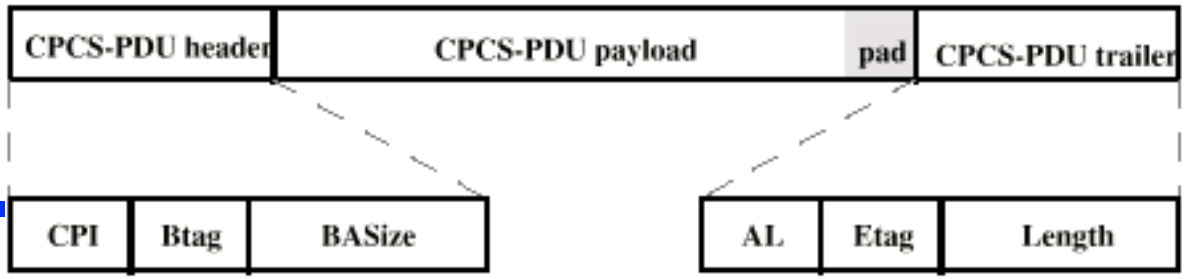
AAL Type 3/4

- Connectionless or connected
- Message mode or stream mode

AAL Type 5

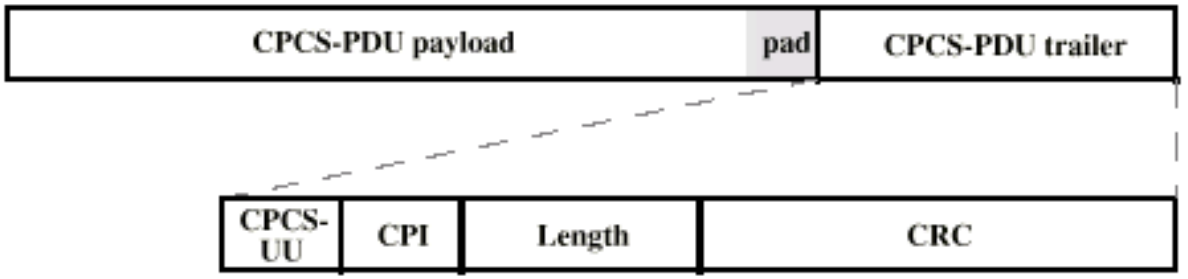
- Streamlined transport for connection oriented higher layer protocols

CPCS PDUs



CPI = common part indicator (1 octet)
Btag = beginning tag (1 octet)
BASize = buffer allocation size (2 octets)
AL = alignment (1 octet)
Etag = end tag (1 octet)
Length = length of CPCS-PDU payload (2 octets)

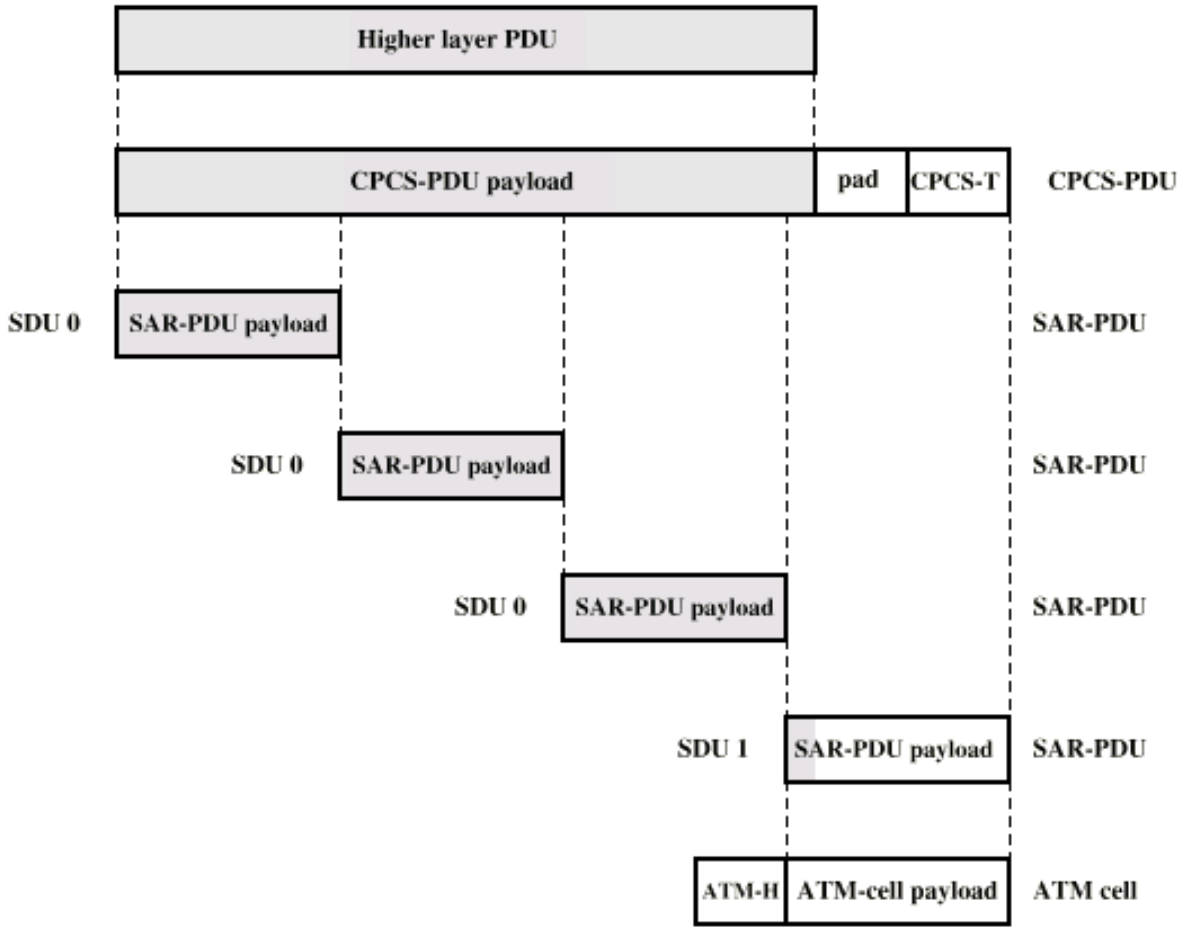
(a) AAL Type 3/4



CPCS-UU = CPCS user-to-user indication (1 octet)
CPI = common part indicator (1 octet)
Length = length of CPCS-PDU payload (2 octets)
CRC = cyclic redundancy check (4 octets)

(b) AAL Type 5

Example AAL 5 Transmission



CPCS = common part convergence sublayer
SAR = segmentation and reassembly
PDU = protocol data unit
CPCS-T = CPCS trailer
ATM-H = ATM header
SDU = Service Data Unit type bit

Summary

- Asynchronous Transfer Mode (ATM)
- architecture & logical connections
- ATM Cell format
- transmission of ATM cells
- ATM services