DATA AND COMPUTER COMMUNICATIONS

## Lecture 4 Wide Area Networks - Asynchronous Transfer Mode

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Based on Lecture slides by William Stallings

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ATM

- a streamlined packet transfer interface
- similarities to packet switching
  - transfers data in discrete chunks
  - supports multiple logical connections over a single physical interface
- ATM uses fixed sized packets called cells
- with minimal error and flow control
- data rates of 25.6Mbps to 622.08Mbps

PROTOCOL ARCHITECTURE
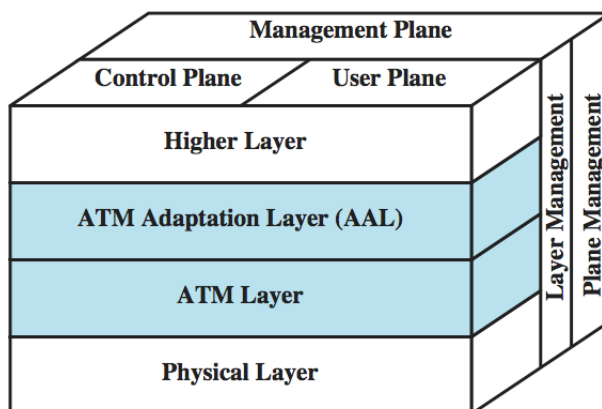
REFERENCE MODEL PLANES

- **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 NETWORK INTERFACES

○ switches are interconnected by point-to-point
ATM links called **interfaces**
- user-network interface (UNI)
- network node interface (NNI)
- interface specification includes:
  ○ definition of link types allowed
  ○ addressing formats
  ○ cell format
  ○ control signaling protocols
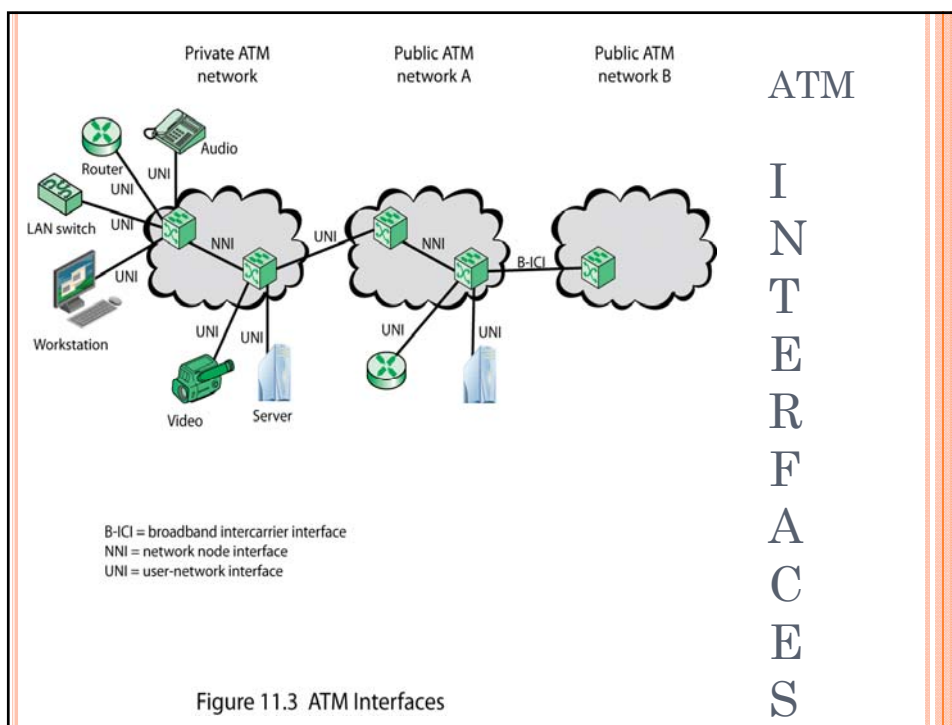
Figure 11.3 ATM Interfaces

ATM

INTERFACES

ATM LOGICAL CONNECTIONS

virtual channel connections (VCC)

- analogous to virtual circuit in X.25

basic unit of switching between two end users

- variable rate
- full duplex
- fixed size cells

VCCs also used for

- user-network exchange (control signaling)
- network-network exchange (network management and routing)

ATM LOGICAL CONNECTIONS

- virtual channel connections (VCC)
  - analogous to virtual circuit in X.25
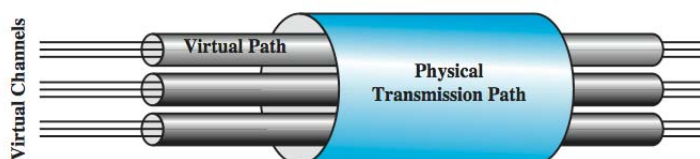- basic unit of switching between two end users
  - full duplex
  - fixed size cells
- also for
  - user-network exchange (control)
  - network-network exchange (network mgmt & routing)
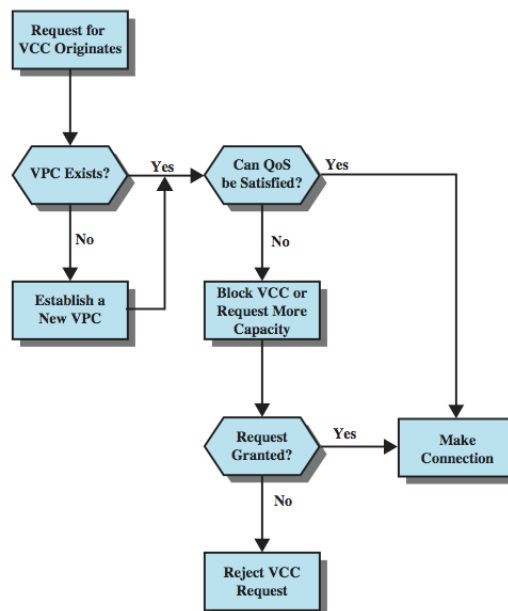
ATM Virtual Path Connection

- virtual path connection (VPC)
  - bundle of VCC with same end points

Advantages of Virtual Paths

- simplified network architecture
- increased network performance and reliability
- reduced processing
- short connection setup time
- enhanced network services

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

VP/VC CHARACTERISTICS

- quality of service
- switched and semi-permanent channel connections
- call sequence integrity
- traffic parameter negotiation and usage monitoring

- VPC only
  - virtual channel identifier restriction within VPC
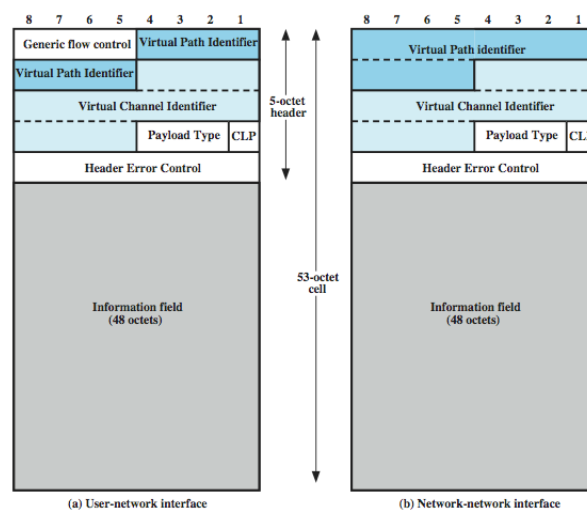
CONTROL SIGNALING - VCC

- to establish or release VCCs & VPCs
- uses a separate connection
- methods are:
  - semi-permanent VCC
  - meta-signaling channel
  - user to network signaling virtual channel
  - user to user signaling virtual channel

CONTROL SIGNALING - VPC

- methods for control signalling for VPCs:
  - Semi-permanent
  - Customer controlled
  - Network controlled

ATM CELLS

ATM HEADER FIELDS

- generic flow control
- Virtual path identifier
- Virtual channel identifier
- payload type
- cell loss priority
- header error control

GENERIC FLOW CONTROL (GFC)

- control traffic flow at user to network interface (UNI) to alleviate short term overload
- two sets of procedures
  - uncontrolled transmission
  - controlled transmission
- every connection subject to flow control or not
- if subject to flow control
  - may be one group (A) default
  - may be two groups (A and B)
- flow control is from subscriber to network

GFC - SINGLE GROUP OF CONNECTIONS

- If TRANSMIT=1 send uncontrolled cells any time. If TRANSMIT=0 no cells may be sent
- If HALT received, TRANSMIT=0 until NO_HALT
- If TRANSMIT=1 & no uncontrolled cell to send:
  - If GO_CNTR>0, TE may send controlled cell and decrement GO_CNTR
  - If GO_CNTR=0, TE may not send controlled cells
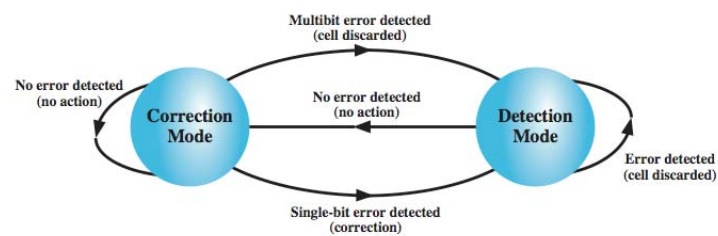- TE sets GO_CNTR to GO_VALUE upon receiving SET signal

USE OF HALT

- to limit effective data rate on ATM
- should be cyclic
- to reduce data rate by half, HALT issued to be in effect 50% of time
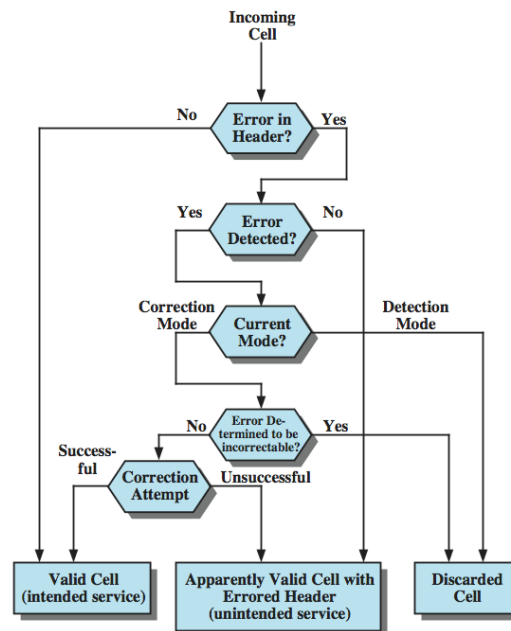- done on regular pattern over lifetime of connection

TWO QUEUE MODEL

○ uses two counters each with current & initial values:
- GO_CNTR_A
- GO_VALUE_A
- GO_CNTR_B
- GO_VALUE_B

HEADER ERROR CONTROL

EFFECT OF ERROR IN CELL HEADER

Incoming Cell

Error in Header? — No / Yes

Error Detected? — Yes / No

Correction Mode — **Current Mode?** — Detection Mode

Error Determined to be incorrectable? — No / Yes

Successful — **Correction Attempt** — Unsuccessful

Valid Cell (intended service)

Apparently Valid Cell with Errored Header (unintended service)

Discarded Cell

IMPACT OF RANDOM BIT ERRORS ON HEC PERFORMANCE

Outcome Probability

Discarded cell probability

Probability of valid cells with errored headers

Bit Error Probability
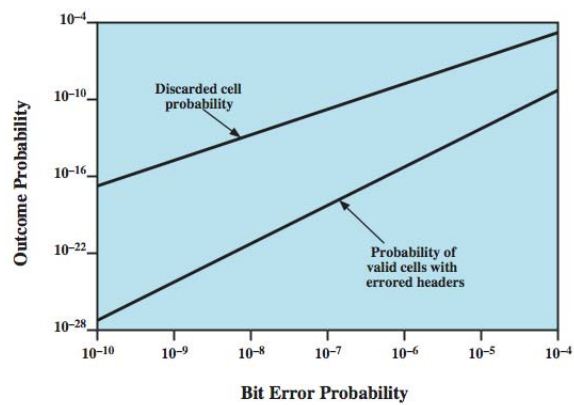
Transmission of ATM Cells

- I.432 specifies several data rates:
  - 622.08Mbps
  - 155.52Mbps
  - 51.84Mbps
  - 25.6Mbps
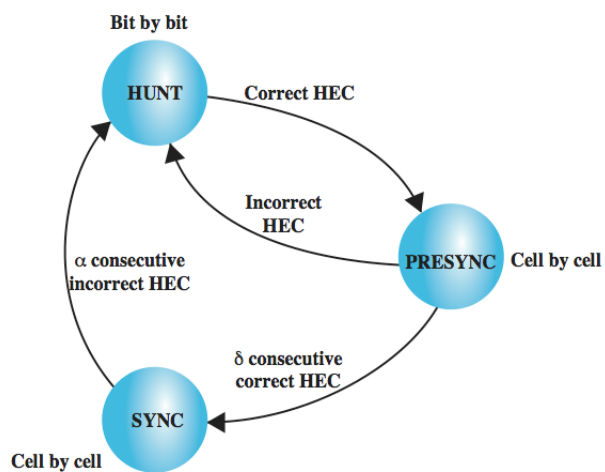- two choices of transmission structure:
  - Cell based physical layer
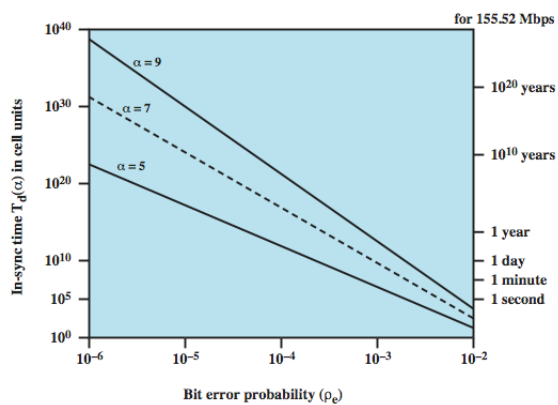 - SDH based physical layer

Cell Based Physical Layer

- no framing imposed
- vontinuous stream of 53 octet cells
- cell delineation based on header error control field

CELL DELINEATION STATE DIAGRAM

Bit by bit

HUNT

Correct HEC

Incorrect HEC

α consecutive incorrect HEC

PRESYNC   Cell by cell

δ consecutive correct HEC

SYNC

Cell by cell

IMPACT OF RANDOM BIT ERRORS ON CELL DELINEATION PERFORMANCE

for 155.52 Mbps

10^{40}

$\alpha = 9$

10^{20} years

10^{30}

$\alpha = 7$

10^{10} years

In-sync time $T_d(\alpha)$ in cell units

10^{20}

$\alpha = 5$

1 year

10^{10}

1 day
1 minute
1 second

10^5

10^0

10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2}

Bit error probability (ρ_e)

ACQUISITION TIME V BIT ERROR RATE
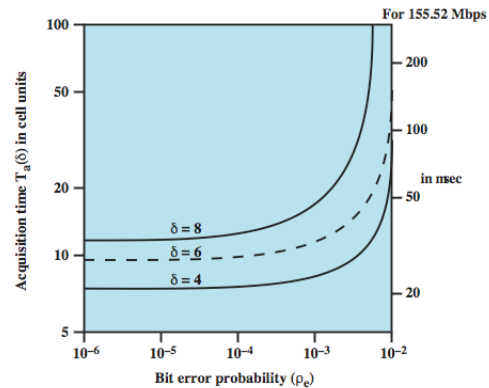
SDH BASED PHYSICAL LAYER

- imposes structure on ATM stream
  - eg. for 155.52Mbps
  - use STM-1 (STS-3) frame
- can carry ATM and STM payloads
- 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

ATM Service Categories

- Real time - limit amount/variation of delay
  - Constant bit rate (CBR)
  - Real time variable bit rate (rt-VBR)
- Non-real time - for bursty traffic
  - Non-real time variable bit rate (nrt-VBR)
  - Available bit rate (ABR)
  - Unspecified bit rate (UBR)
  - Guaranteed frame rate (GFR)

CONSTANT BIT RATE (CBR)

- fixed data rate continuously available
- tight upper bound on delay
- uncompressed audio and video
  - video conferencing
  - interactive audio
  - A/V distribution and retrieval

REAL-TIME VARIABLE BIT RATE (RT-VBR)

- for time sensitive applications
  - tightly constrained delay and delay variation
- rt-VBR applications transmit data at a rate that varies with time
  - eg. compressed video
  - produces varying sized image frames
  - original (uncompressed) frame rate constant
  - so compressed data rate varies
- hence can statistically multiplex connections

NON-REAL-TIME VARIABLE BIT RATE (NRT-VBR)

- it can characterize expected bursty traffic flow
  - eg. airline reservations, banking transactions
- ATM net allocates resources based on this
  - to meet critical response-time requirements
- giving improve QoS in loss and delay
- end system specifies:
  - peak cell rate
  - sustainable or average rate
 - measure of how bursty traffic is

UNSPECIFIED BIT RATE (UBR)

- may be additional capacity over and above that used by CBR and VBR traffic
  - not all resources dedicated to CBR/VBR traffic
  - unused cells due to bursty nature of VBR
- for application that can tolerate some cell loss or variable delays
  - eg. TCP based traffic
- cells forwarded on FIFO basis
- best effort service

AVAILABLE BIT RATE (ABR)

- application specifies peak cell rate (PCR) and minimum cell rate (MCR)
- resources allocated to give at least MCR
- spare capacity shared among all ABR sources
  - eg. LAN interconnection

ATM BIT RATE SERVICES
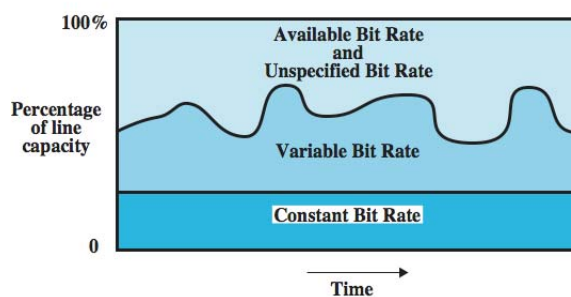
SUMMARY

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