Lecture (06 & 07)
ATM

Dr. Ahmed ElShafee

Agenda

- Introduction
- ATM protocol architecture

Introduction

Features and characteristics

- ATM, also known as cell relay,
- ATM takes advantage of the reliability and fidelity of modern digital facilities to provide faster packet switching than X.25.
- ATM transfer data in discrete chunks, and allows multiple logical connections to be multiplexed over a single physical interface (like X.25 and frame relay).

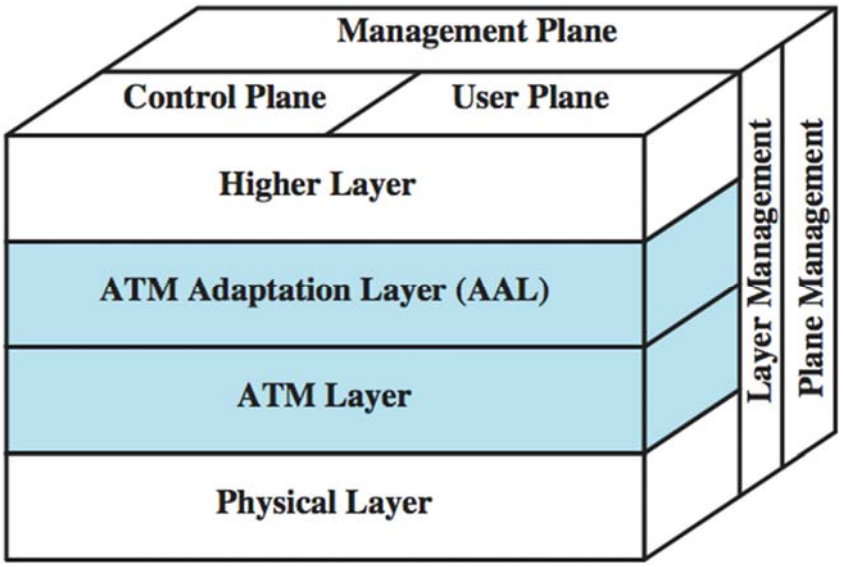
Introduction (cont,..)

Advantages

- ATM uses a fixed-sized chunks, called **cells.**
- ATM is a streamlined protocol uses minimal error and flow control capabilities.
- This reduces the overhead of processing ATM cells and reduces the number of overhead bits required with each cell, thus enabling ATM to operate at high data rates.
- The use of fixed-size cells simplifies the processing required at each ATM node, again supporting the use of ATM at high data rates.
- small cells may reduce queuing delay for a high-priority cell, because it waits less if it arrives slightly behind a lower-priority cell that has gained access to a resource

ATM protocol architecture

ATM protocol architecture (3 layers, 3 plans)



ATM protocol architecture (cont,..)

1. **The physical layer** involves the specification of a transmission medium and a signal encoding scheme.
- The data rates specified at the physical layer range from 25.6 Mbps to 622.08 Mbps.
- Other data rates, both higher and lower, are possible.

2. ATM Layer
- defines the transmission of data in fixed-size cells
- defines the use of logical connections.

ATM protocol architecture (cont,..)

3. ATM adaptation Layer

- Makes ATM network able to transferee data comes from any other protocol.
- The AAL maps higher-layer information into ATM cells
- collects information from ATM cells for delivery to higher layers.

ATM protocol architecture (cont,..)

ATM protocol Reference Model Planes

- **User plane:** Provides for user information transfer, along with associated controls (e.g., flow control, error control)
- **Control plane:** Performs call control and connection control functions
- **Management plane:**
  - performs management functions related to a system as a whole
  - provides coordination between all the planes, and layer management, **layer management:** performs management functions relating to resources and parameters residing in its protocol entities

ATM protocol architecture (cont,..)

virtual channel connections (VCC):

- A VCC is analogous to a virtual circuit in X.25; it is the basic unit of switching in an ATM network.
- A VCC is set up
  - between two end users through the network and a
  - variable-rate,
  - full-duplex flow
  - fixed-size cells is exchanged over the connection.
- VCCs are also used for
  - user-network exchange (control signaling) and
  - network-network exchange (network management and routing).

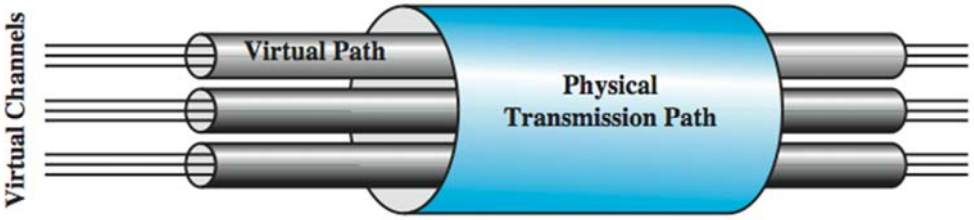
ATM protocol architecture (cont,..)

- So Network management actions are applied to a small number of groups of connections instead of a large number of individual connections.

ATM protocol architecture (cont,..)

virtual path connection (VPC)

- A bundle of VCCs that have the same endpoints.
- All of the cells flowing over all of the VCCs in a single VPC are switched together.



ATM protocol architecture (cont,..)

Why?

- Trend in high-speed networking in which the control cost of the network is becoming an increasingly higher proportion of the overall network cost.
- virtual path technique decrease control cost by grouping connections sharing common paths through the network into a single unit.

ATM protocol architecture (cont,..)

VPC advantages

1. **Simplified network architecture:** network transport transactions applied to a group of virtual channels which share the logical path (same route)
2. **Increased network performance and reliability:** The network deals with fewer, aggregated entities.
3. **Reduced processing and short connection setup time**:
   - All the work is done during virtual path setup.
   - Reserve capacity/path, for any in coming cells
   - virtual channel connections can be established by executing simple control functions at the endpoints of the virtual path (Rx, Tx)

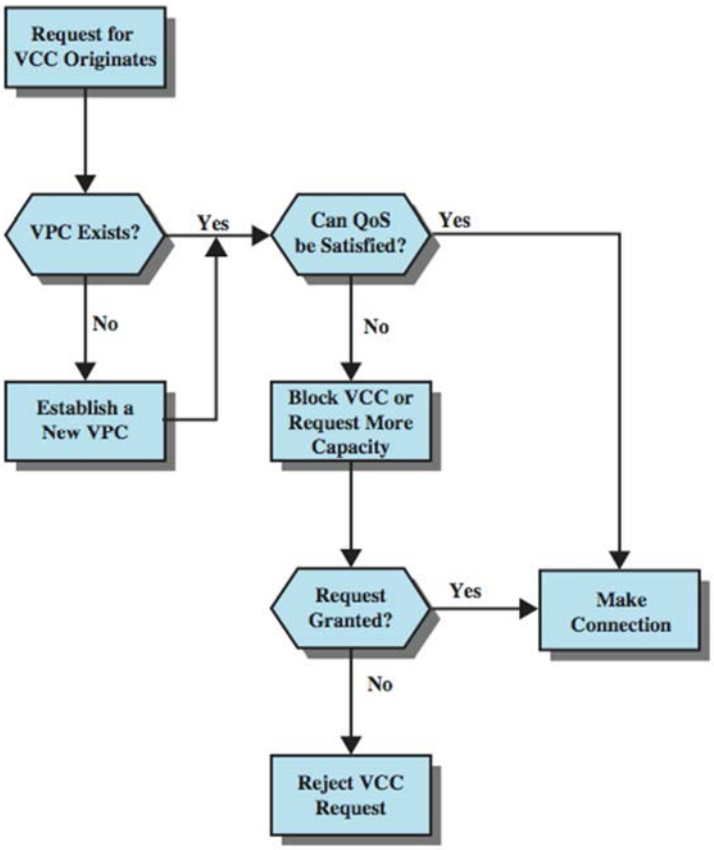
ATM protocol architecture (cont,..)

   - no call processing is required at transit nodes.
   - addition of new virtual channels to an existing virtual path involves minimal processing.
4. **Enhanced network services:**
   - The virtual path is used internal to the network but is also visible to the end user.
   - Thus, the user may define closed user groups or closed networks of virtual channel bundles.

ATM protocol arch

VCC Call Establishment Using VPCs

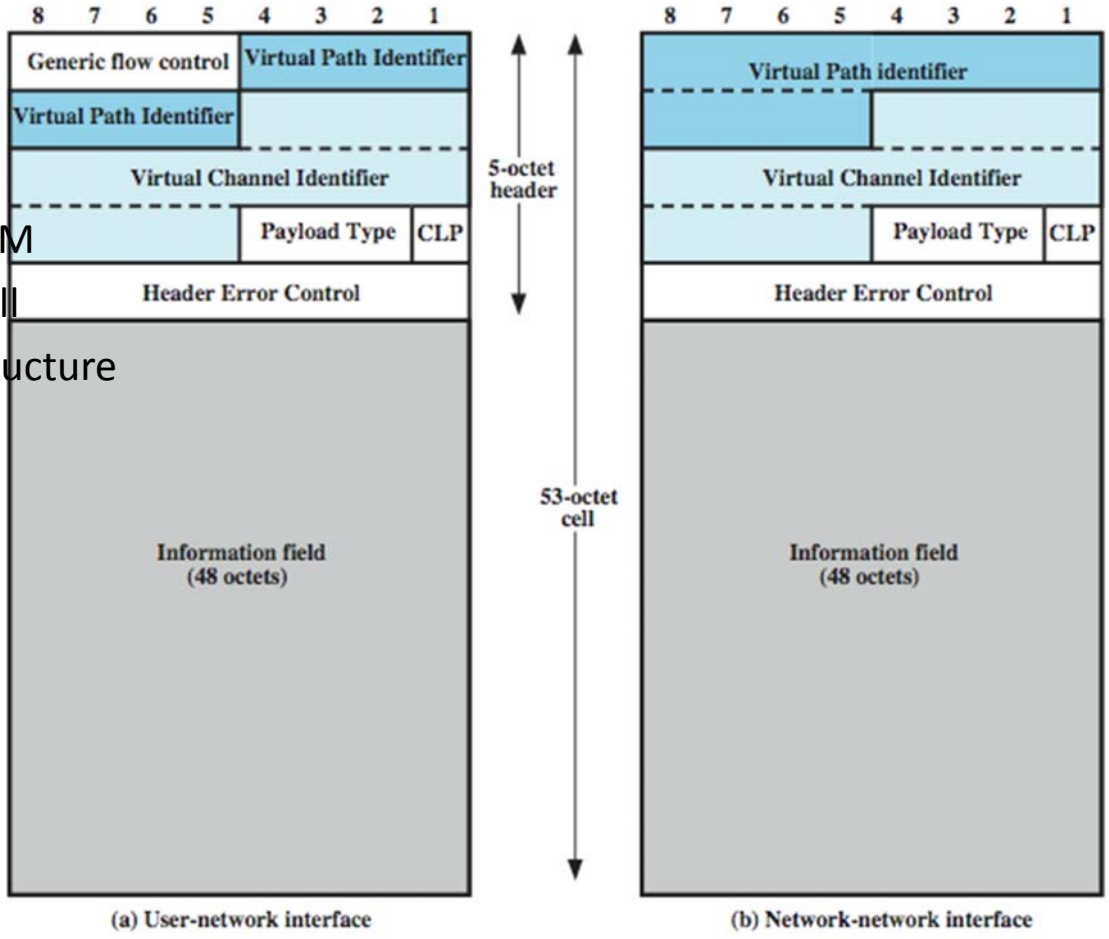
- setting up a virtual path connection is decoupled from the process of setting up an individual virtual channel connection



ATM protocol architecture (cont,..)

- **The virtual path control mechanisms include**
  - calculating routes,
  - allocating capacity, and
  - storing connection state information.
- **To set up a virtual channel,**
  - there must first be a VPC to the required destination node
  - VPC has sufficient available capacity to support the virtual
  - VPC has appropriate quality of service.
- **A virtual channel is setup** by storing the required state information (virtual channel/virtual path mapping).

ATM Cell structure



ATM protocol architecture (cont,..)

- ATM uses a fixed-size cells, consisting of a 5- octet header and a 48-octet information field.

Field	interface	details
Generic Flow Control (GFC)	4 bits user-network interface	Control cell flow only at the local user-network interface
Virtual Path Identifier (VPI)	8 bits →user-network interface 12 bits → network2network interface.	constitutes a routing field for the network.
Virtual Channel Identifier (VCI)	8 bits all	routing to and from the end user.

ATM protocol architecture (cont,..)

Field	interface	details
Payload Type (PT)	3 bits all	Bit1: type of information in the information field (0=user information). Bit2: congestion has been experienced Bit3: types of ATM SDUs (Service Data Unit)
cell loss priority (CLP)	1 bit all	0 cell is a relatively higher priority, 1 cell may ne discard within the network. So it provides guidance to the network in the event of congestion
Header Error Control (HEC)	8 bits all	used for both error control and synchronization

ATM protocol architecture (cont,..)

Generic Flow Control

- GFC used to control traffic flow at user to network interface (UNI) to solve short term overload.
- two sets of procedures are used:
  - uncontrolled transmission
  - controlled transmission.
- every connection is identified as either subject to flow control or not.
- there may be one group of controlled connections say(Group A) that is the default [one-queue model],
- or controlled traffic may be classified into two groups of controlled connections say (Group A and Group B); [two-queues model]

ATM protocol architecture (cont,..)

GFC - Single Group of Connections [one queue model]

- The controlled equipment (terminal equipment - TE), initializes some variables:
  - TRANSMIT is a flag initialized to SET (1),
  - GO_CNTR, which is a credit counter, is initialized to 0.
  - GO_VALUE, is either initialized to 1 or set to some larger value at configuration time.
- And two signals HALT,& SET

ATM protocol architecture (cont,..)

1. If TRANSMIT = 1, cells on uncontrolled connections may be sent at any time.

If TRANSMIT = 0, no cells may be sent on either controlled or uncontrolled connections.

2. If a HALT signal is received from the controlling equipment, →TRANSMIT is set to 0

   remains at zero until a NO_HALT signal is received, then →TRANSMIT is set to 1.

ATM protocol architecture (cont,..)

3. If TRANSMIT = 1 and there is no cell to transmit on any uncontrolled connections, then

   —If GO_CNTR > 0, then the TE may send a cell on a controlled connection.

      The TE marks that cell as a cell on a controlled connection and decrements GO_CNTR.

   —If GO_CNTR = 0, then the TE may not send a cell on a controlled connection.

4. The TE sets GO_CNTR to GO_VALUE upon receiving a SET signal; a null signal has no effect on GO_CNTR

ATM protocol architecture (cont,..)

Why using HALT signal?

- to limit the effective ATM data rate and should be cyclic.
- For example, to reduce the data rate over a link by half, the HALT command is issued by the controlling equipment so as to be in effect 50% of the time.
- This is done in a predictable, regular pattern over the lifetime of the physical connection.

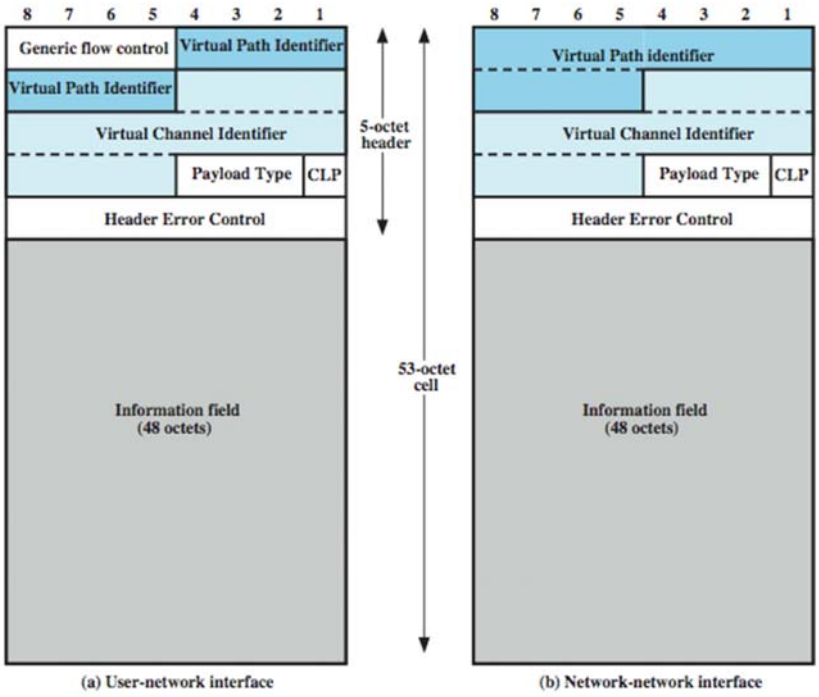
ATM protocol architecture (cont,..)

GFC – two Group of Connections [Two queues model]

- For the two-queue model, there are two counters, each with a current counter value and an initialization value:
  - GO_CNTR_A,
  - GO_VALUE_A,
  - GO_CNTR_B,
  - GO_VALUE_B.
- This enables the network to control two separate groups of connections.

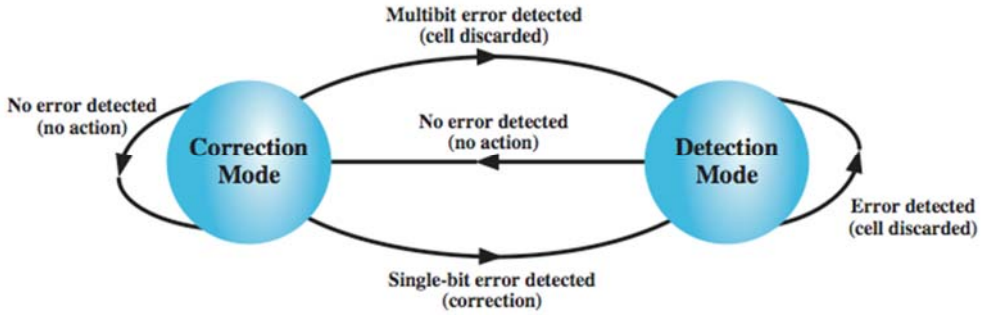
Header error control

- ATM cell includes an 8-bit HEC field that is calculated based on the remaining 32 bits of the header.



Header error control (cont,..)

- The polynomial used to generate the code is $X^8 + X^2 + X + 1$.
- The input is relatively short (32 bits) compared to HEC (8 bits) allows the code to be used for actual error correction.
- The sufficient redundancy in the code is used to recover from certain error patterns.



Header error control (cont,..)

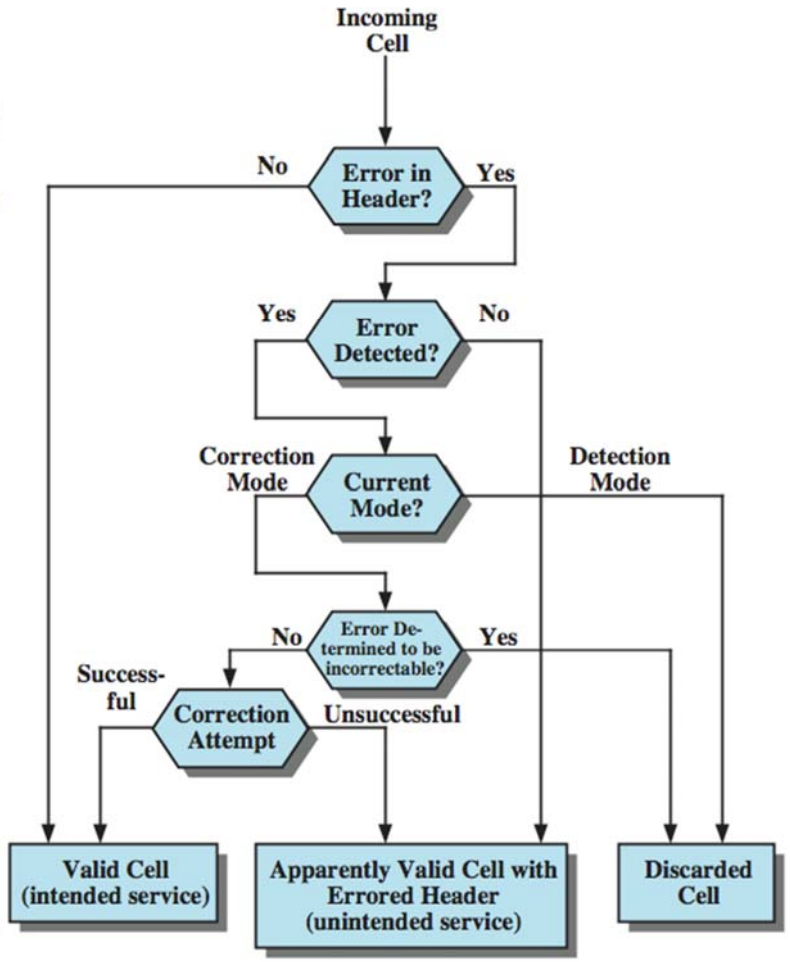
- At initialization, the receiver's error correction algorithm is in the default mode for single-bit error correction.
- As each cell is received, the HEC calculation and comparison is performed.
- As long as no errors are detected, the receiver remains in error correction mode.
- When an error is detected, the receiver will correct the error if it is a single-bit error or will detect that a multi bit error has occurred.
- In either case, the receiver now moves to detection mode.

Header error control (cont,..)

- In detection mode, no attempt is made to correct errors.
- The reason for this change is a recognition that a noise burst or other event might cause a sequence of errors, a condition for which the HEC is insufficient for error correction.
- The receiver remains in detection mode as long as errored cells are received.
- When a header is examined and found not to be in error, the receiver switches back to correction mode.

Header error cor

The whole story



Header error control (cont,..)

- The main function of Header Error Control is to provide
  - recovery from single-bit header errors
  - a low probability of the delivery of cells with errored headers under bursty error conditions.

Why?

- The error characteristics of fiber-based transmission systems are a mix of
  - single-bit errors
  - And a relatively large burst errors.

Header error control (cont,..)

Supported Data rate

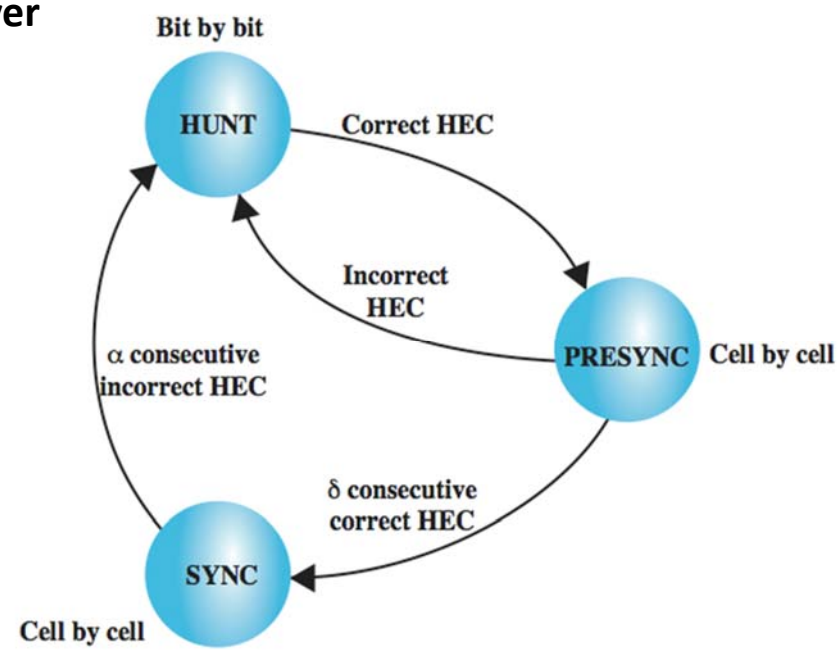
- 622.08Mbps
- 155.52Mbps
- 51.84Mbps
- 25.6Mbps

Data format based on physical layer approaches

- **Cell based physical layer**
- **SDH (**Synchronous Digital Hierarchy**) based physical layer**

Cell based physical layer (cot,..)

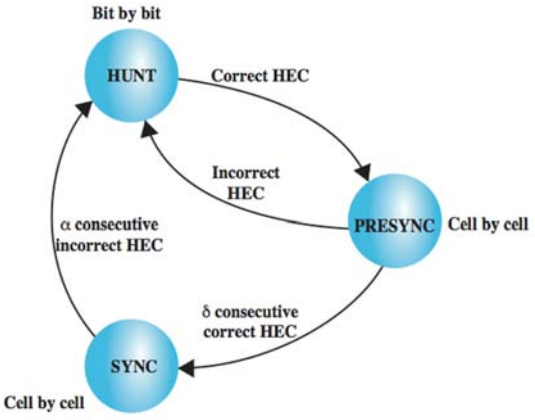
Synchronization mechanism (cell delineation algorithm**) in cell based physical layer**



Cell based physical layer (cot,..)

1. In the HUNT state,

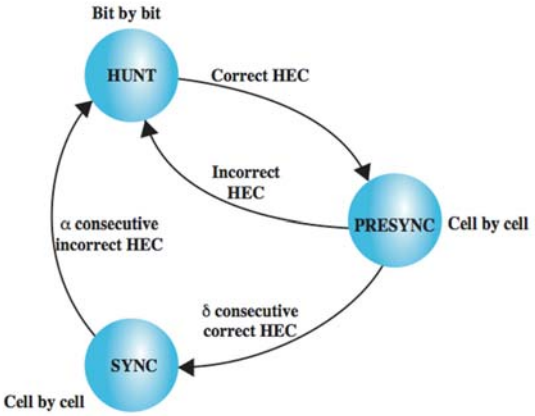
- a cell delineation algorithm is performed bit by bit to determine if the HEC coding law is observed (i.e., match between received HEC and calculated HEC).
- Once a match is achieved, it is assumed that one header has been found, and the method enters the PRESYNC state.



Cell based physical layer (cot,..)

2. In the PRESYNC state,

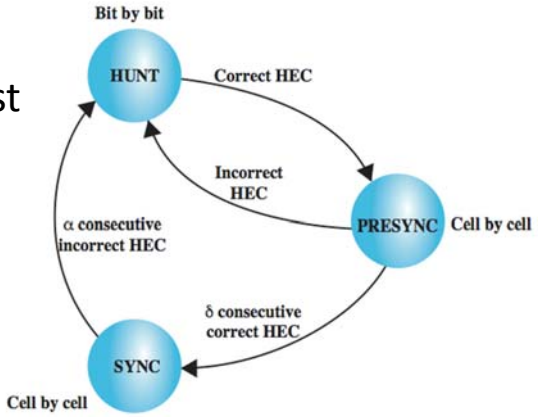
- a cell structure is now assumed.
- The cell delineation algorithm is performed cell by cell until the encoding law has been confirmed consecutively δ (delta) times.



Cell based physical layer (cot,..)

3. In the SYNC state,

- The HEC is used for error detection and correction .
- Cell delineation is assumed to be lost if the HEC coding law is recognized consecutively as incorrect α (Alpha) times.



Cell based physical layer (cot,..)

What is α and δ ?

- The values of α and δ are design parameters.
- Greater values of δ result in longer delays in establishing synchronization but in greater robustness against false delineation.
- Greater values of α result in longer delays in recognizing a misalignment but in greater robustness against false misalignment.

SDH (Synchronous Digital Hierarchy) Based Physical Layer

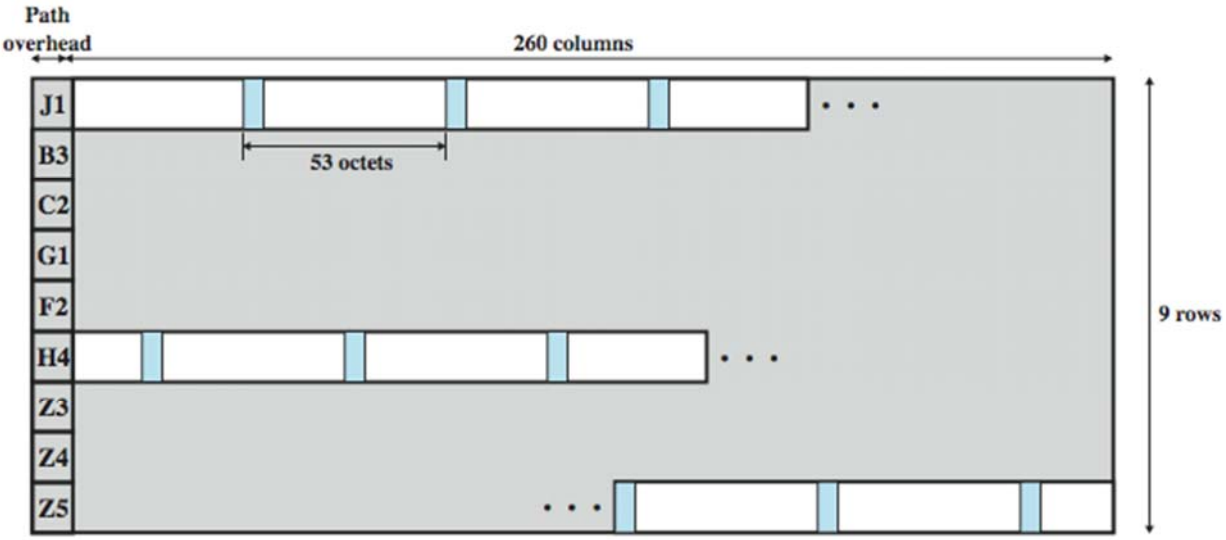
2.1. several ATM streams can be combined to build interfaces with higher bit rates than those supported by the ATM layer at a particular site.

- For example, four separate ATM streams, each with a bit rate of 155 Mbps (STM-1) (Synchronous Transport Module level-1), can be combined to build a 622-Mbps (STM-4) (Synchronous Transport Module level-4) interface.
- This arrangement may be more cost effective than one using a single 622-Mbps ATM stream

SDH Based Physical Layer (cont,..)

SDH frame format

STM-1 Payload (frame) for SDH-Based ATM Cell Transmission



SDH Based Physical Layer (cont,..)

- the payload consists of a 9-octet path overhead portion and the remainder, which contains ATM cells.
- Because the payload capacity (2340 octets) is not an integer multiple of the cell length (53 octets), a cell may cross a payload boundary.
- So payload may be offset from the beginning of the frame, as indicated by the pointer in the section overhead of the frame.
- The H4 octet in the path overhead is set at the sending side to indicate the next occurrence of a cell boundary.
- That is, the value in the H4 field indicates the number of octets to the first cell boundary following the H4 octet.
- The permissible range of values is 0 to 52.

ATM services categories

- An ATM network is designed to be able to transfer many different types of traffic simultaneously, including
  - real-time flows
  - voice,
  - video,
  - bursty TCP flows
- There are two types of services
  - Real time -
  - Non-real time –

ATM services categories (cont,..)

1. Real-Time Service:

- The most important distinction among applications concerns
  - the amount of delay
  - the variability of delay, referred to as jitter, that the application can tolerate.
- Real-time applications typically involve a flow of information to a user that is intended to reproduce that flow at a source.
- Variants include
  - Constant bit rate (CBR)
  - Real-time variable bit rate (rt-VBR)

ATM services categories (cont,..)

2. Non-Real-Time Service: are

- intended for applications that have bursty traffic characteristics and do not have tight constraints on delay and delay variation.
- Accordingly, the network has greater flexibility in handling such traffic flows and can make greater use of statistical multiplexing to increase network efficiency.
- Variants include:
  1. Non-real-time variable bit rate (nrt-VBR),
  2. Available bit rate (ABR),
  3. Unspecified bit rate (UBR), &
  4. Guaranteed frame rate (GFR)

1. Constant Bit Rate (CBR)

- Real-time applications like audio or video information

or any applications that involve interaction between people

  - have tight constraints on delay.
  - any delay above a few hundred milliseconds becomes noticeable and annoying.
  - need to be presented in a continuous, smooth fashion.
  - A lack of continuity or excessive loss results in significant loss of quality.

ATM services categories (cont,..)

- CBR is used for applications that require a
  - fixed data rate during the connection lifetime
  - relatively tight upper bound on transfer delay.
- CBR is commonly used for uncompressed audio and video information.
- Example of CBR applications include:
  - Videoconferencing
  - Interactive audio (e.g., telephony)
  - Audio/video distribution (e.g., television, distance learning, pay-per-view)
  - Audio/video retrieval (e.g., video-on-demand, audio library)

ATM services categories (cont,..)

2. Real-Time Variable Bit Rate (rt-VBR)

- Used for time-sensitive applications, that has tightly constrained delay and delay variation
- Main difference between CBR & rt-VBR, that rt-VBR applications transmit at a rate that varies with time, can be characterized as somewhat bursty streams
- Examples: an approach of video compression results in a sequence of image frames of varying sizes.
- Because real-time video requires a uniform frame transmission rate, the actual data rate varies.

ATM services categories (cont,..)

- The rt-VBR service allows the network more flexibility than CBR.
- The network is able to statistically multiplex a number of connections over the same dedicated capacity and still provide the required service to each connection.

ATM services categories (cont,..)

3. Non-Real-Time Variable Bit Rate (nrt-VBR)

- intended for applications that have bursty traffic characteristics and do not have tight constraints on delay and delay variation.
- nrt-VBR service can be used for data transfers that have critical response-time requirements.
- Examples include
  - airline reservations,
  - banking transactions, and
  - process monitoring.

ATM services categories (cont,..)

- With this service, the end system specifies
  - a peak cell rate,
  - a sustainable or average cell rate, and
  - a measure of how bursty or clumped the cells may be.
- With this information, the network can allocate resources to provide relatively low delay and minimal cell loss.
- the network has greater flexibility in handling such traffic flows and can make greater use of statistical multiplexing to increase network efficiency.

ATM services categories (cont,..)

4. Unspecified Bit Rate (UBR)

- This service is suitable for applications that can tolerate variable delays and some cell losses, which is typically true of TCP-based traffic.
- Cells are forwarded on a first-in-first-out (FIFO) basis using the capacity not consumed by other services; both delays and variable losses are possible.

best-effort service

- No initial commitment is made to a UBR source and no feedback concerning congestion is provided;

Applications :

Text/data/image transfer, messaging, distribution, retrieval; or

- Remote terminal (e.g., telecommuting).

ATM services categories (cont,..)

- At any given time, ATM network capacity is shared between:-
  - CBR services
  - Plus two types of VBR services (real time& non real time).
- Additional capacity is available for one or both of the following reasons:
  1. Not all of the total resources have been committed to CBR and VBR traffic,
  2. the bursty nature of VBR traffic means that at some times less than the committed capacity is being used.
- The rest capacity can be assigned for UBR

ATM services categories (cont,..)

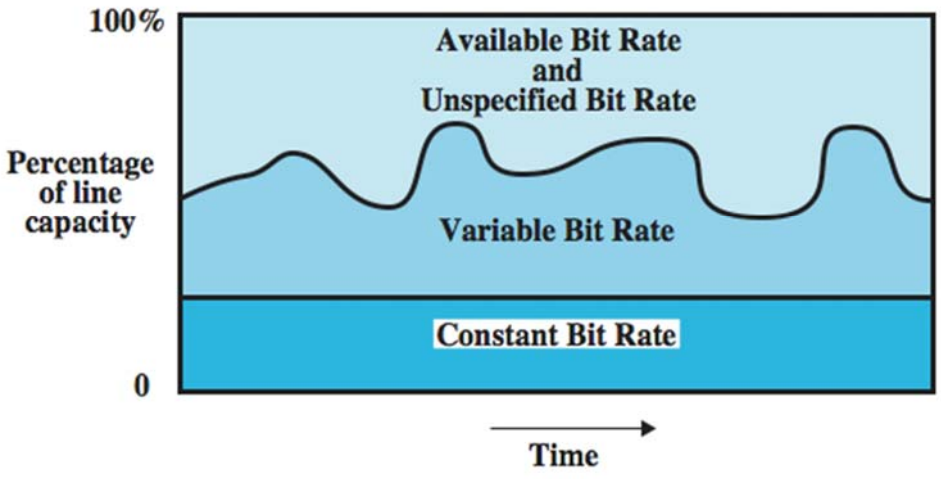
5. Available Bit Rate (ABR)

- Bursty applications that use a reliable end-to-end protocol such as TCP can detect congestion in a network by means of increased round-trip delays and packet discarding.
- TCP has no mechanism for fairly sharing of network resources among various TCP connections.
- Further, TCP does not minimize congestion as efficiently as is possible using explicit information from congested nodes within the network.
- To improve the service provided to bursty sources that would otherwise use UBR, the ABR service has been defined.

ATM services categories (cont,..)

- application specifies
  - peak cell rate (PCR)
  - minimum cell rate (MCR)
- resources allocated to give at least MCR
- spare capacity fairly shared among all ARB sources
- The ABR mechanism uses explicit feedback to sources to assure that capacity is fairly allocated.
- Any capacity not used by ABR sources remains available for UBR traffic.
- example of an application using ABR is LAN interconnection.
- In this case, the end systems attached to the ATM network are routers.

ATM Bit Rate Services



Thanks,…