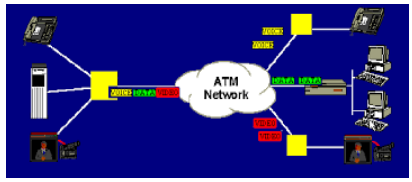
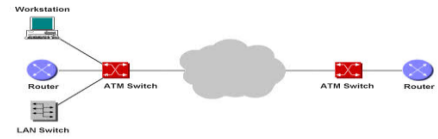
## Asynchronous Transfer Mode (ATM)




## ATM

- Technology for broadband ISDN
- Suitable for wide range of applications
- Originally defined for WANS
  - —Now used with MANs and LANs

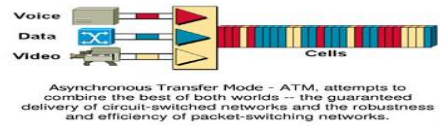



## Essential features:-

- **Fixed length cells**
  - 5 octet header
  - 48 octet payload/information field
- **Virtual path connection**
  - header carries VC id
    - Virtual path identifer
    - virtual circuit identifier
    - (vpi/vci)
- **No flow control in network**
- **error control for header in network**
- **error control for payload in end points**

## Essential features:- (Cont:)

- 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

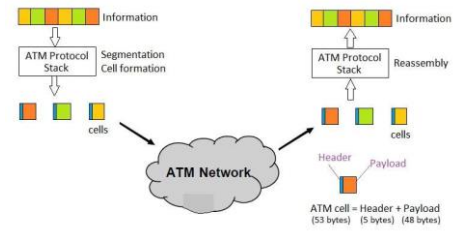



Asynchronous Transfer Mode - ATM, attempts to combine the best of both worlds -- the guaranteed delivery of circuit-switched networks and the robustness and efficiency of packet-switching networks.

## Protocol Architecture

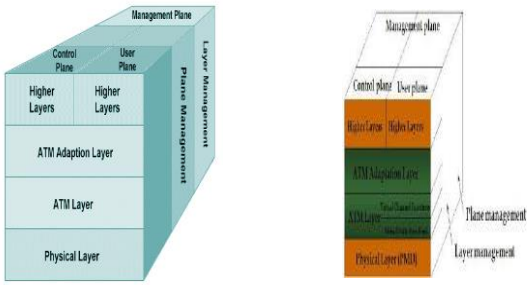
- Similarities between ATM and packet switching
  - —Transfer of data in discrete chunks
  - —Multiple logical connections over single physical interface
- In ATM flow on each logical connection is in fixed sized packets called cells
- Minimal error and flow control
  - —Reduced overhead
- Data rates (physical layer) 25.6Mbps to 622.08Mbps
- 34Mbps & 2Mbps also offered

## Protocol Architecture



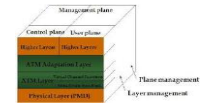
## Protocol Architecture (diag)

The ATM Protocol Stack at the User-Network Interface



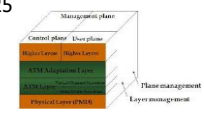

## Reference Model Planes

- 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

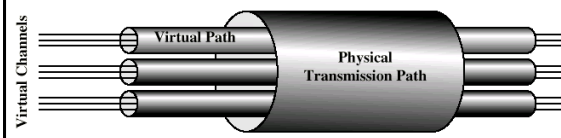



## ATM Logical Connections

- Virtual channel connections (VCC)
- Analogous to virtual circuit in X.25
- Basic unit of switching
- Between two end users
- Full duplex
- Fixed size cells
- Data, user-network exchange (control) and
- Network-network exchange (network management and routing)
- Virtual path connection (VPC)
  - —Bundle of VCC with same end points



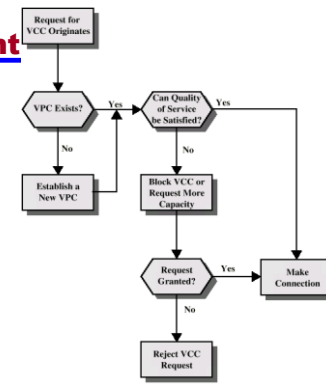

## ATM Connection Relationships

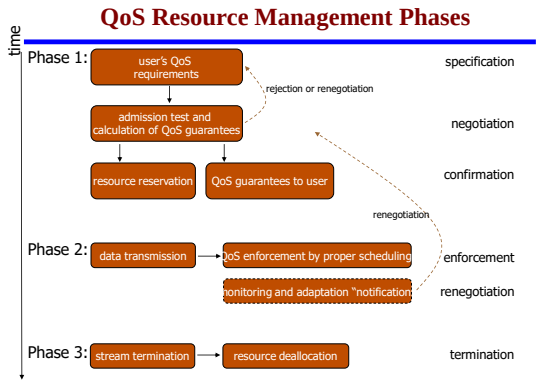



## Advantages of Virtual Paths

- 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 (QoS)
- Switched and semi-permanent channel connections
- Call sequence integrity
- Traffic parameter negotiation and usage monitoring
- VPC only
  - —Virtual channel identifier restriction within VPC

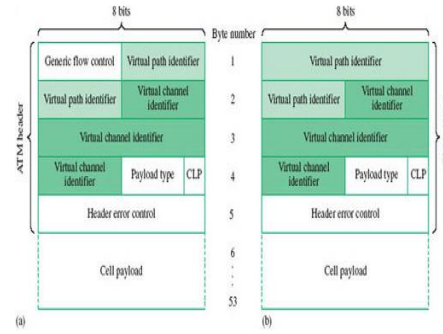
## Control Signaling - VCC

- Done on separate connection
- Semi-permanent VCC
- Meta-signaling channel
  - —Used as permanent control signal channel
- User to network signaling virtual channel
  - —For control signaling
  - —Used to set up VCCs to carry user data
- User to user signaling virtual channel
  - —Within pre-established VPC
  - —Used by two end users without network intervention to establish and release user to user VCC

## Control Signaling - VPC

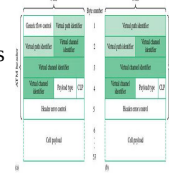
- Semi-permanent
- Customer controlled
- Network controlled

## ATM Cell Format



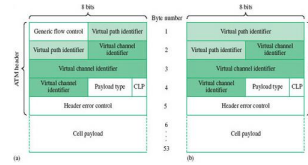
## ATM Cell Header Format

- Generic flow control (GFC) – 4 bits, used only in user-network interface
  - —Used to alleviate short-term overload conditions in network
- Virtual path identifier (VPI) – 8 bits at the user-network interface, 12 bits at network-network interface
  - —Routing field
- Virtual channel identifier (VCI) – 8 bits
  - —Used for routing to and from end user



## ATM Cell Header Format

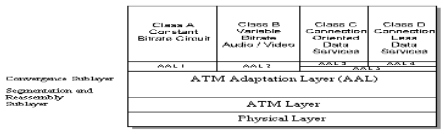
- Payload type (PT) – 3 bits
  - —Indicates type of information in information field
- Cell loss priority (CLP) – 1 bit
  - —Provides guidance to network in the event of congestion
- Header error control (HEC) – 8 bit
  - —Error code



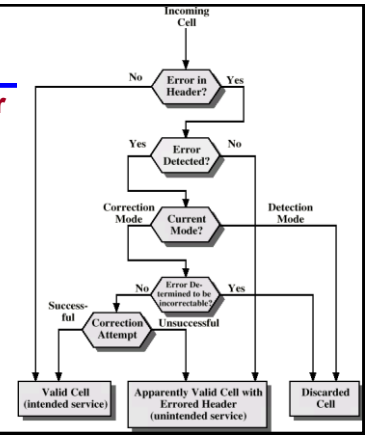
## Reference Model Planes

| OSI layer | ATM layer | ATM sublayer | Functionality |
|---|---|---|---|
| 3/4 | AAL | CS | Providing the standard interface (convergence) |
| | | SAR | Segmentation and reassembly |
| 3/2 | ATM | | Flow control<br>Cell header generation/extraction<br>Virtual circuit/path management<br>Cell multiplexing/demultiplexing |
| 2 | | TC | Cell rate decoupling<br>Header checksum generation and verification<br>Cell generation<br>Packing/unpacking cells from the enclosing envelope<br>Frame generation |
| 1 | Physical | PMD | Bit timing<br>Physical network access |

The ATM layers and sublayers and their functions.

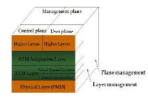



## Effect of Error in Cell Header

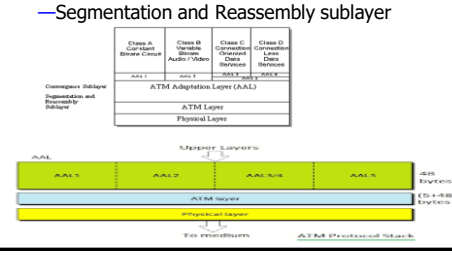



## ATM Adaptation Layer

- Function is to *adapt* higher layer application characteristics to bearer service (ATM 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

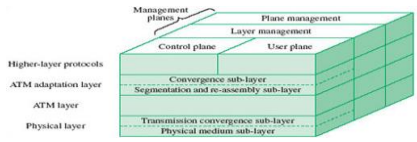


- ATM Adaptation Layer (AAL)
- Two Sublayers
  - —Convergence sublayer
  - —Segmentation and Reassembly sublayer

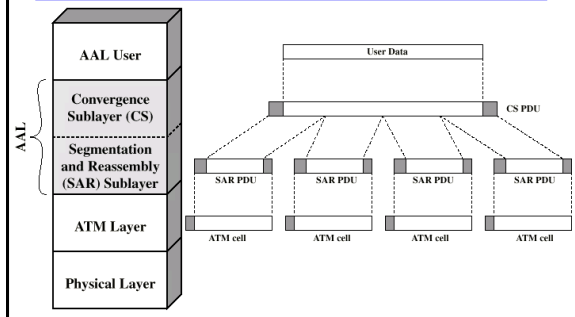


## Adaptation Layer Services

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

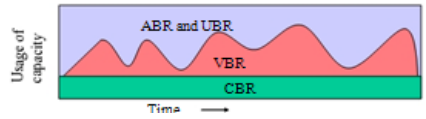



## AAL Protocols




## ATM Services at the ATM Layer

Constant Bit Rate (CBR)
Real-time Variable Bit Rate (rt-VBR)
Non-real-time Variable Bit Rate (nrt-VBR)
Available Bit Rate (ABR)
Unspecified Bit Rate (UBR)
Guaranteed Frame Rate (GFR)




## Examples of CBR Applications

- Videoconferencing
- Interactive audio (e.g., telephony)
- Audio/video distribution (e.g., television, distance learning)
- Audio/video retrieval (e.g., video-on-demand, audio library)
- guarantees a fixed capacity, similar to circuit switching.
- guarantees a maximum delay for cells

## Examples of Available Bit Rate (ABR)

- guarantees 'fairness" with respect to other traffic •
- guarantees an average throughput and maximum delay•

## Examples of UBR applications

- Text/data/image transfer, messaging, distribution, retrieval
- Remote terminal (e.g., telecommuting)
- service is on a "best effort" basis •

## Examples of Guarantees Frame Rate (GFR)

- Throughput guarantee for multiple cell frames

Guaranteed frame rates ensure smooth video images, a prerequisite of producers.

## 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)
  - —Guaranteed frame rate (GFR)

## rt-VBR

- 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-VBR

- 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

## UBR

- 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

## 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
- e.g. LAN interconnection

## Guaranteed Frame Rate (GFR)

- Designed to support IP backbone subnetworks
- Better service than UBR for frame based traffic
  - —Including IP and Ethernet
- Optimize handling of frame based traffic passing from LAN through router to ATM backbone
  - —Used by enterprise, carrier and ISP networks
  - —Consolidation and extension of IP over WAN
- ABR difficult to implement between routers over ATM network
- GFR better alternative for traffic originating on Ethernet
  - —Network aware of frame/packet boundaries
  - —When congested, all cells from frame discarded
  - —Guaranteed minimum capacity
  - —Additional frames carried of not congested

## AAL Protocols

- Convergence sublayer (CS)
  - —Support for specific applications
  - —AAL user attaches at Service Access Point (SAP)
- Segmentation and re-assembly sublayer (SAR)
  - —Packages and unpacks info received from CS into cells
- Four types
  - —Type 1
  - —Type 2
  - —Type 3/4
  - —Type 5

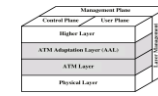
## Classes of Service

- The Convergence Sublayer (CS) interprets the type and format of incoming information based on 1 of 4 classes of service assigned by the application
- Class A: Constant bit rate (CBR), Connection oriented, strict timing relationship between source and destination, i.e voice
- Class B: Variable bit rate (VBR), Connection oriented, strict timing, e.g. packet-mode video for video conferencing
- Class C: Connection oriented VBR, not strict timing, e.g. LAN
- data transfer applications such as Frame Relay
- Class D: Connectionless VBR, not strict timing, e.g. LAN data
- transfer applications such as IP

## ATM Adaptation Layer (AAL)

**Segmentation and Reassembly (SAR) sublayer**

- **AAL Type 1**
- CBR source
- SAR packs and unpacks bits
- Block accompanied by sequence number

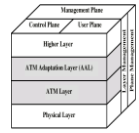



- **Carries Class A Services**
  - —e.g. CBR packetised voice (traditional circuit switched)
  - —48 octet payload

## ATM Adaptation Layer (AAL)

**Segmentation and Reassembly (SAR) sublayer**

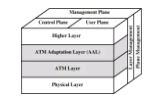
- **AAL - Type 2**
- VBR
- Analog applications




- **Carries Class B Services**
  - —Not fully developed yet, but some characteristics are:-
    - Transfer of Service Data Units with variable source bit rate
    - Transfer of timing information

## ATM Adaptation Layer (AAL)

**Segmentation and Reassembly (SAR) sublayer**




- **AAL - Type 3/4**
- Connectionless or connected
- Message mode or stream mode
- **Carries Class C&D Services**
  - —Can operate in message or stream mode
  - —Message mode entire message carried in one CS-PDU
  - —Stream mode involves many CS-PDUs.

## ATM Adaptation Layer (AAL)

**Segmentation and Reassembly (SAR) sublayer**

- **AAL - Type 5**
- Streamlined transport for connection oriented higher layer protocols
- Carries Class C & D Services
  - —Designed for same class of traffic as AAL3/4
  - —Simpler, less overhead
  - —SAR-PDU for instance has no header / trailer
  - —Essentially CS-PDU is segmented and segments mapped to ATM payload

## ATM Concepts: Service Categories

- ABR (Available bit rate):
  - —Source follows network feedback.
  - —Max throughput with minimum loss.
- UBR (Unspecified bit rate):
  - —User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate.
  - —Throughput, delay and delay variation guaranteed.
- VBR (Variable bit rate): Declare avg and max rate.
  - —rt-VBR (Real-time): Conferencing.
    - Max delay guaranteed.
  - —nrt-VBR (non-real time): Stored video.

## Real Time Services

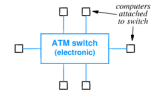
- Amount of delay
- Variation of delay (jitter)

### CBR

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

## *Asynchronous Transfer Mode* ATM - Star network

- *Asynchronous Transfer Mode* technology consists of electronic packet switches to which computers can connect .
- ATM switches form *hub* into which computers connect in a *star* topology .
- Computers get point-to-point connections - data from transmitter is routed directly through hub switches to destination

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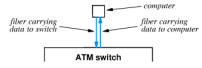
## ATM details

- Transmits data at over 100Mbps
- Uses fiber optics to connect computer to switch
- Each connection includes two fibers

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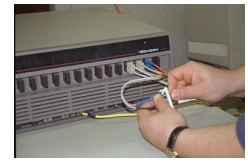
## ATM switches



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