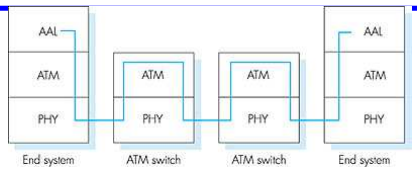
## Asynchronous Transfer Mode (ATM)

## Asynchronous Transfer Mode: ATM

- **1990's/00 standard for high-speed** (155Mbps to 622 Mbps and higher) *Broadband Integrated Service Digital Network* architecture
- Goal: *integrated, end-end transport of carry voice, video, data*
  - meeting timing/QoS requirements of voice, video (versus Internet best-effort model)
  - "next generation" telephony: technical roots in telephone world
  - packet-switching (fixed length packets, called "cells") using virtual circuits

## ATM architecture

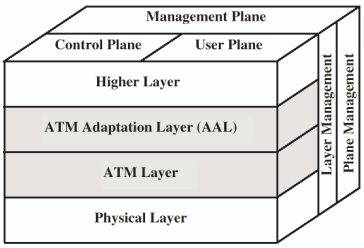



- adaptation layer: only at edge of ATM network
  - data segmentation/reassembly
  - roughly analogous to Internet transport layer
- ATM layer: "network" layer
  - cell switching, routing
- physical layer

## 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

## Protocol Architecture (diag)



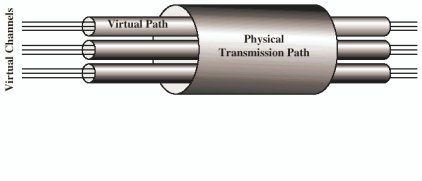

## Reference Model Planes

- 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 Logical Connections

- Virtual channel connections (VCC)
- 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

## 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

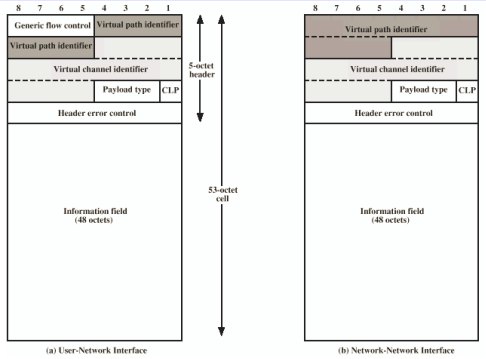
## Control Signaling - VCC

- 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

## 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




## Header Format

- Generic flow control
  - Only at user to network interface
  - Controls flow only at this point
- Virtual path identifier
- Virtual channel identifier
- Payload type
  - e.g. user info or network management
- Cell loss priority
- Header error control

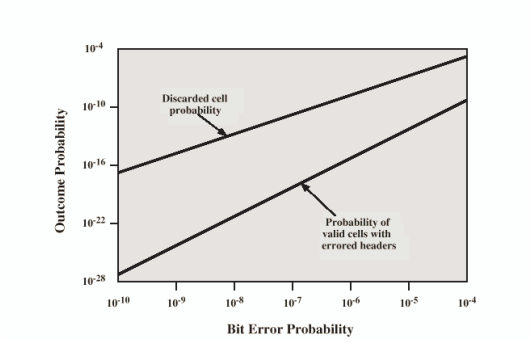
## Generic Flow Control (GFC)

- Control traffic flow at user to network interface (UNI) to alleviate short term overload
- Two sets of procedures
  - Uncontrolled transmission
  - Controlled transmission
- Every connection either subject to flow control or not
- Subject to flow control
  - May be one group (A) default
  - May be two groups (A and B)
- Flow control is from subscriber to network
  - Controlled by network side

## Header Error Control

- 8 bit error control field
- Calculated on remaining 32 bits of header
- Allows some error correction

## 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

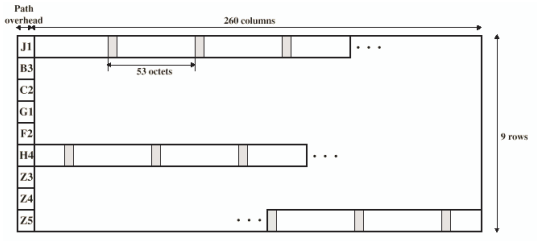
## Cell Based Physical Layer

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

## SDH Based Physical Layer

- Imposes structure on ATM stream
- e.g. 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
  - 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)

## CBR

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

## 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

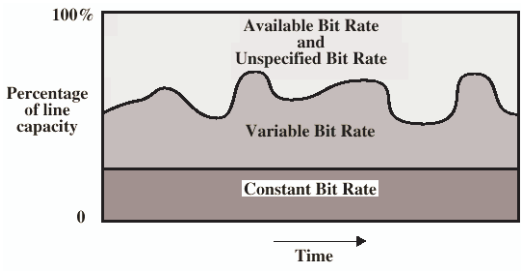
## UBR

- 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 ARB sources
- e.g. LAN interconnection

## ATM Bit Rate Services




## 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

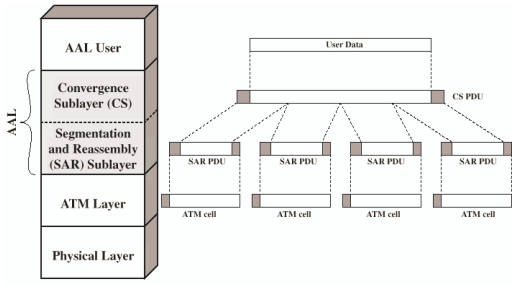
## Supported Application types

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

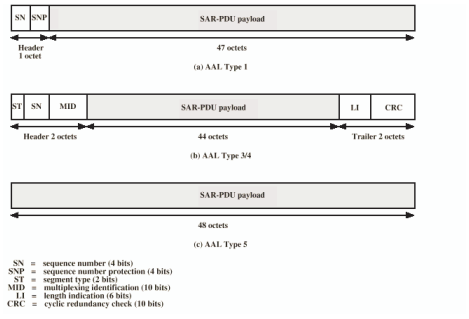
## AAL Protocols

- Convergence sublayer (CS)
  - Support for specific applications
  - AAL user attaches at 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

## AAL Protocols




## Segmentation and Reassembly PDU



## AAL Type 1

- 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

## User Data Transfer

- One frame type
  - User data
  - No control frame
- No inband signaling
- No sequence numbers
  - No flow nor error control

## ATM: network or link layer?

Vision: end-to-end transport: "ATM from desktop to desktop"
- ATM *is* a network technology

Reality: used to connect IP backbone routers
- "IP over ATM"
- ATM as switched link layer, connecting IP routers