ATM

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Recap

- Traffic characterization
- Switching techniques
- Internetworking

This lecture

- ATM
- Features
- Services
- Protocol
- ATM switching

ATM

- Asynchronous Transfer Mode
- To carry ISDN traffic

Basic Features

- Connection-oriented network service using virtual circuits. Virtual circuits are referred to as virtual channels and have associated virtual channel identifer (VCI)
- Constant length packets of 53 bytes called cells
  - » 5-byte header, 48-byte payload

Basic Features

- Cells delivered in order but with possible cell loss
- Statistical multiplexing of cells from VC's sharing a link
- Switches may discriminate among cells belonging to different VC's to provide different QoS

Virtual Path

- The concept introduced only in ATM.
- It bundles a number of VCs that have the same end point.
- It is developed in response to the high control cost of high-speed networks.
  - Control of same Vc all at once

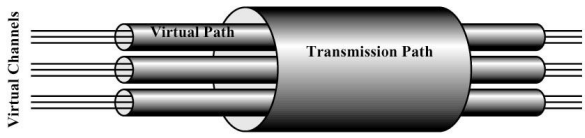


Figure 4.2 ATM Connection Relationships

Virtual Path Advantages

- Simplified network architecture
- Increased network performance and reliability
- Reduced processing and short connection setup time
- Enhanced network services

Fixed cell size

- Advantages of fixed cell size
  - » expedites switching
  - » allows cell boundaries to be determined implicitly--i.e., without delimiters
    - last byte of 5-byte header is header error control (HEC) field
    - by shifting 1-bit at a time until find a 5-byte segment where last byte checks first 4 bytes, cell boundary can be determined

Fixed cell size

- once cell boundary is found, future cell boundaries can be determined by counting 53 bytes
- if CRC appears wrong for several consecutive cells, then resynchronization is probably required

Why short cell length?

- Short cell length has disadvantage of large overhead (9.4%)
- Short cell length chosen to reduce packetization delay for real-time voice
  - » Transmission time per switch (assuming 155 Mbps) is about 3 ms. If 10 switches in path, total is 30 ms, which is negligible
  - » Propagation delay for 1000 km path is about (1000 km)(5 ms/km) = 5000 ms

QoS and Traffic Parameters

- Network and user negotiate 'contract'
  - » network agrees to provide specified QoS (delay, loss, rate, etc.) provided user traffic conforms to specifications (bit rate, burstiness, etc.)

User Traffic Parameters

- Peak cell rate (PCR)
  - » reciprocal of minimum time between consecutive cells
- Sustained cell rate (SCR)
  - » long-term average cell rate
- Cell delay variation tolerance (CDVT)
  - » measures permissible departure from periodicity

User Traffic Parameters (cont.)

- Burst tolerance (BT)
  - » maximum number of cells in burst of back-to-back cells
- Meaning of CDVT and BT made precise via Generalized Cell Rate Algorithm (GCRA)

QoS Parameters

- Cell loss ratio (CLR)
  - » long-term proportion of cells that are lost
- Maximum cell transfer delay (Max CTD)
- Mean cell transfer delay (Mean CTD)
- Cell delay variation (CDV)
  - » refers to output stream while CDVT refers to input

QoS Parameters (cont.)

- Minimum cell rate (MCR)
  - » reciprocal of maximum time between consecutive cells

Categories of service

- Constant bit rate (CBR)
  - » essentially periodic stream of cells with some acceptable jitter
  - » telephony, real-time audio/video streams
  - » contract specifies CLR, CDV, Max CTD, PCR, CDVT
  - » regulated at source (open loop)

Categories of service (cont.)

- Variable bit rate-real time (VBR-RT)
  - » bursty traffic with real-time constraints
  - » compressed video (e.g., MPEG2)
  - » contract specifies CLR, CDV, Max CTD, PCR, CDVT, SCR, BT
  - » regulated at source (open loop)

Categories of service (cont.)

- Variable bit rate-nonreal time (VBR-NRT)
  - » bursty traffic without real-time constraints
  - » multimedia email
  - » contract specifies CLR, Mean CTD, PCR, CDVT, SCR, BT
  - » regulated at source (open loop)

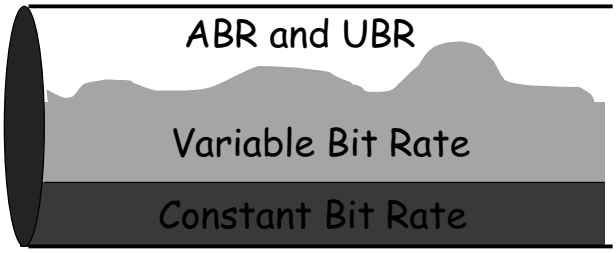
Categories of service (cont.)

- Available bit rate (ABR)
  - » bursty traffic whose bandwidth is approximately known
  - » contract specifies CLR, PCR, CDVT, MCR
  - » network guarantees to accept traffic at MCR; additional traffic may be accepted based on feedback information
  - » Regulated by source and destination (closed loop)

Categories of service (cont.)

- Unspecified bit rate (UBR)
  - » best effort service; no QoS is guaranteed
    - contract specifies only PCR, CDVT
  - » application: transporting IP packets

ATM Bit Rate Services

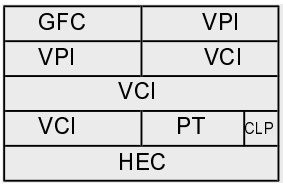


B-ISDN Service Classes

Service Class	Timing Relation	Bit Rate	Connection Mode	Examples
Class A	Required	Constant	Connection Oriented	CBR-Video
Class B	Required	Variable	Connection Oriented	VBR-Video
Class C	Not required	Variable	Connection Oriented	Data
Class D	Not required	Variable	Connectionless	Data

ATM Header Structure

- » At user-network interface
- » GFC=generic flow control
- » VPI=virtual path identifier
- » VCI=virtual channel iden.
- » PT=payload type
- » CLP=cell loss priority
- » HEC=header error control
- » NNI similar to UNI but GFC replaced by 4 extra bits for VPI



Header structure (cont.)

- GFC may be used by network to signal to user of need for (temporary) changes in instantaneous cell stream rate
- VCI is equivalent to virtual circuit number
  - » local to link
- VPI: virtual channels with same VPI form group
  - » routed and switched together
    - speeds up processing since switching is based on shorter VPI (as opposed to VCI)

Header structure (cont.)

» BW and buffer allocations for VP can be fixed at time of service subscription. During operation, fixed resources for VPI can be allocated to various VCI's
  - functions like private network

- PT permits network to distinguish between data cells and control cells

Header structure (cont.)

- CLP indicates whether cell is discard-eligible (CLP=1)
  » may be specified by user or assigned by network if negotiated traffic rate exceeded

Header structure (cont.)

- HEC
  - » equivalent to CRC code
  - » can correct single bit errors and detect multiple bit errors
  - » error control algorithm has two states: correction (C) and detection (D)
    - error in cell causes transition from C to D. If single bit, error corrected; if multiple bit, cell discarded
    - when in D, cells with detected errors (even if single bit) are discarded. A correct cell causes transition back to C

ATM Protocol Architecture

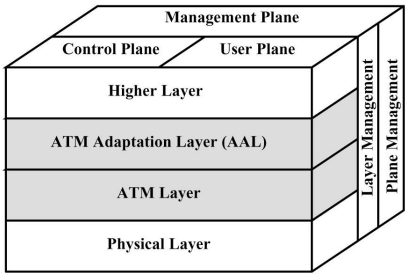
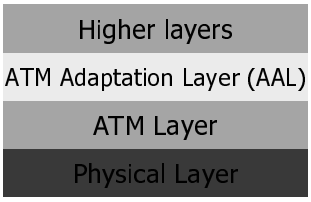


Figure 4.1 ATM Protocol Architecture

ATM Protocol Architecture



ATM Layer

- Cell header generation and extraction
- Cell multiplex and demultiplex
- VPI and VCI translation and switching
- Generic flow control

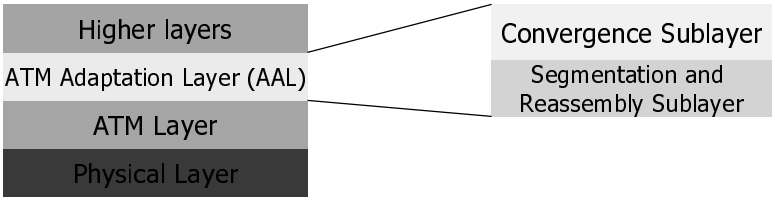
ATM Adaptation Layer

- End-to-end layer above ATM layer
  - » unlike true transport layer (e.g., TCP), does not guarantee reliable end-to-end transport
    - – some AAL protocols support error detection, but not retransmissions.

ATM Adaptation Layer (Cont.)

- Several distinct sets of AAL protocols. Each is designed for particular type of application.
  - » AAL 1: for CBR traffic
  - » AAL 2: for VBR-RT traffic
  - » AAL 3/4: for NRT traffic, either stream or message
  - » AAL 5: for NRT message traffic

ATM Protocol Architecture



Convergence Sublayer (CS)

- upper sublayer of AAL
- purpose is to interface with application
- consists of a application specific part and common part
  - common part is same for all applications using the particular type of AAL
- generates packets in standardized format (CS-PDU's) which are passed to SAR sublayer
  - packets may contain CS overhead

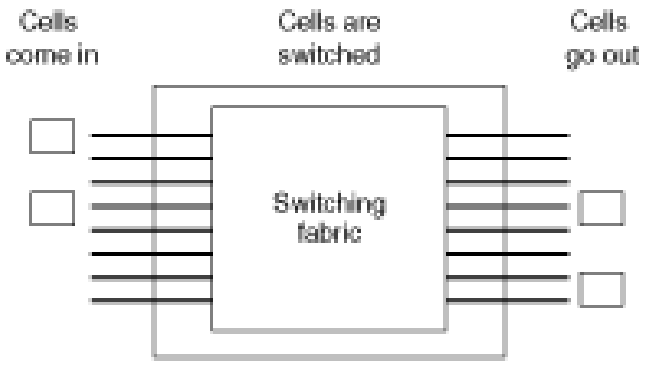
Segmentation and reassembly (SAR) sublayer

- » at source, segments CS-PDU's and adds overhead to form 48-byte cells that are passed to ATM layer
- » at destination, reassembles CS-PDU's which are passed to CS-sublayer.

AAL Services

Service Class	Class A	Class B	Class C	Class D
Timing Relation	Required		Not required	
Bit Rate	Constant		Variable	
Connection Type	Connection Oriented			Connectionless
AAL Type	1	2	3	4
Examples	Circuit emulation, CBR audio/video	VBR audio/video	FTP	UDP

Generic ATM Switch

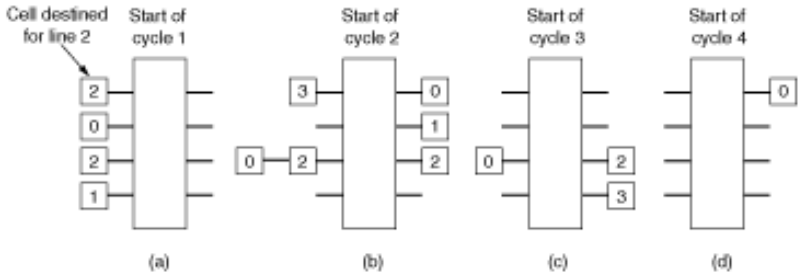


ATM Switching

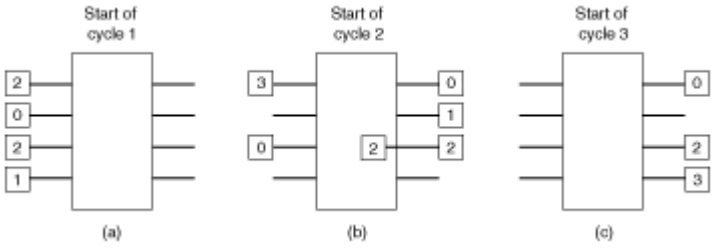
- Cells get switched in a synchronous fashion.
- During one cell time:
  - » a cell is taken from an input port
  - » a cell is witched inside the fabric
  - » a cell is served on the output port

Input Queuing

- Head-of-line blocking.



Output Queuing



Homework #1

- Using MATLAB, build an ATM switch as described earlier. The switch should do input queuing, output queuing or both.
  - Start with a single queue
  - Build a 2x2 switch
  - Build an NxN switch
- Deadline is Saturday Feb 24, 2001.