Label Switching Optimization

- Remember:
  - VPI: Particular VP
  - VCI: Particular VC within the chosen VP
- A lot of computing power spent in the switches to find the output line from the VPI/VCI *for each cell*
- Route only on the VPI field and not on the VCI field
  - Except at the final hop (switch – host)
  - So, between two switches only the virtual path information is used
- The VPI/VCI example we have seen applies here as well, but only the VPI is used

Label Switching Optimization Advantages

- Once a VP is established from a source to a destination all other VCs along that path can just follow the existing path

- No new routing decisions

- Routing of individual cells becomes easier:

- Instead of looking at a 24-bit number (VPI/VCI), simply look at a 8-bit number (VPI)

  * Indexing into a table of 2^8 instead of indexing into a table of 2^24

- Rerouting requires less operations:

- Basing routing on VPs makes it easier to change entire groups of VCs with a single operation

- ATM VPNs (virtual private networks):

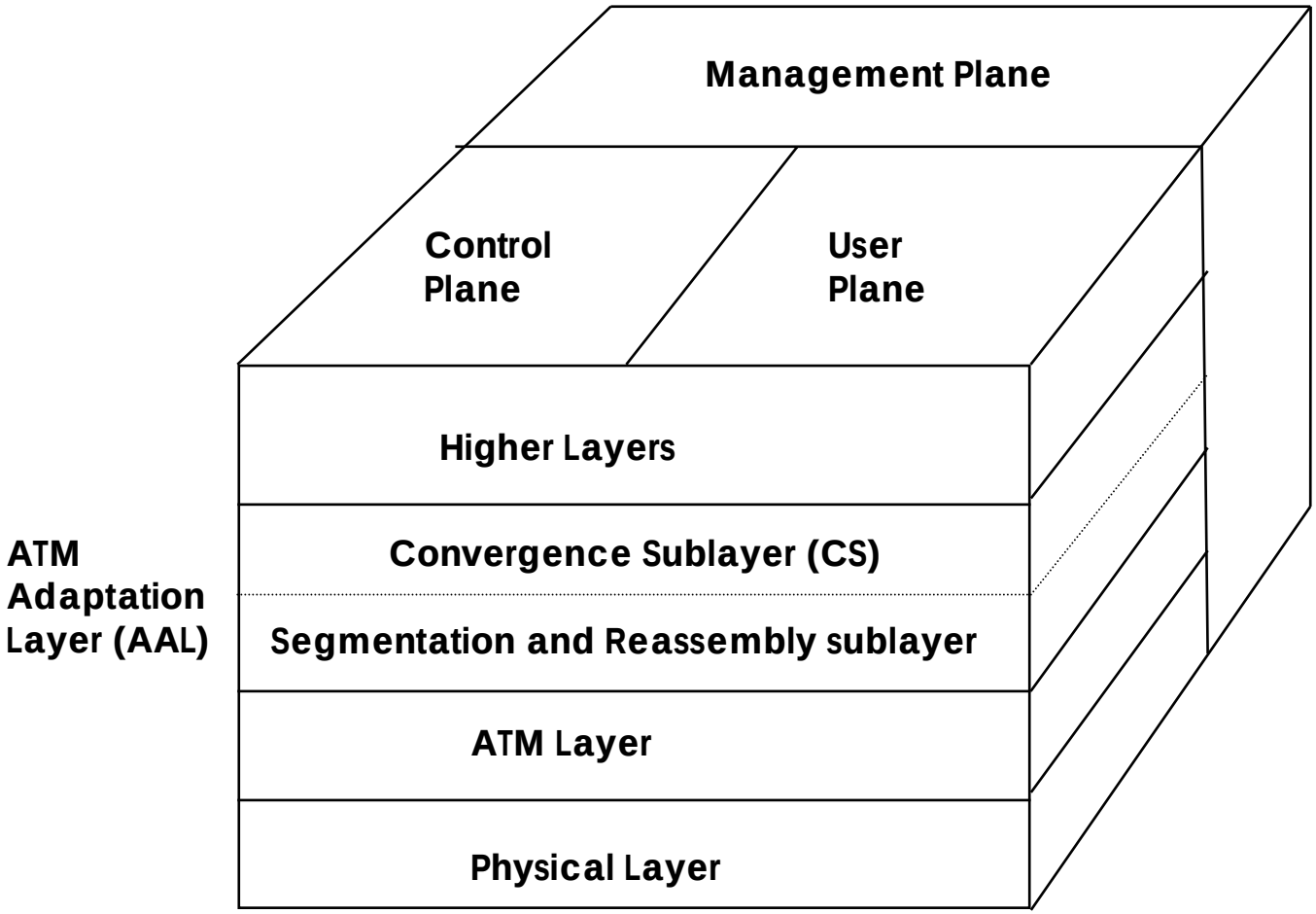
- A carrier can setup permanent virtual paths connecting a customer's locations

- VCs within these VPs can be setup later on demand

- No calls from outside can use these VPs and come in the ATM VPN

- No calls from inside can leave it (except via specially configured gateways)

B-ISDN/ATM: Reference Model (1/3)



B-ISDN/ATM Reference Model (2/3)

- Different from OSI and TCP/IP
- Physical layer: Deals with the physical medium (voltages, bit timing, etc.)

- ATM cells may be packaged in the payload of other carrier systems (i.e. physical layer independency)

- ATM layer:

- Cell layout
- Cell header extraction/generation
- Cell transport
- Establishment and release of VCPs (switched or permanent)

- ATM adaptation layer (AAL): Higher interface to the ATM layer for convenience

- Allows sending/receiving of packets larger than ATM cells
- *Convergence Sublayer (CS):* Provides different services for ATM networks build for different purposes
  * E.g.: File transfer and video on demand have different requirements from error handling, timing, etc.
- *Segmentation And Reassembly (SAR) sublayer:* Segments these packets to cells, transmits them and reassembles them on the receiving end

B-ISDN/ATM Reference Model (3/3)

- Unlike OSI and TCP/IP, defined as being three-dimensional
- User plane: Data transport, flow control, error correction and other user (application) functions
- Control plane: Connection management (call setup, call control, etc.)
- Management plane:

- Resource management
- Interlayer coordination
- Operation, administration, maintenance

ATM Connection Setup

- Not part of the ATM layer:
  - Handled by the control plane
- A *separate* VC for signaling is required before data can be exchanged
  - PVCs: Pre-configured
  - SVCs: Established dynamically

SVC Connection Establishment

Message	Meaning (sent by host)	Meaning (sent by network)
SETUP	Please establish a VC	Incoming call
CALL_PROCEEDING	I saw the incoming call	Your call request will be attempted
CONNECT	I accept the incoming call	Your call request was accepted
CONNECT_ACK	Thanks for accepting	Thanks for making the call
RELEASE	Please terminate the call	The other end wants to terminate the call
RELEASE_COMPLETE	Call termination acknowledgment	Call termination acknowledgement

ATM Multicast VCs

- ATM allows the creation of multicast VCs
  - One sender and more than one receiver
- A connection is created to one of the destinations (chosen in random, or in an application specific way) in the usual way
- New message type: ADD_PARTY
  - Sent to attach a second destination to the VC established in the previous step
- Additional ADD_PARTY messages can be sent later to increase the size of the multicast group

ATM Addressing

- End hosts identified by ATM addresses
  - Three different formats are supported
  - 1st byte indicates which of them is used
- 1st format (20 bytes long):
  - 2nd and 3rd specify the country
  - 4th: Format of the rest of the message
    * 3-byte authority
    * 3-byte domain
    * 2-byte area
    * 6-byte address
    * 2 remaining bytes for future use
- 2nd format:
  - Same as the 1st, but bytes 2 and 4 specify an int'l. organization
- 3rd format:
  - 15-digit decimal telephone numbers

ATM Service Categories

- CBR (Constant Bit Rate):
  - Bits are put on one end, come off the other end
  - No processing (error checking, flow control, etc.)
  - Smooth transition from POTS to B-ISDN
    * Telephone system, i.e. interactive real-time audio streams
- VBR (Variable Bit Rate):
  - *Real-time (RT-VBR)*: Strict RT requirements, e.g. video-conferencing, no delays
  - *NRT-VBR*: Timely deliver important, but a certain amount of delay can be tolerated, e.g. multimedia applications that store data to the local disk before use
- ABR (Available Bit Rate):
  - No commitment to a fixed bandwidth
  - E.g.: Bandwidth between two points must always be at least 5 Mbps, but might have peaks up to 10
  - 5 Mbps are guaranteed, the carrier will do its best to provide 10, but with no promises
- UBR (Unspecified Bit Rate):
  - No promises of bandwidth or delivery
  - Suitable for IP traffic since, as we will see, IP also makes no promises about delivery
  - For applications that make their own error and flow control (file transfer, email, etc.)

ATM Service Categories Summary

Characteristic	**CBR**	**RT-VBR**	**NRT-VBR**	**ABR**	**UBR**
Bandwidth guarantee	Yes	Yes	Yes	Only to a minimum	No
Suitable for real-time traffic	Yes	Yes	No	No	No
Suitable for ``bursty'' traffic	No	No	Yes	Yes	Yes
Congestion feedback	No	No	No	Yes	No

B-ISDN/ATM Summary

- Backwards compatible with N-ISDN
- Provides a way of linking a wide range of devices (from telephones to computers)
- Combines packet and circuit switching ideas
- It can use any kind of physical media (copper, fiber)
- Wide range of transmission speed
- Allows QOS (quality of service) parameters (real-time voice, video, etc.)
- Supports any type of traffic
- Allows sources of different bit rates
- Uses fixed size packets called *cells*
- No error correction or flow control on hop-by-hop basis
- Operates in *connection-oriented* mode
- Supports *connectionless* mode

ATM Disadvantages

- Expense: ATM switches orders of magnitude more expensive than Ethernet switches (same for NICs)
- Connection setup latency: In small applications the time to setup the connection may be longer than the time using it
- Header ``tax'': ~10% header overhead (Ethernet: ~1% header overhead)
- Service requirements: Must be specified on connection establishment, too weak or too strong may cause problems
- No efficient hardware broadcast/multicast: Simulation by arranging copies of data to be passed to each end point in the set
- Homogeneity assumption: Designed to be a single, universal system; minimal provision for interoperating with other networking technologies

B-ISDN/ATM History

- 1980: N-ISDN adopted
- Early 80s: A lot of research on fast switching
- 1985: B-ISDN study group formed, mainly by telecommunications companies of the U.S.
- 1986: ATM chosen as the underlying transfer technology of B-ISDN
- 1987: First ATM standardization document
- 1989: Cell size of 53 (5 + 48) bytes chosen
- 1991: ATM Forum formed
- 1992: Second version of ATM standard
- 1993: First generation ATM switches
- 1995: Service categories finalized
- 1996: Second generation ATM switches
- 1999: Third generation ATM switches
- October 1999: AAL and its sublayers finalized
- Currently still used in the Internet backbone
- ATM killer: Gigabit Ethernet

- Old Ethernet hardware can be upgraded rather than replaced with the more expensive ATM hardware