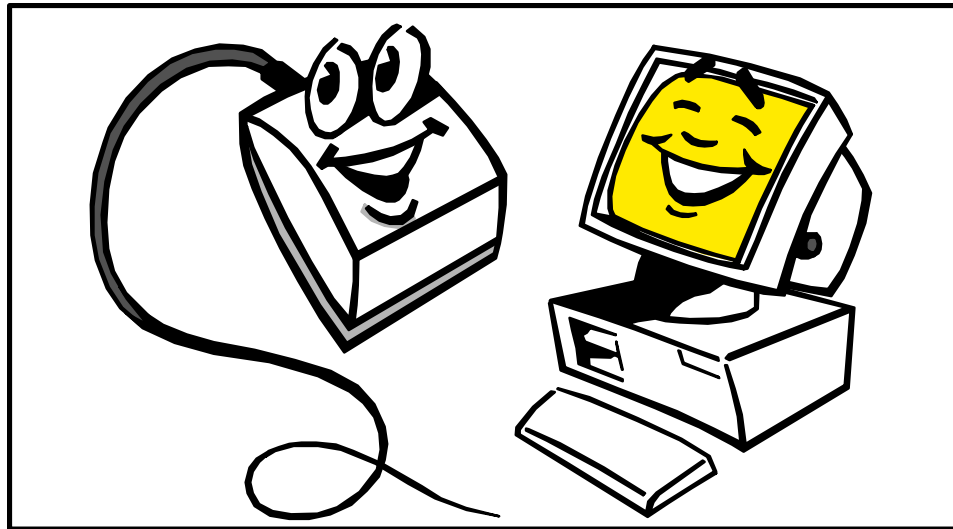


ATM Networks: An Overview



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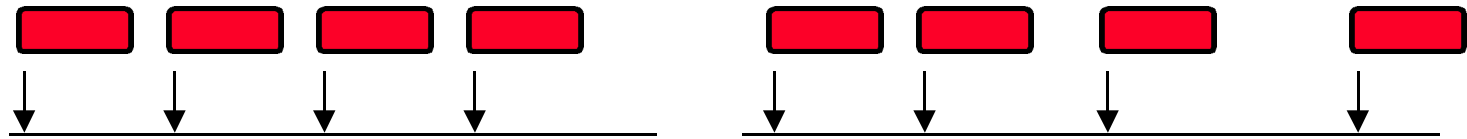
<http://www.cis.ohio-state.edu/~jain/>



- q ATM: Overview
- q ATM Protocol Layers
- q Adaptation Layers
- q LAN Emulation
- q Network Interfaces

ATM Networks: Overview

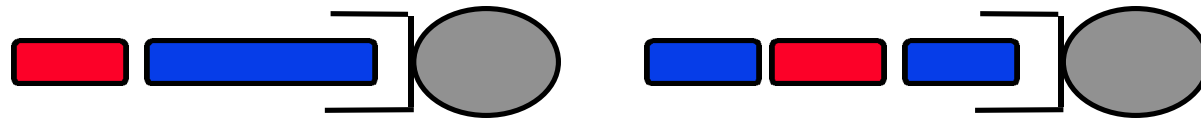
- q STM = Synchronous Transfer Mode,
ATM = Asynchronous Transfer Mode



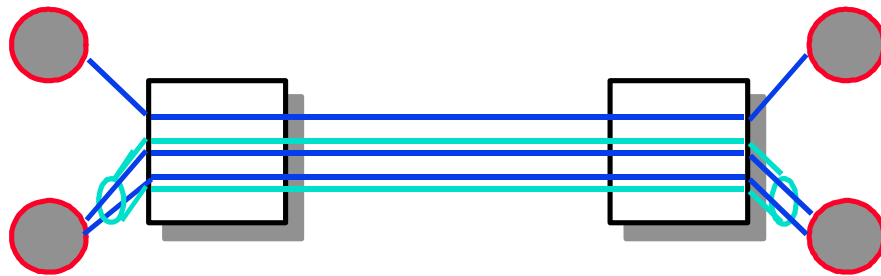
Allows **any-speed** and even **variable rate** connection

Broadband = Rate greater than primary rate (1.5 Mbps)

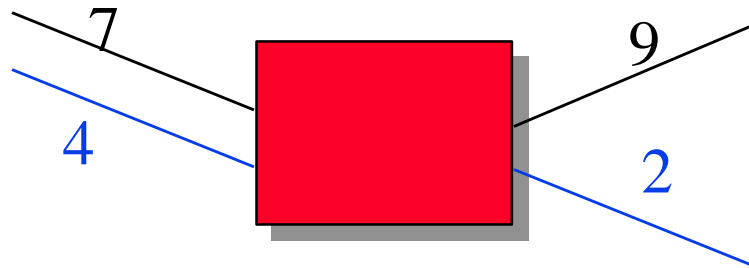
- q ATM = Short fixed size 53-byte cells



- q Connection oriented \Rightarrow Virtual Channels (VC)



- q Labels vs addresses
⇒ Better scalability in number of nodes

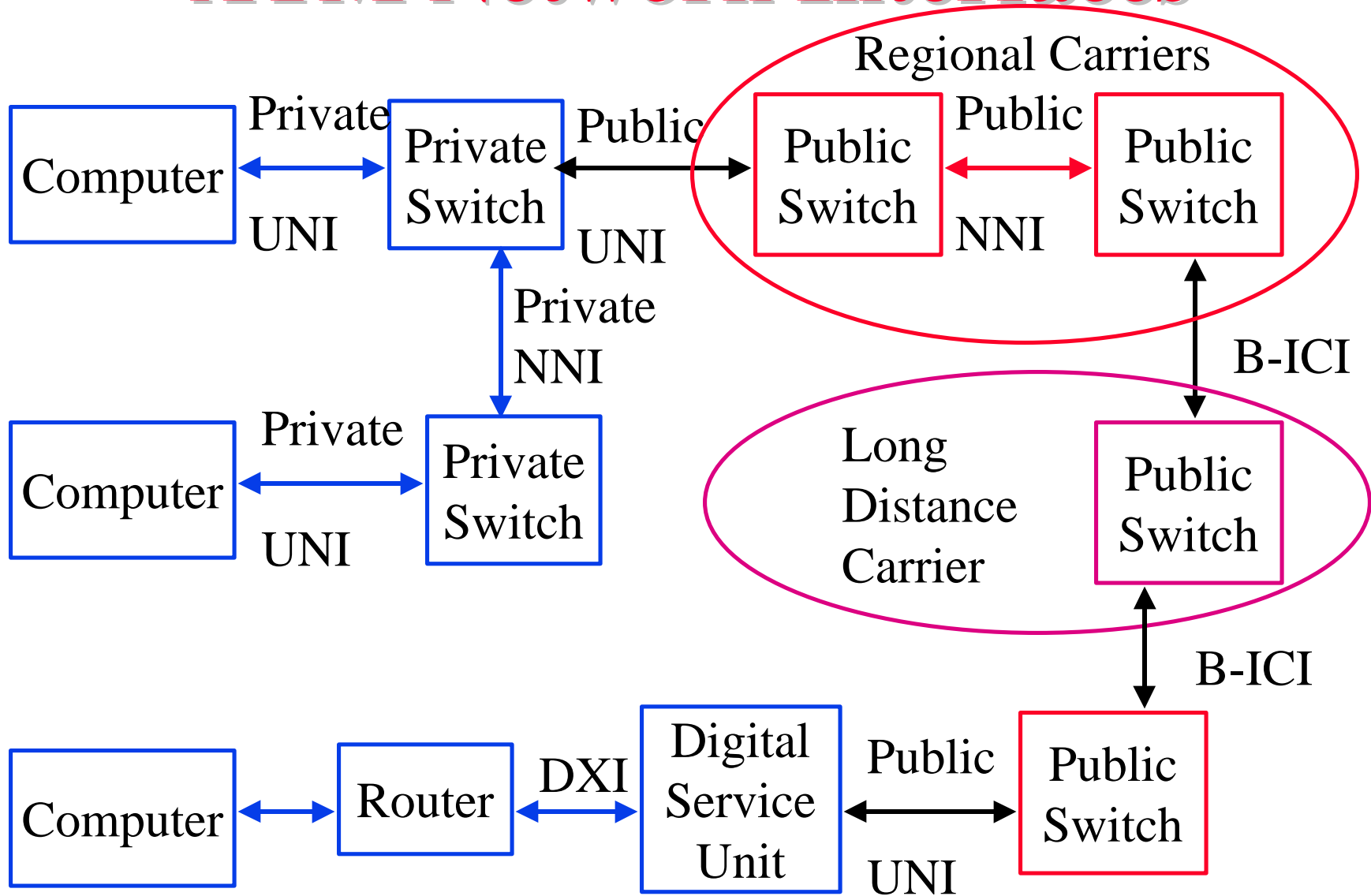


- o Slotted system ⇒ Better scalability in distance-bandwidth
- o Switches vs routers
⇒ Cheaper due to fixed size, short address, simplicity
- o Seamless ⇒ Same technology for LAN, MAN, WAN
- o Data, voice, video integration
- o Everyone else is doing it

History of ATM

- q 1980: Narrowband ISDN adopted
- q Early 80's: Research on Fast Packets
- q Mid 80's: B-ISDN Study Group formed
- q 1986 ATM approach chosen for B-ISDN
- q June 1989: 48+5 chosen (64+5 vs 32+4).
- q October 1991: ATM Forum founded
- q July 1992: UNI V2 released by ATM Forum
- q 1993: UNI V3 and DXI V1
- q 1994: B-ICI V1

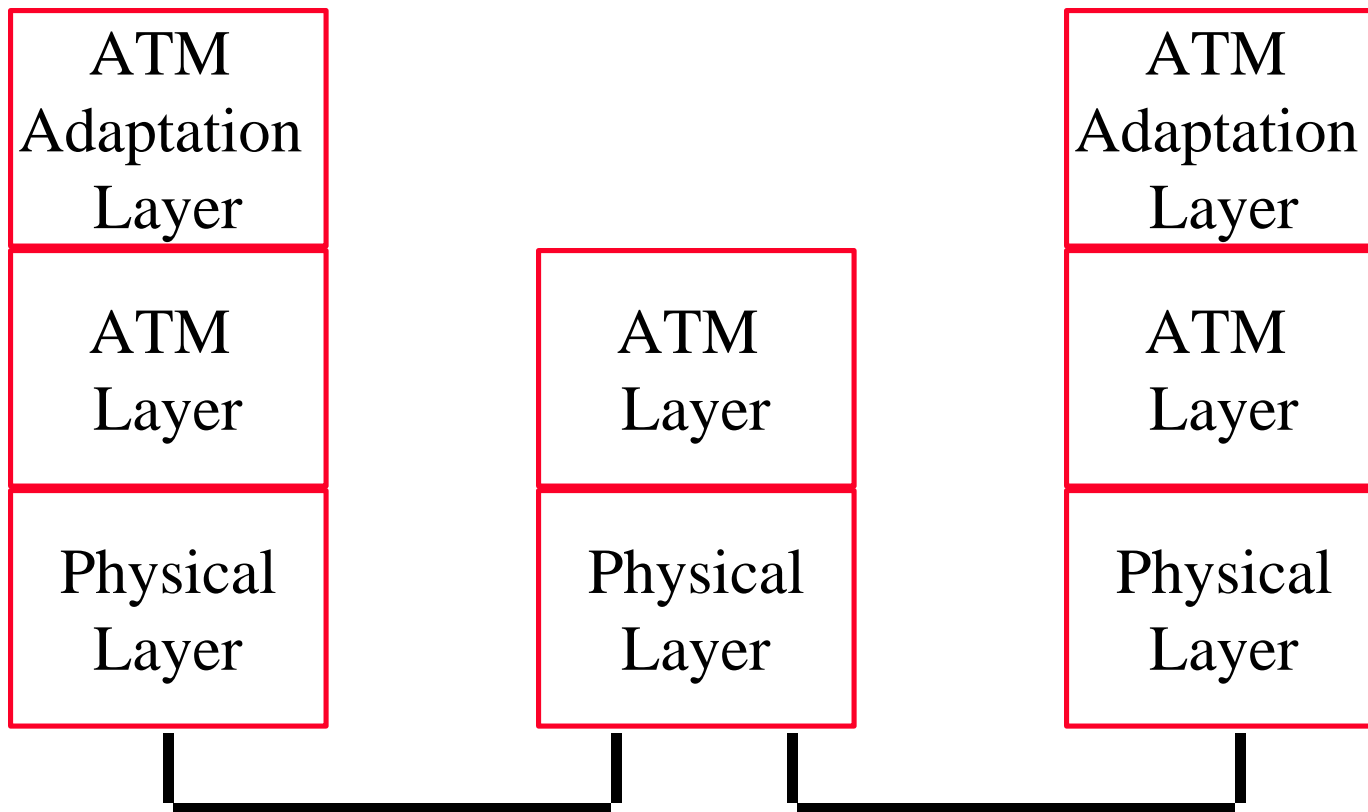
ATM Network Interfaces



ATM Network Interfaces

- q User to Network Interface (UNI):
Public UNI, Private UNI
- q Network to Node Interface (NNI):
 - q Private NNI (P-NNI)
 - q Public NNI = Inter-Switching System Interface (ISSI)
Intra-LATA ISSI (Regional Bell Operating Co)
 - q Inter-LATA ISSI (Inter-exchange Carriers)
⇒ Broadband Inter-Carrier Interface (B-ICI)
- q Data Exchange Interface (DXI)
Between packet routers and ATM Digital Service Units (DSU)

Protocol Layers

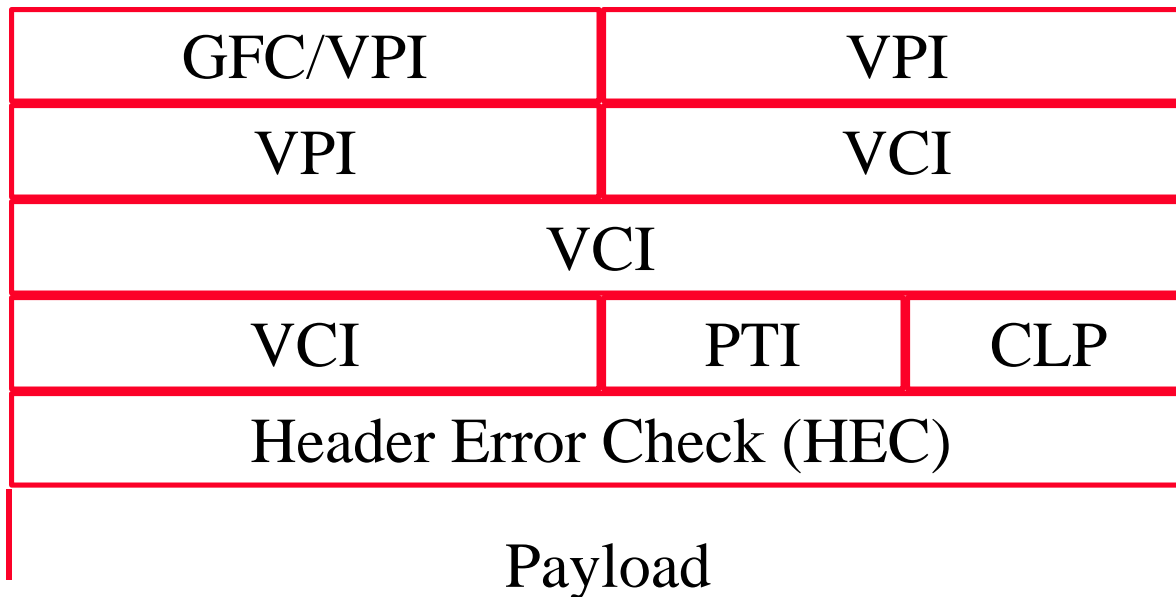


Protocol Layers

- q The ATM Adaptation Layer
 - q How to break application messages to cells
- q The ATM Layer
 - q Transmission/Switching/Reception
 - q Congestion Control/Buffer management
 - q Cell header generation/removal at source/destination
 - q Reset connection identifiers for the next hop (at switch)
 - q Cell address translation
 - q Sequential delivery

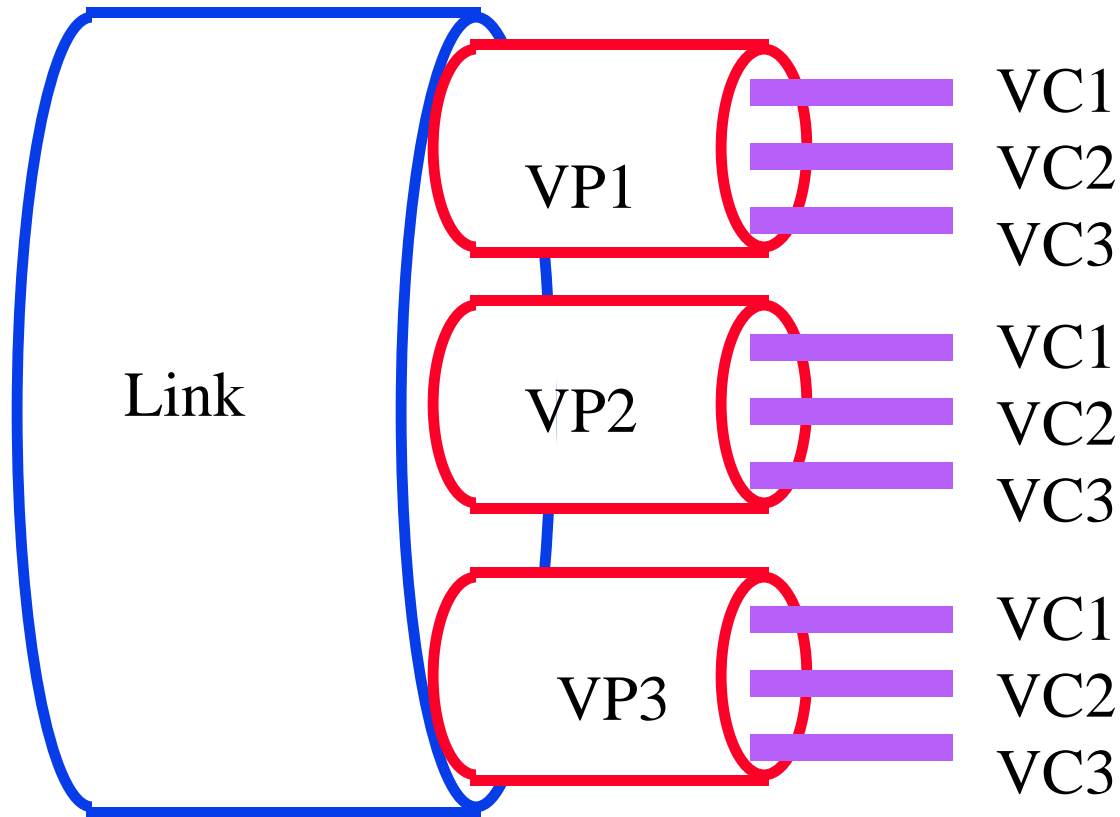
ATM Cell Header Format

- q GFC=Generic Flow Control
 - q (Was used in UNI but not in NNI)
- q VPI/VCI=0/0 \Rightarrow Idle cell; 0/n \Rightarrow Signalling
- q HEC: $1 + x + x^2 + x^8$



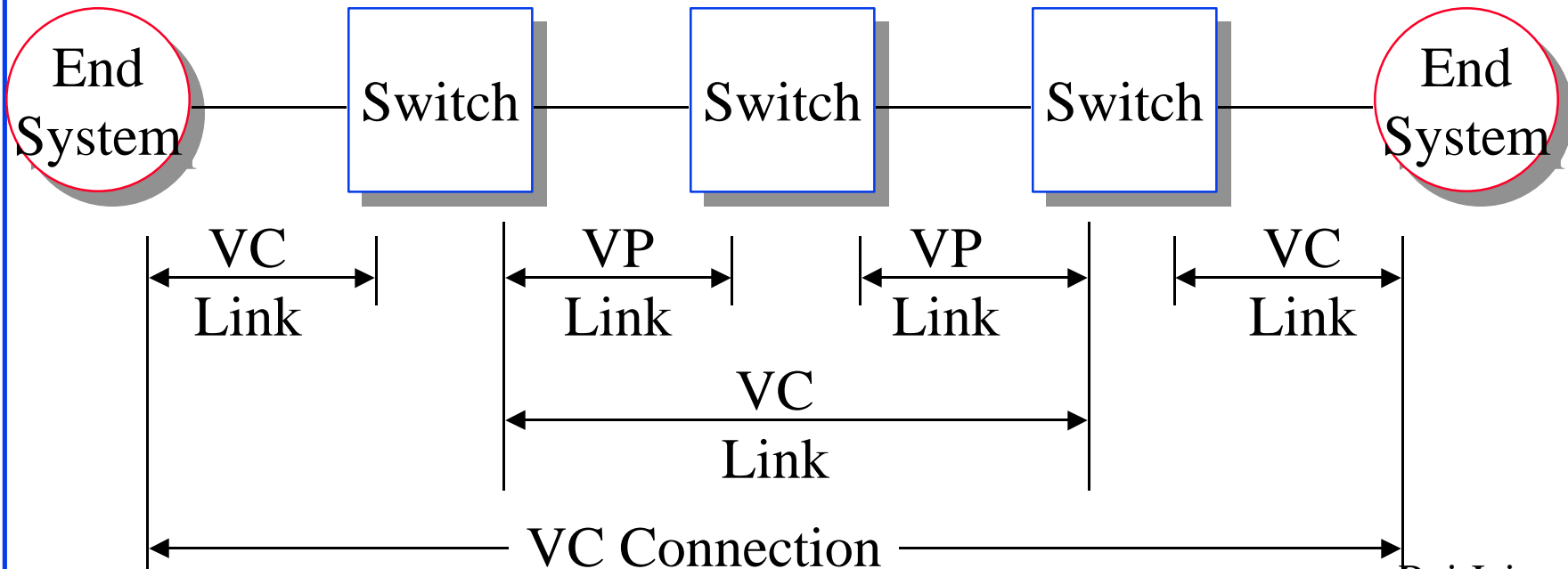
Connection Identifiers

- q Each cell contains a 24/28-bit connection identifier
First 8/12 bits: Virtual Path, Last 16 bits: Virtual Channel
- q VP service allows new VC's w/o orders to carriers

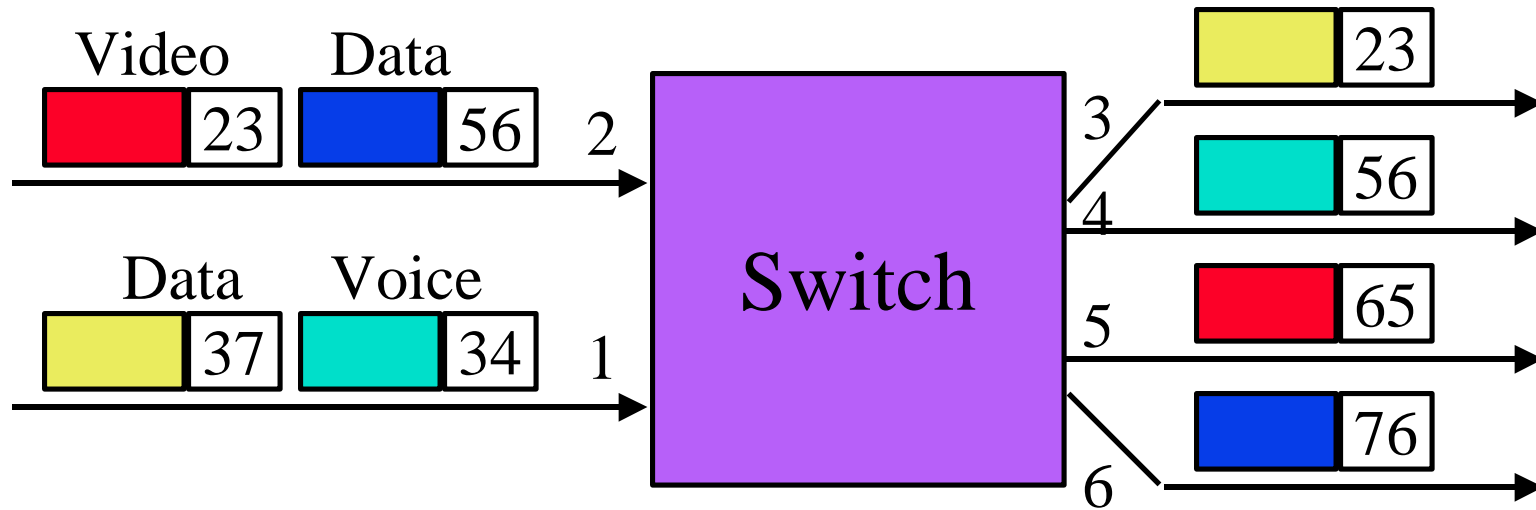


Connections Vs Channels

- q VP connections (VPCs) = Series of VP Links
- q VC connections (VCCs) = Series of VC Links
to make an end-to-end link
- q VC = VCL or VCC, VP=VPL or VPC
- q Call = Multiple connections



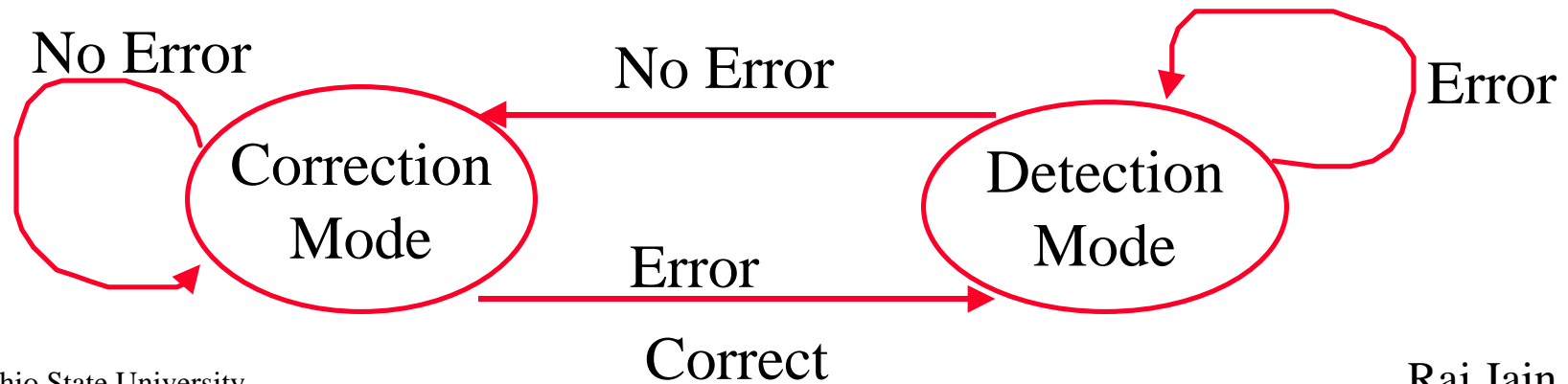
VP/VC Assignment/Use



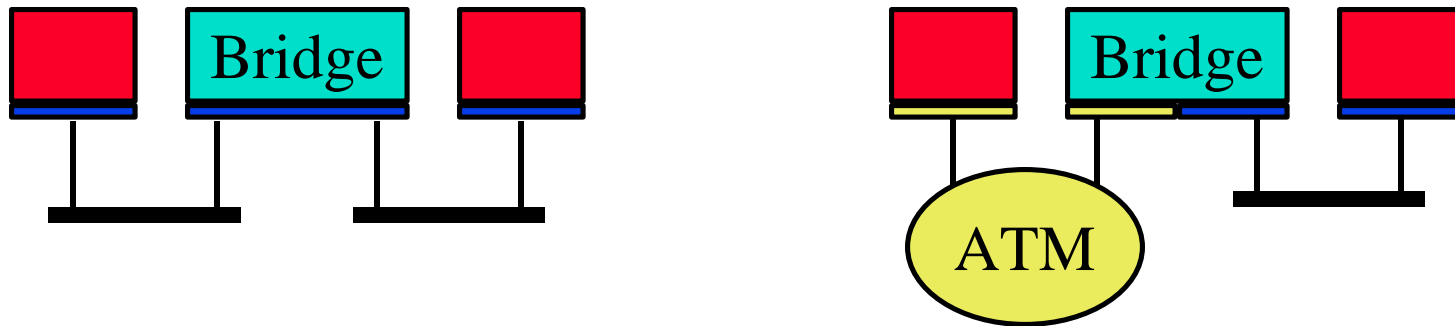
In		Out	
Port	VPI/VCI	Port	VPI/VCI
1	0/37	3	1/23
1	0/34	4	0/56
2	0/23	5	0/65
2	0/56	6	4/76

Header Error Check (HEC)

- q Protects header only
- q Optional Correction mode: Correct one bit errors if no earlier errors
- q Discard cells with bad HEC
- q Used for cell delineation in SONET
- q Recalculated on each hop



LAN Emulation



- q Problem: Need new networking s/w for ATM
- q Solution: Let ATM network appear as a virtual LAN
- q LAN emulation implemented as a device driver below the network layer

Protocol Layers

ATM Host

Existing Applications	
IP	IPX
NDIS	ODI
LAN Emulation	
AAL5	
ATM	
Physical Layer	

ATM Switch

ATM	
Physical Layer	Physical Layer

ATM-LAN Bridge

Bridging	
LAN Emulation	Media Access Control
AAL5	
ATM	
Physical Layer	Physical Layer

LAN Host

Existing Applications	
IP	IPX
NDIS	ODI
Media Access Control	
Physical Layer	

q NDIS = Network Driver Interface Specification

q ODI = Open Datalink Interface

Features

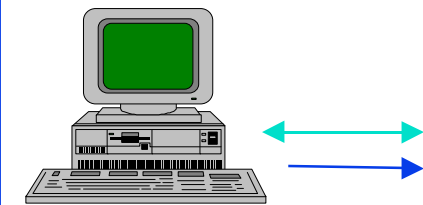
- q One ATM LAN can be multiple virtual LANs
- q Logical subnets interconnected via routers
- q Need drivers in hosts to support each LAN
- q Only **IEEE 802.3** and **IEEE 802.5** frame formats supported
- q Doesn't allow passive monitoring
- q No token management (SMT), collisions, beacon frames

LE Header (2 Bytes)

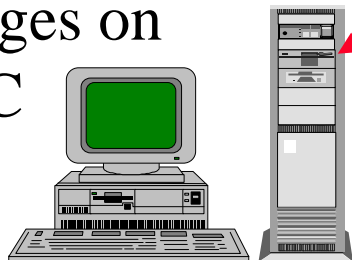
Standard IEEE 802.3 or 802.5 Frame

LAN Emulation

1. Clients get recipient's address from LES and setup a VC.

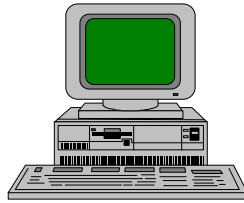


2. Clients send messages on the VC

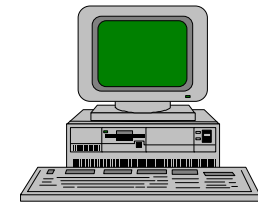


Broadcast/Unknown Server (BUS)

LAN Emulation Server (LES)

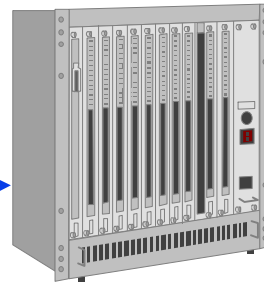


3. Messages for ATM clients are delivered directly.



ATM client B

ATM Switches



4. Messages for non-ATM clients are forwarded through a bridge

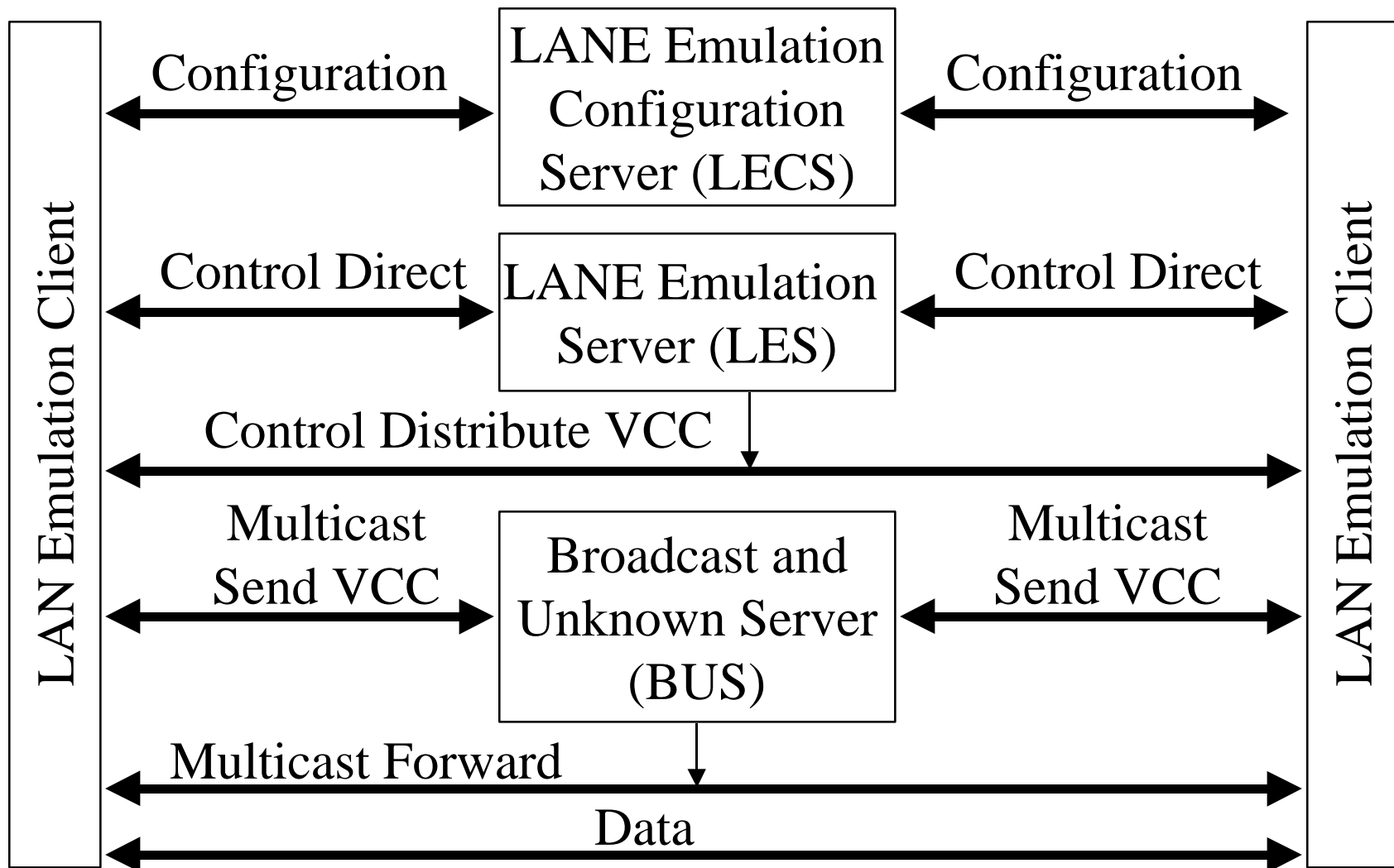


Non-ATM client
Raj Jain

Operation

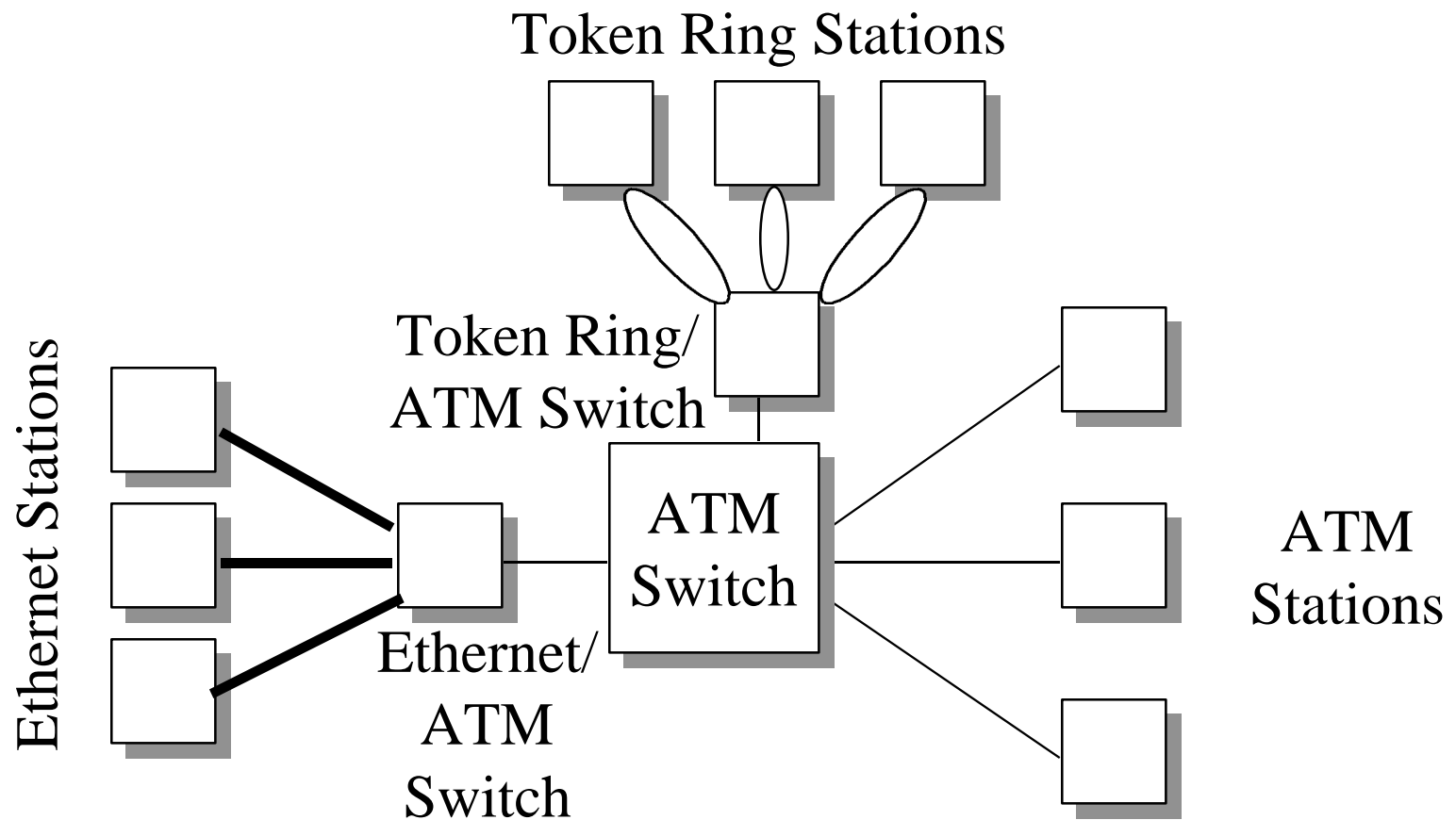
- q Initialization: Client gets Server's address from a well known ATM address
- q Registration: Client sends a list of its MAC addresses to Server
- q Address Resolution: Client sends ARP request to Server
 - q Server, Clients, Bridges answer ARP
 - q Client setups a direct connection
- q Broadcast/Unknown Server (BUS):
Forwards multicast traffic to all members

LANE Components



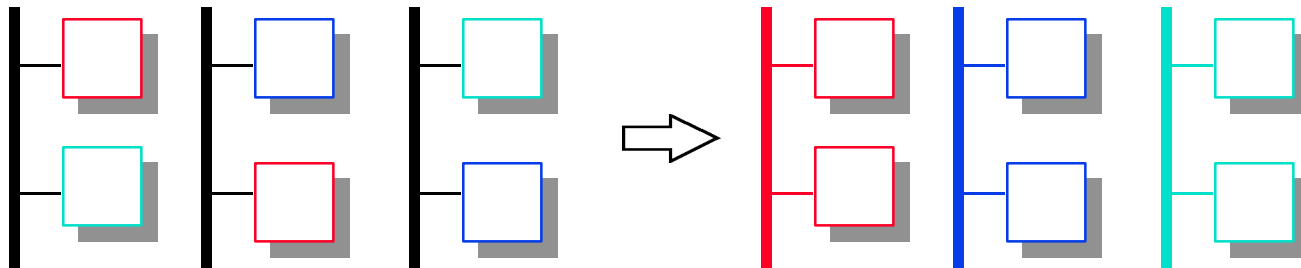
LAN Emulation Configuration 1

- q LAN/ATM switches provides bridging functions



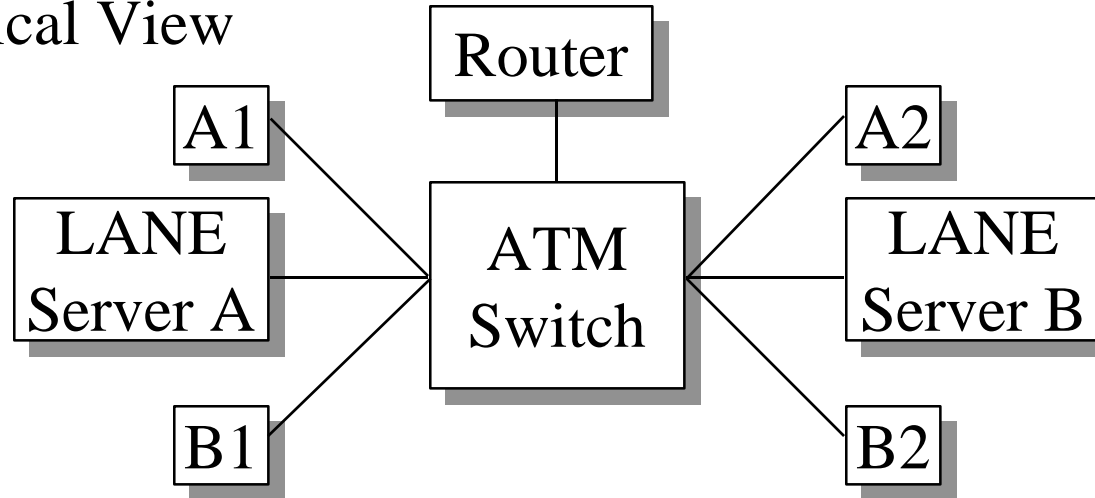
Virtual LANs

- q Group of users that appear to be interconnected by one LAN
One LAN = One broadcast domain
- q They may be on physically different LANs
- q Stations can be grouped by:
 - q All stations that have the same IP subnet address
 - q All stations that are connected to the same switch port
 - q Stations whose specific addresses are specified

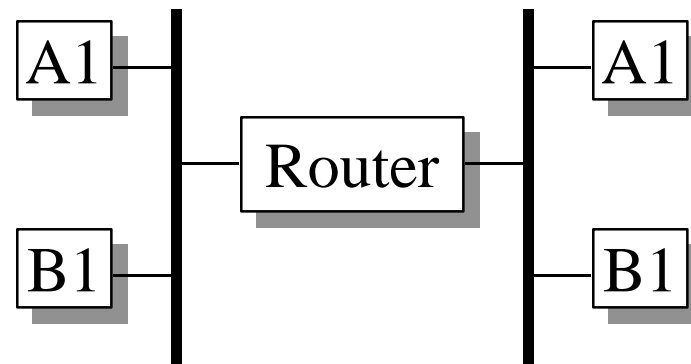


ATM Virtual LANs

q Physical View



q Logical View

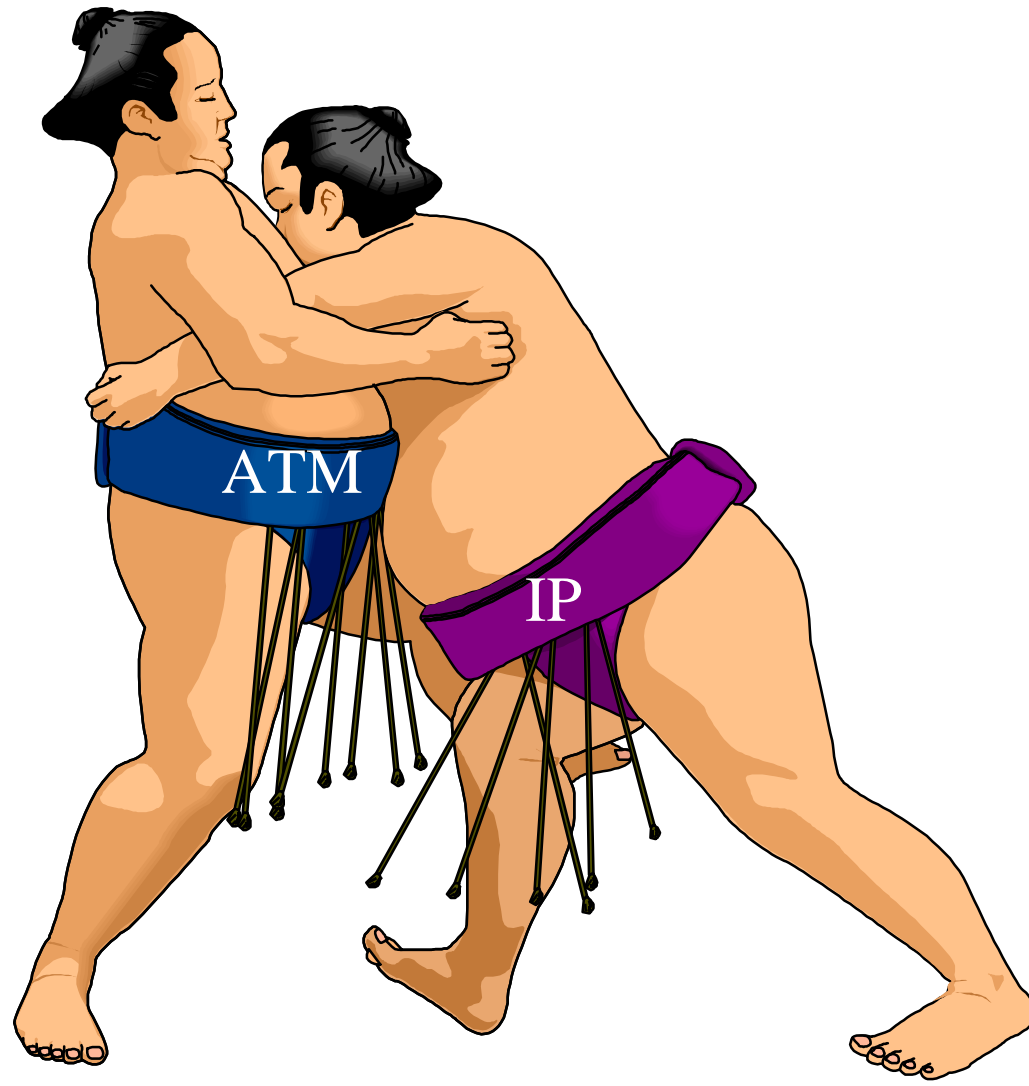


LAN Emulation: Summary

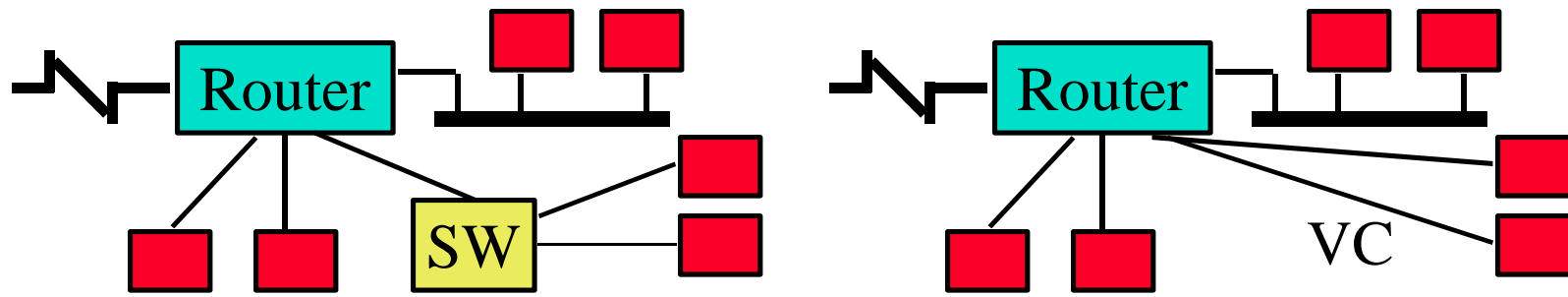


- q LAN emulation allows current applications to run on ATM networks without changes
- q Multiple virtual LANs on one ATM network
- q Disadvantage:
ATM is hidden from applications
⇒ Can't use new ATM services

IP Over ATM

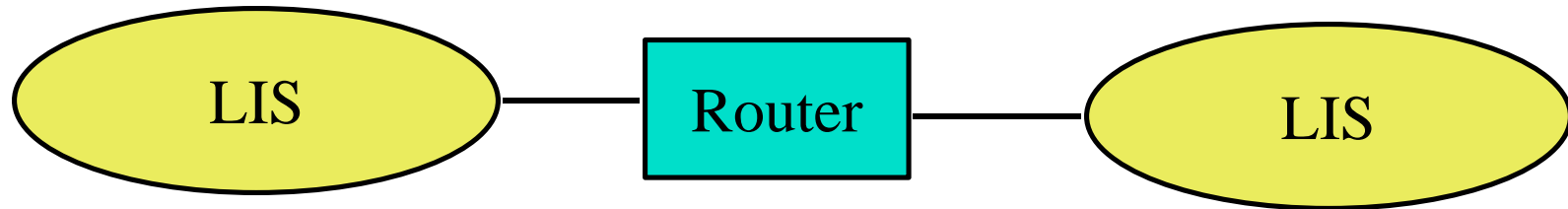


IP Over ATM



- q ATM similar to point-to-point WANs.
Simpler than LAN emulation
- q IP address:123.145.134.65
ATM address:...1-614-999-2345-...
- q Issue: IP Address \Leftrightarrow ATM Address translation
 - q Address Resolution Protocol (ARP)
 - q Inverse ATM ARP: VC \Rightarrow IP Address
- q Solution: Logical IP Subnet (LIS) Server
- q Ref: RFC 1577

IP Over ATM



- q Clients within LIS use direct VCs
- q All traffic between LIS passes through a router
- q ATM AAL5 PDU size = 9180 + 8 LLC/SNAP header
- q Problem: Need router even if ATM connection between LIS
- q Solution: Routing Over Large Clouds (ROLC)

ARP Over ATM

- q Only one ATM ARP server per subnet
⇒ No database synchronization issues
- q Clients are configured with server's ATM address
- q Clients setup a VC with the server
- q Server sends an inverse ARP request
(What's your IP Address?)
- q Client responds with its IP Address
- q Clients ask server by ARP request
(What's ATM address of 123.145.134.65?)
- q Server replies with ATM address
- q Server sends NAK if not in table
- q ARP requests are **NOT** broadcast to all LIS members

ARP Database Maintenance

- q Clients register with the server at startup
- q Can use ARP requests to update entry for requester
- q Entries at clients age out after 15 minutes
- q Entries at servers age out after 20 minutes
- q Server sends inverse ARP on active VC before aging out
- q Otherwise clients resend registration every 20 minutes

IP Multicast/Broadcast

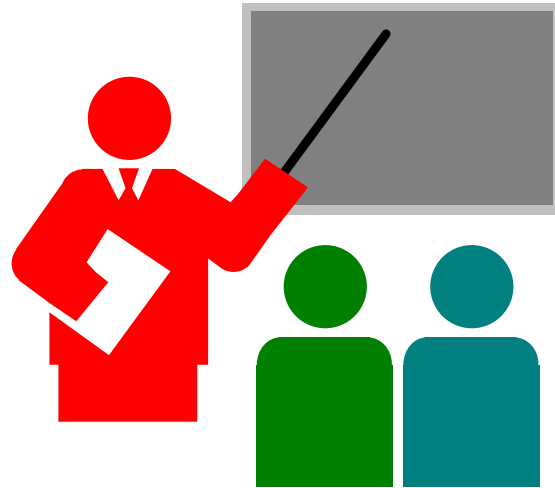
- q No broadcast or multicast in LIS
- q IP multicast/broadcast packets handled as in WAN
- q Clients must process broadcasts/multicasts as if addressed to them
- q No mappings from IP multicast to ATM multicast services
- q MBONE and IP tunneling operate over ATM as if on WAN

IP Over ATM: Summary



- q Virtual circuits in place of real circuits
- q IP to ATM address translation
⇒ ARP and inverse ARP
- q Clients register addresses with server
- q Broadcasts are expensive
⇒ Not used

Summary



- q ATM Overview: History, Why and What
- q Interfaces: PNNI, NNI, B-ICI, DXI
- q Protocol Layers: AAL, ATM, Physical layers, Cell format
- q LAN Emulation
- q IP over ATM

ATM Books

- q H. Dutton and Peter Lenhard, "Asynchronous Transfer Mode (ATM) Technical Overview," 2nd Ed., Prentice Hall, 1995.
- q R.O. Onvural, "Asynchronous Transfer Mode Networks: Performance Issues," 2nd Ed., Artech House, 1995, 535 pp.
- q W. Stallings, "ISDN and Broadband ISDN with Frame Relay and ATM," Prentice-Hall, 1995, 581 pp.
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- q M. de Prycker, "Asynchronous Transfer Mode," 3rd Edition, Prentice Hall, New York, 1995, 380 pp.

- q M. Boisseau, M. Demange, and J-M Munier, "An Introduction to ATM Technology," Thompson Publishing, 1995, 97 pp.
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- q B. Kumar, "Broadband Communications: A professional's guide to ATM, Frame Relay, SMDS, SONET, and B-ISDN," McGraw-Hill, 1994, 513 pp.
- q R. Handel, M.N. Huber, and S. Schroder, "ATM Networks: Concept, Protocols, Applications," 2nd Edition, Addison-Wesley, 1994, 285 pp.
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- q D. Minoli and G. Dobrowski, "Principles of Signalling for Cell Relay and Frame Relay," Artech House, 1994, 305 pp.
- q A.S. Acampora, "An Introduction to Broadband Networks: LANs, MANs, ATM, B-ISDN and Optical Networks for Integrated Multimedia Telecommunications," Plenum Press, New York, 1994, 336 pp.

- q B. C. Lindberg, "Digital Broadband Networks and Services," McGraw-Hill, 1994, 248 pp.
- q H. Saito, "Teletraffic Technologies in ATM Networks," Artech House, Norwood, MA, 1993, 176 pp.
- q Y. Viniotis and R.O. Onvural, Ed., "Asynchronous Transfer Mode," Proceedings of TRICOMM'93, Plenum Press, New York, April 1993, 224 pp.

ATM Books (Cont)

- q B.G. Lee, M. Kang, and J. Lee, "Broadband Telecommunications Technology," Artech House, Boston, 1993, 580 pp.
- q L.G. Cuthbert and J-C Sapanel, "ATM: The Broadband Telecommunication Solution," IEE 1993, London, 161 pp.
- q *Asynchronous Transfer Mode: Bandwidth for the Future*, Telco Systems, (800)221-2849 or (617)551-0300.

References: ATM Overview

- q S. Siu and R. Jain, "A brief overview of ATM: Protocol Layers, LAN Emulation and Traffic Management" *Computer Communications Review (ACM SIGCOMM)*, April 1995. Available at <http://www.cis.ohio-state.edu/~jain/>
- q David Benham, *ATM in Local Area Networks*, 11 April 1994, Hughes LAN Systems, (800)395-LANs, (415)966-7300.
- q J. Boudec, "The Asynchronous Transfer Mode: A Tutorial," *Computer Networks and ISDN Systems*, May 1992.
- q J. Burg and D. Dorman, "Broadband ISDN Resource Management: The Role of Virtual Paths," *IEEE Communications Magazine*, September 1991.

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- q ATM Forum, “LAN Emulation over ATM Version 1.0,” January 1995.
- q T. Newton, “Baseline Text for LAN Emulation Client Management,” AF-LANE 94-0737R1, January 20, 1995.
- q J.D. Keene, “LAN Emulation over ATM Version 2 -LNNI Specification,” Draft 0, ATM Forum Contribution 95-1082, October 1, 1995
- q H.L. Truong, et al, “LAN Emulation on an ATM Network,” IEEE Communication Magazine, May 1995, pp. 70-85.
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- q M. Doar and G. Marshall, “Design of Real Networks with LAN Emulation,” InterOp Engineer’s conference, 1995.

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- q RFC1577, "Classical IP and ARP over ATM" by M. Laubach, 01/20/1994, 17 pp.
- q RFC1626, "Default IP MTU for use over ATM AAL5" by R. Atkinson, 05/19/1994, 5 pp.
- q RFC1680, "IPng Support for ATM Services" by C. Brazdziunas, 08/08/1994, 7 pp.
- q RFC1695, "Definitions of Managed Objects for ATM Management Version 8.0 using SMIV2" by M. Ahmed, K. Tesink, 08/25/1994, 73 pp.

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- q RFC1755, "ATM Signaling Support for IP over ATM" by M. Perez, F. A. Mankin, E. Hoffman, G. Grossman, A. Malis, 02/17/1995, 32 pp.
- q RFC1754, "IP over ATM Working Group's Recommendations for the ATM Forum's Multiprotocol BOF Version 1" by M. Laubach, 01/19/1995, 7 pp.
- q Internet Draft, "Integrated Services IP Multicasting over ATM," 07/07/1995, <draft-milliken-ipatm-services-00.txt>
- q Internet Draft, "IPv6 multicast over ATM," 06/21/1995, <draft-armitage-ipatm-ipv6mc-00.txt>

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- q Internet Draft, "Using the MARS to support IP Unicast over ATM," 06/14/1995, <draft-armitage-ipatm-mars-unicast-01.txt>
- q Internet Draft, "Issues surrounding a new encapsulation for IP over ATM.," 06/26/1995, <draft-armitage-ipatm-encaps-02.txt>
- q Internet Draft, "IP Broadcast over ATM Networks.," 07/07/1995, <draft-smith-ipatm-bcast-01.txt>
- q Internet Draft, "IP/ATM Integrated Routing & Addressing (IRA) Model," 03/24/1995, <draft-fink-ipatm-ira-00.txt>

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- q Internet Draft, "Router Architecture Extensions for ATM : Overview," 03/03/1995, <draft-katsube-router-atm-overview-00.txt>
- q Internet Draft, "Inter-Domain Routing over ATM networks," 02/16/1995, <draft-rekhter-idr-over-atm-00.txt>
- q Internet Draft, "IP Architecture Extensions for ATM," 07/06/1995, <draft-rekhter-ip-atm-architecture-01.txt>
- q Internet Draft, "Conventional IP over ATM," 03/08/1995, <draft-ohta-ip-over-atm-01.txt>
- q Internet Draft, "IP over ATM: A Framework Document," 06/27/1995, <draft-ietf-ipatm-framework-doc-03.txt, .ps>

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- q Internet Draft, "Support for Multicast over UNI 3.1 based ATM Networks.," 05/31/1995, <draft-ietf-ipatm-ipmc-05.txt>
- q Internet Draft, "IP Multicasting over ATM: System Architecture Issues," 07/07/1995, <draft-ietf-ipatm-arch-00.txt>
- q Internet Draft, "Definitions of Supplemental Managed Objects for ATM Management," 07/06/1995, <draft-ietf-atommib-atm2-02.txt>
- q Internet Draft, "Definitions of Textual Conventions for ATM Management," 07/06/1995, <draft-ietf-atommib-atm2TC-00.txt>

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- q I.113 Vocabulary of Terms for Broadband Aspects of ISDN, 1991
- q I.121 Broadband Aspects of ISDN, 1991
- q I.150 B-ISDN ATM Functional Characteristics, 1993
- q I.211 B-ISDN Service Aspects, 1993
- q I.311 B-ISDN General Network Aspects, 1993
- q I.321 B-ISDN Protocol Reference Model and Its Application, 1993
- q I.327 B-ISDN Functional Architecture, 1993
- q I.361 B-ISDN ATM Layer Specification, 1993

B-ISDN Recommendations

- q I.362 B-ISDN ATM Adaptation Layer (AAL) Functional Description, 1993
- q I.363 B-ISDN ATM Adaptation Layer (AAL) specification, 1993
- q I.364 Support of Broadband Connectionless Data Service on B-ISDN, 1993
- q I.371 Traffic Control and Congestion Control in B-ISDN, 1993
- q I.413 B-ISDN User-Network Interface, 1993
- q I.414 Overview of Recommendations on Layer 1 for ISDN and B-ISDN Customer Access, 1993

B-ISDN Recommendations

- q I.432 B-ISDN User-Network Interface Physical Layer Specification, 1993
- q I.555 Frame Relay and ATM Interworking
- q I.580 General Arrangements for Interworking Between B-ISDN and 64 kbps Based ISDN, 1993
- q I.610 B-ISDN Operation and Maintenance Principles and Functions, 1993
- q Q.2931 B-ISDN Call Control
- q Q.SAAL Signaling AAL

ANSI Standards

- q T1.624, "Broadband ISDN User-Network Interfaces: Rates and Formats Specification."
- q T1.627, "Broadband ISDN - ATM Layer Functionality and Specification."

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- q *User-Network Interface Specifications, V3.0*, Prentice-Hall, September 10, 1993., (515)-284-6751
- q ATM UNI 3.1, July 21, 1994.
- q ATM B-ISDN Intercarrier Interface (B-ICI), V1.0, June 1, 1993.
- q ATM DXI Specification, V1.0, August 1993, ATM Forum, (415)-578-6860
- q ATM DS1 PHY V1.0 specs
- q ATM 52 Mbps Category 3 UTP
- q ATM 155 Mbps Category 5 UTP V1.0 Specification
- q LAN Emulation over ATM V1.0 Specification

ATM Forum Specs (Approved)

- q Interim Inter-Switch Signaling Protocol (IISP) V1.0 Specification
- q 6312 kbps UNI V1.0 Specification
- q Introduction to ATM Forum Test Specifications V1.0
- q PICS Proforma for the DS3 Physical Layer Intervade V1.0 Specification
- q PICS Proforma for the 100 Mbps Multimode Fibre Physical Layer Interface V1.0 Specification
- q PICS Proforma for the SONET STS-3c Physical Layer Interface V1.0 Specification

ATM Forum Specs (Final)

- q Conformance Abstract Test Suite for ATM Layer of Intermediate Systems
- q Interoperability Abstract Test Suite for the ATM Layer
- q Interoperability Abstract Test Suite for the Physical Layer
- q PICS Proforma for the DS1 Physical Layer Interface
- q PICS Proforma for the UNI ATM Layer
- q E3 Public UNI
- q LAN Emulation Client Management Specification

Documents listed above have been sent for final vote (7/95)

Information Sources

- q ATM Forum (415)578-6860 info@atmforum.com
 - q Fax on Demand: (415)-688-4318
 - q <http://WWW.ATMFORM.COM>
 - q Paris: +33 1 46 39 56 26 cguyot@interop.com
 - q Tokyo: +81 3 3438 3694 kyb01621@niftyserve.or.jp
- q Internet Engineering Task Force
 - q IP over ATM: atm-request@hpl.hp.com
 - q Routing over Large Clouds: rolc-request@nsco.netcom.com
 - q atommib-request@thumper.bellcore.com
 - q RFCs: mail-server@nisc.sri.com (Send Help in message)
 - q Draft RFC's: Internet-Drafts@cnri.reston.va.us

Information Sources

- q Internet News: cell-relay-request@indiana.edu
 - q comp.dcom.cell-relay@indiana.edu
- q Frame Relay Forum: frf@interop.com
- q Switched Multimegabit Data Service (SMDS):
sig@interop.com

Quiz

T F Please check True/False

1. ATM cells always arrive periodically at the same time.
2. ATM cells are always of the same size (bytes) at all speeds
3. ATM cells are always of the same time (seconds) at all speeds.
3. Each ATM cell contains 4 bytes of destination address
4. A VP switch uses only the VP field for switching
5. A VC switch uses only the VC field for switching
6. The VP field in the cell is changed at each hop
7. Whenever a cell arrives with errors, HEC will correct it.
8. The ATM switching is done in the AAL layer
9. The ATM layer is responsible for segmenting user messages into fixed size cells.

Quiz

T F Please check True/False

1. LANE allows ATM stations to talk to existing Ethernet stations
2. FDDI is not supported by ATM LANE
3. ATM stations can not talk to stations on FDDI
3. On an emulated Ethernet, you can monitor collisions
4. In LANE, all broadcasts are sent to BUS
5. LES broadcasts unknown queries to all members of the emulated LAN via BUS
6. All traffic between LIS's passes through routers
7. You will not need a router, if all hosts of an IP network are on a single ATM network.
8. Unknown ARP requests are broadcast to all LIS members