Asynchronous Transfer Mode (ATM)
Broadband ISDN (B-ISDN)

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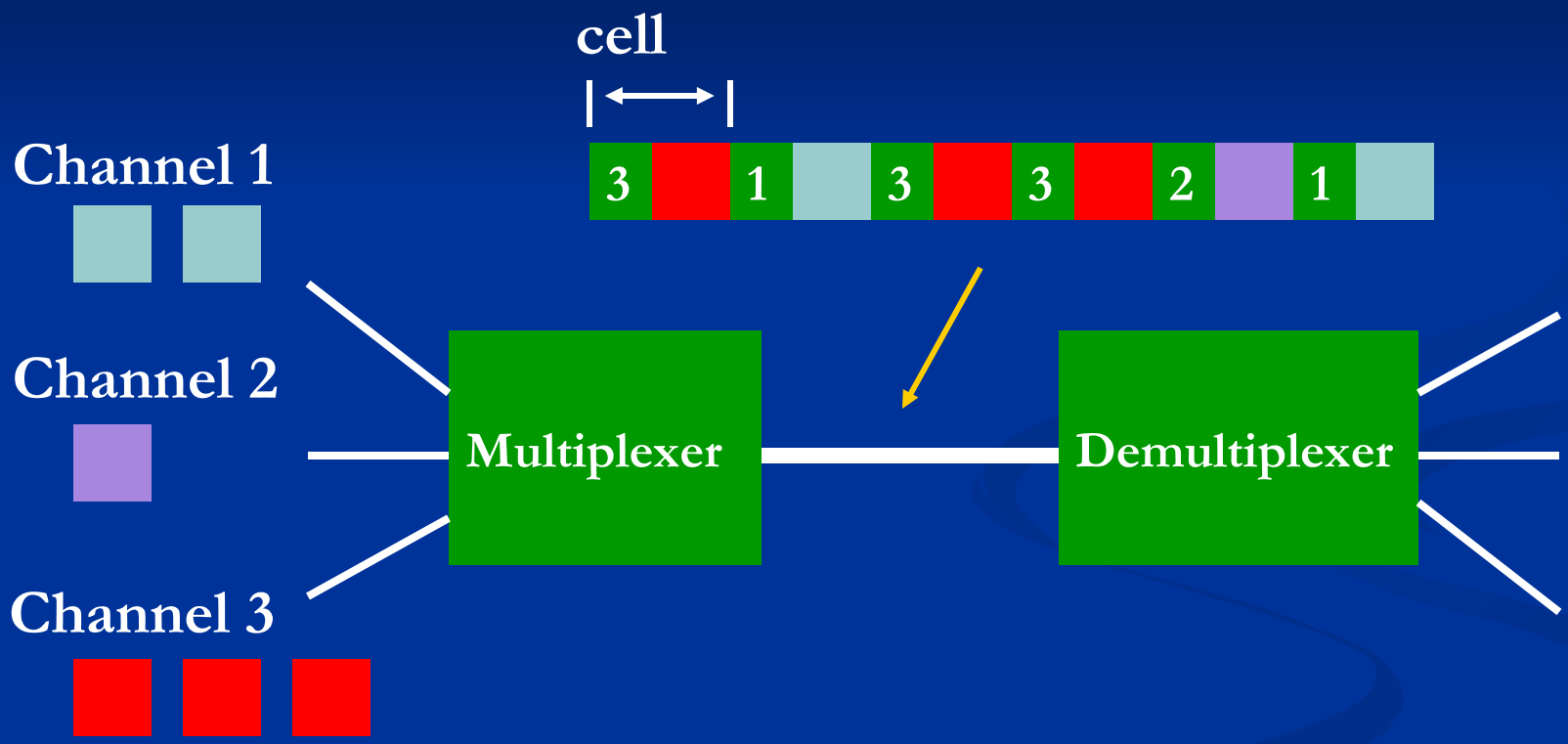
ATM basic characteristics

- Integrates transfer of voice, video, data and other media using statistical multiplexing
  - multiplexes cells of fixed length
  - QoS-aware
- Combines advantages of circuit-switched networks (constant delay, guaranteed capacity) and packet-switched networks (flexibility, efficiency for intermittent data transfers)
  - using (bidirectional) virtual circuits

Statistical multiplexing principle



ATM network

- implemented using polygonal infrastructure based on ATM switches
  - point-to-point lines allows to combine various media types and transfer rates
  - provides scalable bandwidth from a few Mbps to many Gbps
- ATM switches maintain switching tables for established virtual circuits

ATM Endpoints

- (Workstations)
- Routers, LAN switches
- Digital service units (DSUs)
- Video coder-decoders (CODECs)
- …

ATM virtual circuits

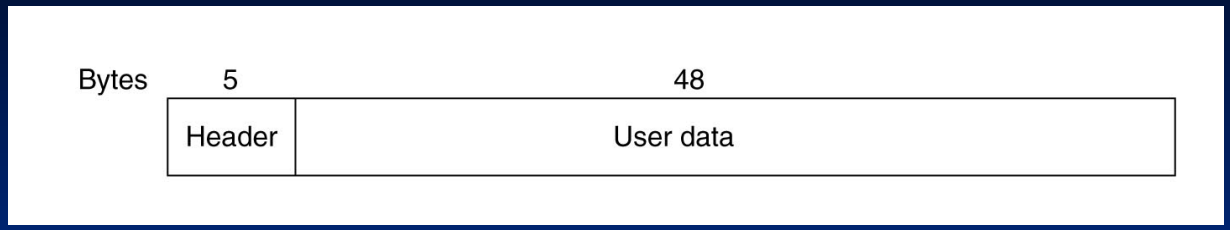
- Each cell carries virtual circuit identifier in it's header (VPI+VCI)
  - some VPI/VCIs reserved for signalling and management
- Permanent and switched virtual circuits (PVC, SVC)
  - PVC: manual setup, no network resiliency
  - SVC: signalling protocol needed
- Virtual circuits are QoS-enabled
  - separate QoS contract can be appointed in each direction

- Point-to-point (unidirectional/bidirectional) VCs
- Point-to-multipoint (unidirectional) VCs

VPI and VCI

- VPI+VCI together identify virtual circuit
- virtual path
  - identified by virtual path identifier (VPI)
  - bundle of virtual channels, all of them can be switched transparently across the ATM network as a bundle (based on the common VPI)
- virtual channel
  - identified by the combination of a VPI and VCI

ATM Cell



- Total cell length is 53B
- Fixed and short payload length (48B)
  - short and deterministic delay – priority cells can be sent without waiting for finish of transmission of previous long packets
  - well suited to transfer voice and video intolerant of delays and delay variation
  - 48 B is trade-off between 32 and 64B suggestions

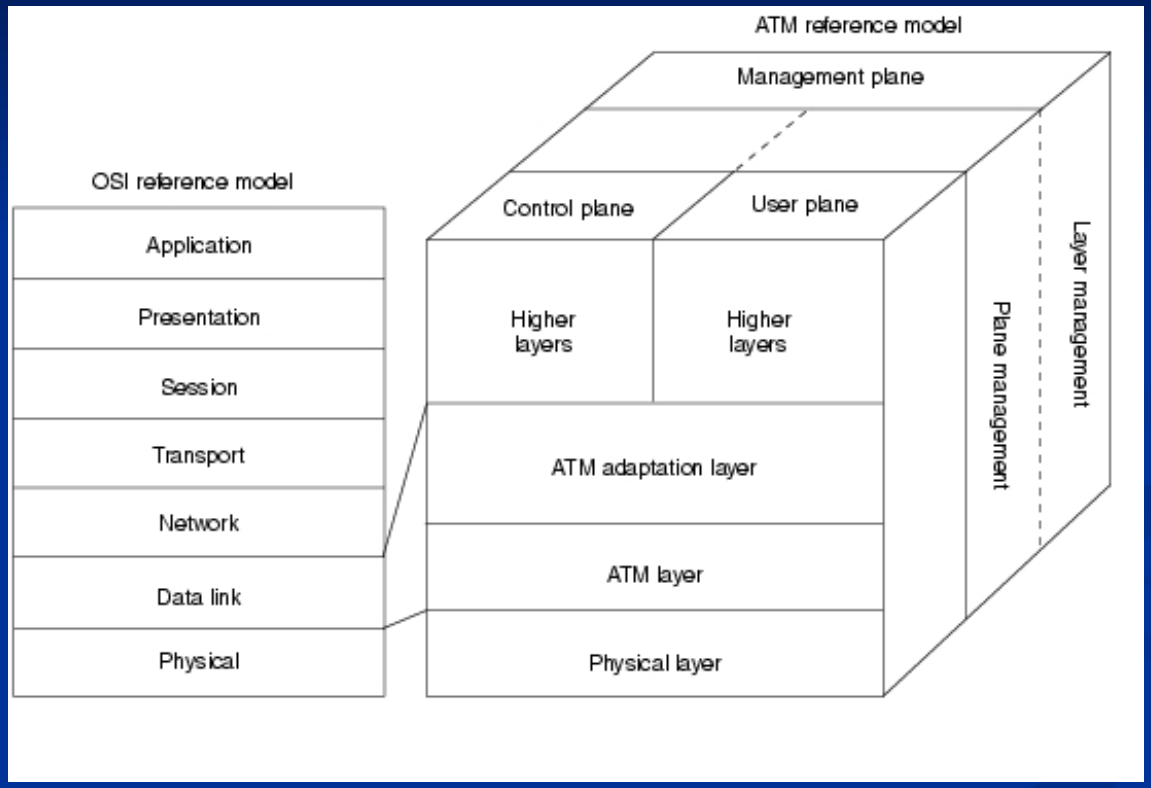
ATM Cell header

- VPI, VCI - Virtual Path Identifier, Virtual Circuit Identifier
  - identify virtual circuit (local significance)
- PT - Payload Type
  - Bit 1: cell carries data / system control & management
  - Bit 2: congestion notification
  - Bit 3: indicates whether the cell is the last in a series of cells that represent a single frame (AAL5)
- CLP - Cell Loss Priority
- HEC - Header Error Control
  - can correct a single bit error in header
- Generic Flow Control (GFC)
  - Provides various local functions (typically not used)

Idle cells have reserved header bit pattern

ATM layers and reference model

ATM Reference model (Comparison with OSI RM)



Picture from http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/atm.htm

Covers physical layer and part of data link layer

ATM Reference model planes

- **Control -** responsible for signalling
- **User -** responsible for data transfer
- **Management**
  - Layer management manages layer-specific functions, such as the detection of failures and protocol problems
  - Plane management manages and coordinates functions related to the complete system

Physical layer

- Manages medium-dependent issues
  - Converts cells into bitstream
    - and packages it into frames of underlying technology (SDH, E3, …)
  - Tracks for cell boundaries
- Uses various media, various transfer rates
  - plesiochronous hierarchy (E/T lines), SDH/SONET, dark fiber, TP, …

ATM layer

- Switches cells according to switching table
  - forwarding + VPI/VCI rewrite
- Controls sharing of physical link by multiple VCs
  - negotiated VC QoS parameters have to be fulfilled
- Controls SVC connection establishment
  - connection setup (including setup request routing and switching table creation) decoupled from fast switching process

ATM Adaptation layer

- isolates higher-layer protocols from details of the ATM network
  - prepares user data for conversion into cells
  - segments data into 48-byte cell payloads
- Adapts existing upper-layer services to ATM
- Multiple adaptation layer types defined in for various user service classes (AAL1-AAL5)
  - connection-oriented synchronous constant bit rate (AAL1)
  - bursty variable bit rate traffic with constrained timing requirements (AAL2)
  - connection-oriented or connectionless data (AAL5)

ATM QoS

ATM Traffic Classification

- Constant Bit Rate (CBR)
  - isochronous applications like digitalized voice (AAL1)
- Variable Bit Rate (VBR)
  - bursty data transfer (MPEG video)
- Available Bit Rate (ABR)
  - guarantees minimal flow bitrate, tries to reach better
  - implements flow-control
- Unspecified Bit Rate (UBR)
  - no obligatory bitrate

Examples of ATM VC QoS parameters

- Peak Cell Rate
- Sustained Cell Rate
- Minimum Cell Rate
- Cell Delay Variation
- Cell Loss Ratio
- Cell Transfer Delay
- Cell Error Ratio,Cell Misinsertion Ratio, Severely Errored Cell Block Ratio
  - not appointed, given by network nature

ATM Addresses

- Identify ATM end systems
  - Needed for SVC establishment
- ITU-T dictates use of E.164 addresses
  - similar to telephone numbers
- ATM Forum defines extended ATM addresses for private networks
  - 20B ATM address (OSI NSAP-based, hierarchical)
  - ATM address resolution protocol (ATM ARP) may be used to map higher-layer addresses to their corresponding ATM addresses.

Signalling and SVC Establishment Request Routing

Building of SVC

- Messages similar to ISDN signalling
  - VPI = 0, VCI = 5
- Request contains peer endpoint's ATM address and QoS parameters required
- Switch-by-switch request forwarding and VC establishment
  - building of switching tables in ATM switches
  - routing needed to find way to the opposite endpoint
  - if no resources available on some path, request backtracks and tries to find another route (cranckback)
  - final destination either accepts or rejects the connection request
- Routes calculated based on topology information and Generic Connection Admission Control (GCAC) algorithm
  - GCAC used to guess whether ATM switch accept another connection or not

Connection request routing protocols

- Interim Inter-switch Signalling Protocol
  - Static routing (manual route setup)
- Private-NNI
  - discovers ATM topology
  - link-state protocol (same principle as OSPF)
  - Multiple metrics, load balancing support

Routing protocols have to find alternate paths if shortest one cannot fulfill required QoS parameters because of insufficient resources

Integrated Local Management Interface (ILMI)

- Enables devices to determine status of components at the other end of a physical link and to negotiate a common set of operational parameters
  - e.g. ATM address prefix

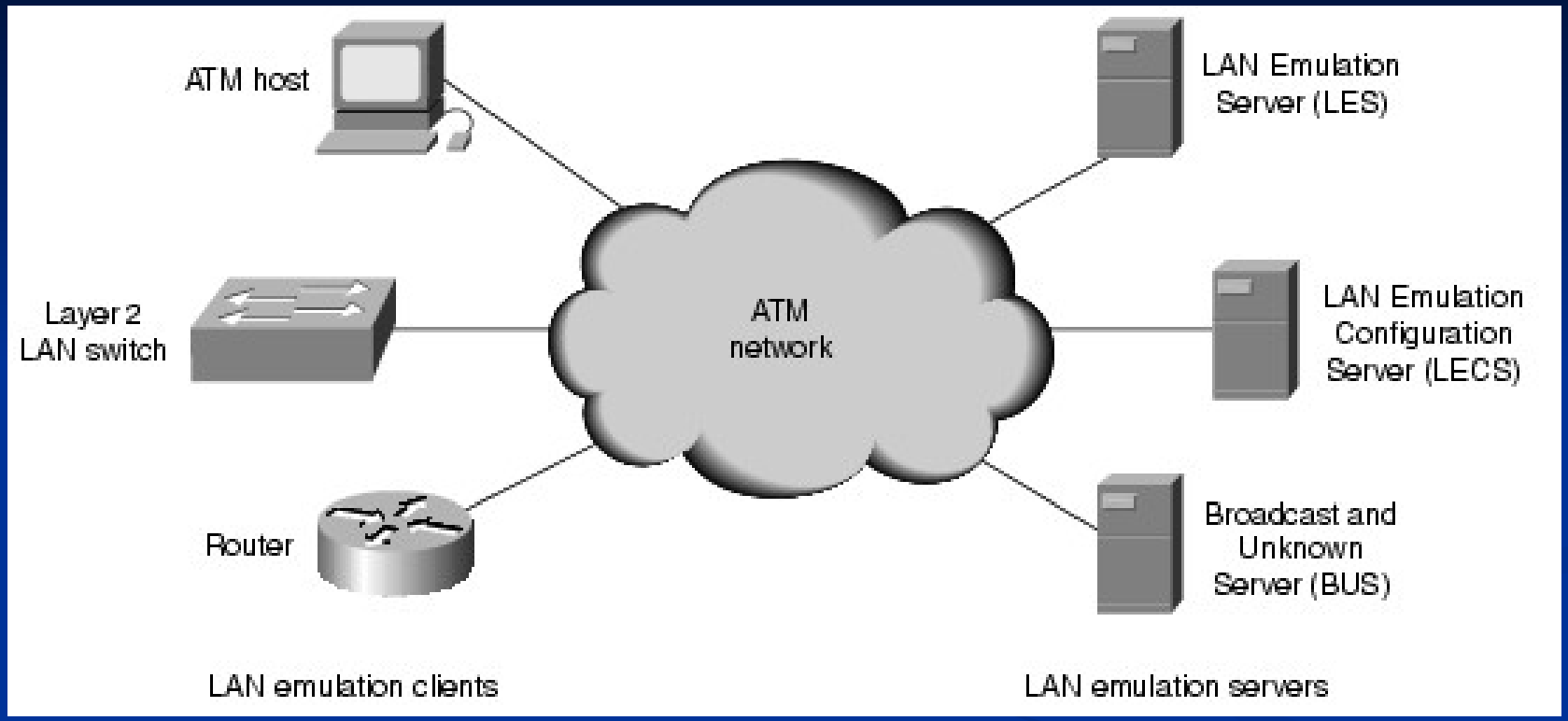
Usage of ATM for Data Transfers

LAN Emulation - LANE

LAN Emulation

- Gives to stations attached via ATM the same capabilities that they normally obtain from legacy LANs
- LAN emulated on OSI layer 2
  - ELAN emulates one LAN segment
- Emulates IEEE 802.3 Ethernet or an 802.5 Token Ring LAN
  - does not attempt to emulate the actual MAC protocol of the specific LAN (CSMA/CD for Ethernet or token passing for IEEE 802.5).
  - does not support QoS
  - defines a service interface for network layer protocols that is identical to that of existing LANs
- LANE operation is transparent to ATM switches
  - uses only standard ATM SVC signaling
  - no need of ATM switch modification
- LANE protocol maps MAC addresses to ATM addresses, so that LANE end systems can set up direct connections between themselves to forward data

LANE Components



Picture from http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/atm.htm

LANE components are implemented by SW in some ATM switch or LAN switch/router with ATM interface

LAN Emulation Client (LEC)

- entity in end system (station or router/switch) that performs
  - MAC-to-ATM address resolution
  - registration of MAC addresses behind it with the LAN Emulation Server
  - connection establishment to other LECs and data forwarding
- Provides a standard LAN interface to higher-level protocols on legacy LANs
- If end system connects to multiple ELANs, it has one LEC per ELAN

LAN Emulation Server (LES)

- maintains a list of MAC addresses in the ELAN and the corresponding ATM addresses of LECs
- LECs registers MAC addresses behind them with LES
- can answer questions from LECs wanting to obtain an ATM address corresponding to given MAC address

One LES exists per ELAN

Broadcast and Unknown Server (BUS)

- used to flood traffic to yet-unknown destination addresses and broadcast traffic to all end-systems behind all LECs within a particular ELAN
- Each LEC is associated with BUS for every ELAN

LAN Emulation Configuration Server (LECS)

- maintains a database of LECs and ELANs to which they belong
- accepts queries from LECs and responds with the appropriate ELAN parameters
  - ATM address of the LES

One LECS per administrative domain serves all ELANs within that domain.

Classical IP over ATM (CLIP)

Classical IP over ATM Architecture

- Defined in RFC 1577
- Uses ATM ARP to map IP addresses to ATM addresses
- Mappings maintained at ATM ARP server
  - ATM ARP server operates in scope of Logical IP Subnet (LIS)
  - Every node of LIS register it's ATM and IP address with ATM ARP server
- Communication between LIS has to pass router
- Typical MTU 9kB

ATM position today

- Telco company backbone (some advantages over SDH)
  - very flexible
  - allows VBR VCs (videoconferencing)
  - used as infrastructure for Frame Relay service VCs
- A few year ago, it was considered a promising backbone technology of campus networks
  - Shifted out today and replaced by (10)Gigabit Ethernet
    - much more simpler administration, cheaper
- Lot of today-s technologies use ATM principles at physical layer
  - DSL
  - IEEE 802.16
    - (Wireless Local Loop, WiFi replacement for MANs)

For Further Study

See full version of ATM presentation for additional details