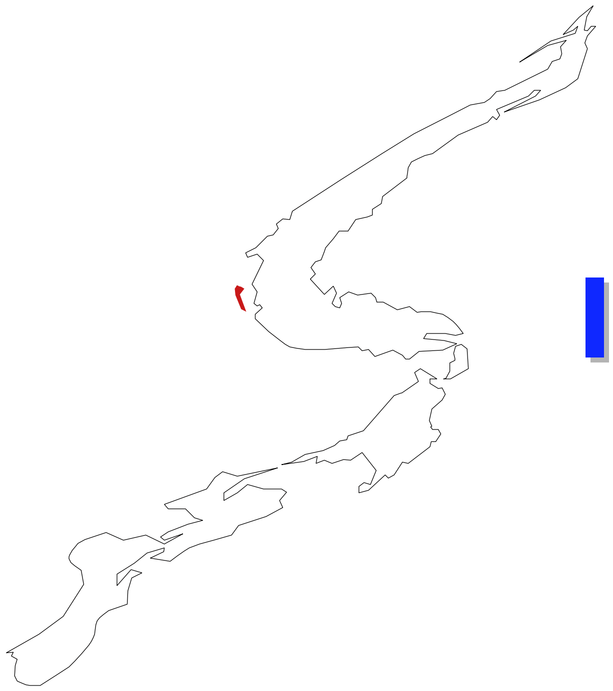
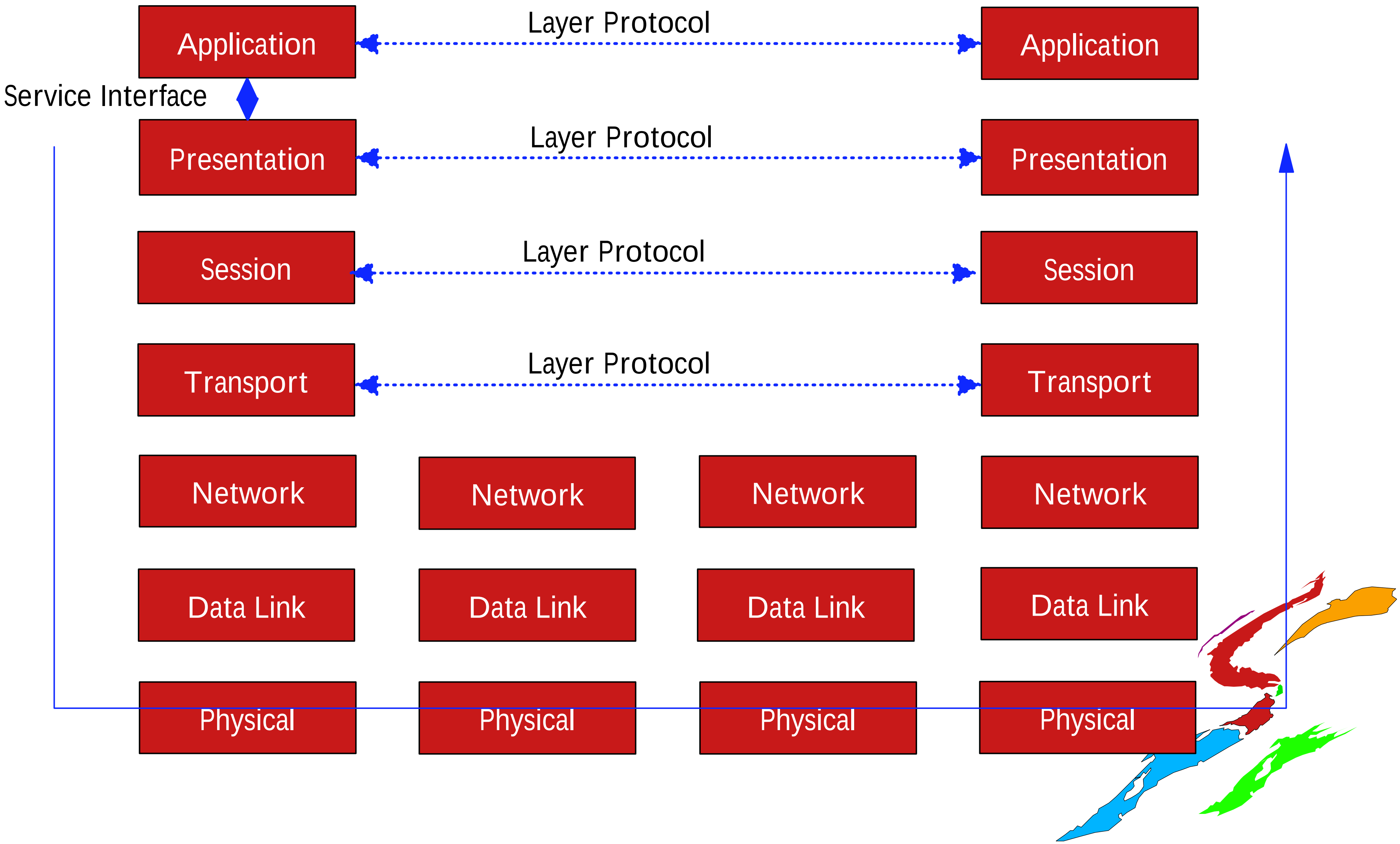


Introduction to Layering

Dr. G. A. Marin

OSI Reference Model



Layers, Services, Protocols

- Layers: offer services to higher layers that are requested by parameters being passed to service access points (SAPs).
- Services: A set of primitives (operations) that a layer can perform for its users
- Protocol: is a set of rules governing the format and meaning of frames, packets, or msgs exchanged by peer entities. Protocols implement the services.

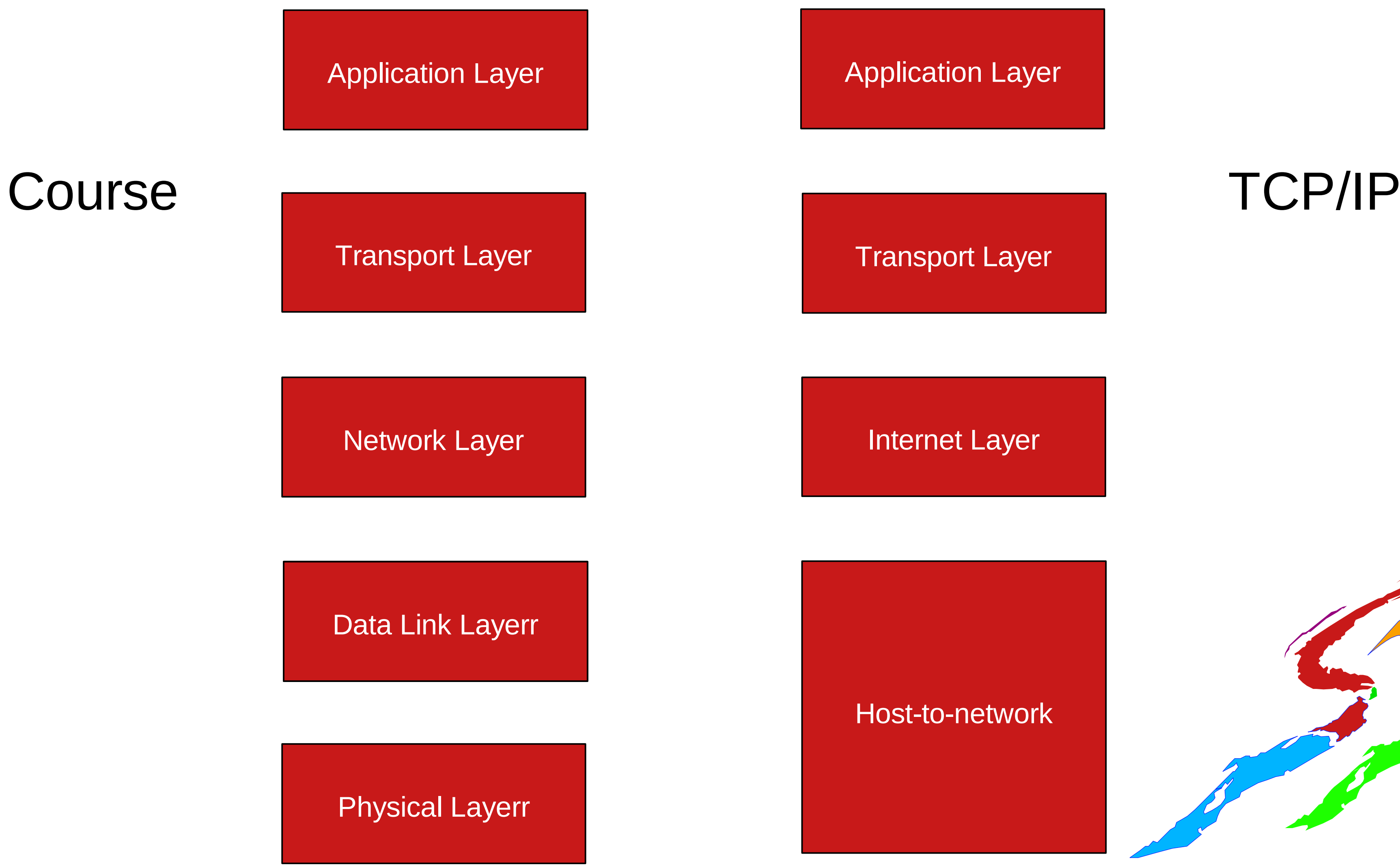
Layer Overview

- Physical Layer: Transmits bits over comm channel. How to represent bits and ensure reception. (Physical medium lies logically below.)
- Data Link Layer: Takes raw transmission facility and transforms to line free of undetected transmission errors. Sends data frames. Retransmits if needed. Flow control usually provided.
- Network Layer: Gets packets from source to destination across a network. Provides routing, network congestion control (call admission), net - net i/f, perhaps accounting to support net mgt.
- Transport Layer: Accept data from session layer, segmentation & reassembly if needed, pass to network layer, assure all pieces arrive safely at other end. First end-to-end layer. Multiplexing, flow control

Layer Overview (continued)

- Session Layer: Provides enhanced services to certain applications over those provided by transport layer. Synchronization as example.
- Presentation Layer: Provides additional functions such as translation among different character, numerical, and bit-string representations.
- Application Layer: Supports protocols needed by applications such as network virtual terminal, file format conversions, electronic mail, remote job entry, etc.

TCP/IP & Course Reference Models



TCP/IP Layer Overview

- Internet Layer: Heart of the Internet architecture. Hosts insert packets into IP network that travel independently to destination (over distinct subnets). Implements the IP (Internet Protocol) "protocol." Routing and network congestion avoidance are key issues.

- Transport Layer: End-to-end peer protocol as in OSI model. Two protocols defined: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). TCP is reliable and connection-oriented. Supports segmentation and reassembly (with sequence no's) as well as flow control. UDP is unreliable and connectionless. Used with aps that do their own thing or voice or video or…

TCP/IP Application Layer

- Contains all higher level protocols including:
  - Telnet virtual terminal protocol
  - FTP file transfer protocol
  - SMTP Simple Mail Transfer Protocol
  - DNS Domain Name Service
  - HTTP World-Wide-Web page trasfer protocol

Design to Application Requirements

- Message arrival rate: Simple models includ Poisson arrivals, deterministic arrivals, uniformly distributed arrivals
  - Messages often segmented into packets in data comm nets
- Session holding time
- Expected message length and distribution of length
- Allowable delay (examples)
  - realtime control: millisecs (includes voice)
  - terminal interaction: 1 or 2 secs
  - file transfer: minutes
- Reliability: (examples)
  - error free: banking or medical imaging
  - occasional bit error ok: email
  - loss of packet and/or bit ok: packetized voice
- Message and packet ordering: packets in a message must either be maintained in correct order or re-ordered before being presented to many applications. How to handle order and what to retransmit are key design issues.

Four representative applications

- Interactive terminal sessions
  - short messages
  - low message rate
  - moderate delay requirements
  - high reliability
- File transfer sessions
  - long messages
  - very low message rate
  - relaxed delay requirement
  - high reliability

Four representative applications *(continued)*

- High resolution graphics
  - long messages (10**9 bits)
  - low message rate
  - stringent delay requirement
  - high reliability
- Packetized voice
  - message concept not useful
  - packets short and packet arrival rate high
  - max delay requirement is stringent
  - low reliability

Example Networks

- System Network Architecture (SNA)
  - IBM's networking architecture used by 10,000+ business networks
  - Mainframe model of computing...hierarchical
  - Followed by Advanced Peer-to-Peer Networking (APPN) architecture
- Novell Netware
  - Predominant PC-based network architecture...client/server model...downsizing
  - Proprietary protocol stack derived from XNS...similarities to IP
  - IPX uses 10-byte vs 4-byte (IP) addresses
  - Network Core Protocol (NCP) for connection-oriented transport

Example Networks (continued)

- ARPANET
  - Funded by Advanced Research Projects Agency (ARPA) in early 60s as command/control network
  - Introduction of packet-switching (vs circuit-switching)
  - Hosts connected to subnet of IMPs (Interface Msg Processors)
  - See Fig 1-25 on p 49: Growth of Arpanet
  - Led to invention of TCP/IP model in 1974 (Vint Cerf & Bob Kahn)
  - Protocols integrated into Berkeley UNIX (by BBN) and provided free with UNIX license...explosive!

Example Networks (continued)

- NSFNET
  - Designed by National Science Foundation as highspeed successor to ARPANET for university access
  - First connected six supercomputer centers: San Diego, Boulder, Champaign, Pittsburgh, Ithaca, Princeton
  - First TCP/IP WAN
  - Eventually 20 regional networks connected to backbone
  - In 1990 ANS (Advanced Networks and Services) took over and renamed ANSNET...45 mbps links & first step towards commercialization
  - In 1995 ANSNET sold to AOL and regional networks went to commercial service

Example Networks (Continued)

- Internet
  - In mid-80s this collection of IP-based networks began to be viewed as "the Internet"
  - Growth exponential
  - Defn: Machine on Internet if runs TCP/IP, has IP @, and sends IP packets to other internet hosts
  - Internet Society founded in Jan 1992
  - WWW (Word-wide Web) application brought millions of non-academic users to Internet in early 90s (web pages, links, ubiguitous URLs)

1.6.1 SMDS - Switched Multimegabi Data Service

- A public network service that connects multiple LANs efficiently
- Designed 1980s and deployed 1990s
- Offers lower tariffs than point-to-point interconnect
  - Avoid leasing of multiple trunks
  - Designed for bursty traffic
- Typically 45 mbps
- connectionless, best-effort, variable-length payload (1-28)
- @s based on 4-bit encoded decimal telephone numbers
- Broadcast service available
- Incoming and Outgoing screening available
- Enforces an average rate

SMDS Average Rate Example

Assume 45 mbps line with counter (per line) incremented 1/(10 usecs). This is a byte counter. Upon packet arival, packet sent if counter>packet bytes; else discarded!

1 byte/10 usecs = 100,000 bytes/sec on average.

User may burst at line speed:

- If line idle 10 ms, counter = 1000. Can send 1000 bytes at full line speed of 45 mbps.

1.6.2 X.25 Networks

- A standard developed by CCITT (now ISO) in 1970s
- Defines the user/network (or host/network) interface
- Physical layer is X.21 - mostly analog RS-232 used instead
- Network layer handles addressing, flow-control, delivery confirmation
- User establishes a "virtual circuit" and sends max 128 byte packets reliably and in order.
  - both permanent and switched virtual circuits (PVC,SVC)
- Flow control ensures fast sender does not swamp receiver
- For non-X.25 terminals a Packet assembler/disassembler is used (PAD)
  - Terminal - X.28 - PAD - X.29 standards also defined.
- Note: X.25 limited to 64 kbps; widespread in Europe

1.6.3 Frame Relay

- Also connection-oriented standaard for moving bits generally across a public network.
- Takes advantage of fact that leased lines are now fast, digital, reliable --> simple protocols.
- Predominantly a virtual leased line (PVC) today.
- Frames can be up to 1600 bytes and carry a number (dlci) identifying the virtual circuit.
- Contract with carrier for an average service
  - burst allowed as in SMDS
- Generally operates at T1 (1.5mbps) or above
- FR determines start and end of frame, detects some transmission errors, discards bad frames.
- No flow control yet defined only a CI bit.

B-ISDN architecture

- envisioned for *universal networking...*

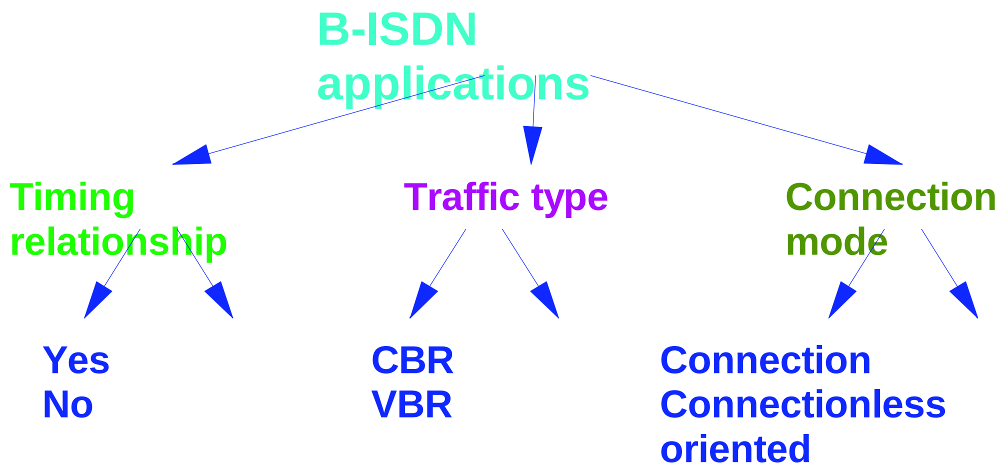
- integrated networking
  * *voice, video, data, and image in the same network*

- scaleable in distance
  * *LAN, MAN, WAN*

- scaleable in bandwidth
  * *1.5 Mbps to several Gbps*

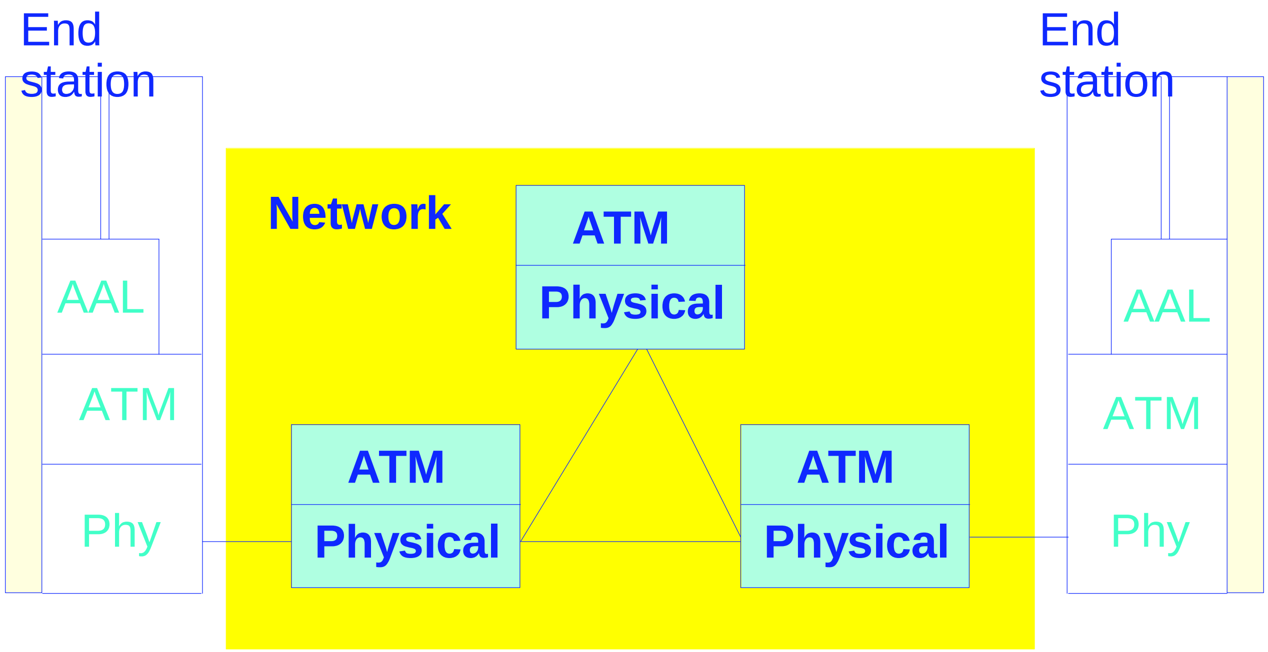
B-ISDN Services

B-ISDN supports switched, semi-permanent and permanent, point-to point and point-to-multipoint connections and provides on demand reserved and permanent services. Connections in B-ISDN support both circuit mode and packet mode services of a mono and multimedia type and of a connectionless and connection oriented nature and in bidirectional and unidirectional configurations.



All integrated in the network

Asynchronous Transfer Mode (ATM)



An ATM network provides an ATM layer connecttivity among ATM end stations