Welcome

OSI Layer 1-4 Overview

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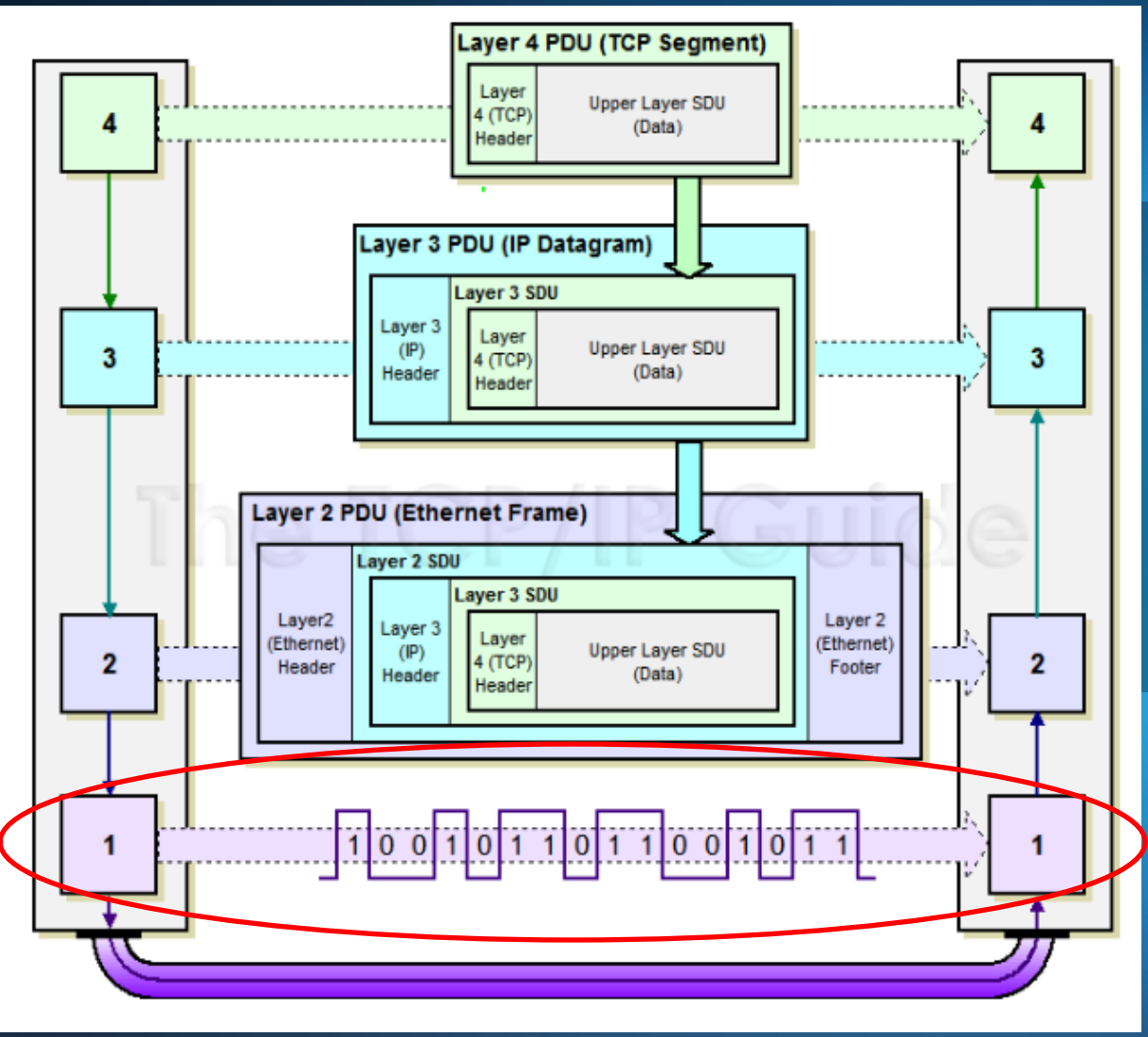
3/24/2011

EXFO | Assessing Next-Gen Networks

OSI Layers 1-4

Layer 1 – Physical Layer



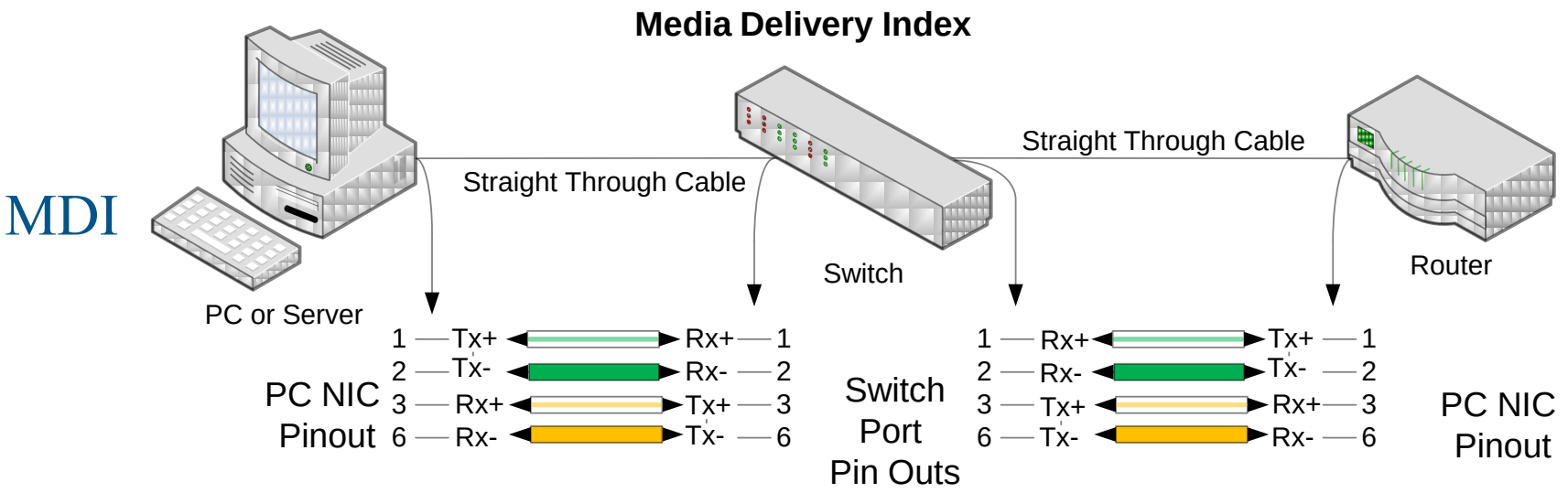
Physical Layer – Fiber/Copper/COAX

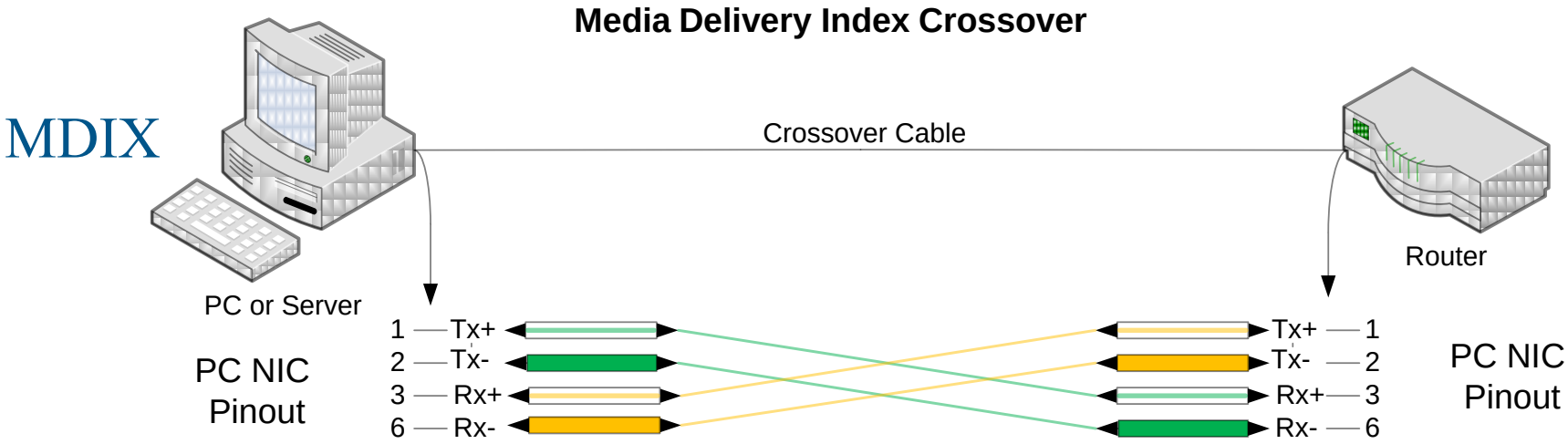
Physical Layer defines the electrical, mechanical, procedural and functional specifications for activating , maintaining and deactivating the physical link between communicating network systems

Bandwidth Comparison Chart

Line Size	Data Speed	# of DS0's	# of DS1's	Is Equal to	European Equivalent
DS0	64 Kbps	1	-	-	64 Kbps
DS1	1.544 Mbps	24	1	-	-
-	2.048 Mbps	32	-	-	E1
DS1C	3.152 Mbps	48	2	-	-
DS3	44.736 Mbps	672	28	-	E3
DS4	274.760 Mbps	4,032	168	-	-
OC1	51.84 Mbps	672	28	1 DS3	-
OC3	155.52 Mbps	2,016	83	3 DS3's	STM1
OC9	466.56 Mbps	6048	252	9 DS3's	-
OC12	622.08 Mbps	8,064	336	4 OC3's	STM4
OC48	2.488 Gbps	32,256	1,334	16 OC3's	STM16
OC192	9.953 Gbps	129,024	5,376	64 OC3's	STM64
OC255	13.271 Gbps	169,320	7,055	85 OC3's	-
OC768	39.813 Gbps	516,096	21,504	4 OC192's	4 STM64's

MDI or MDIX





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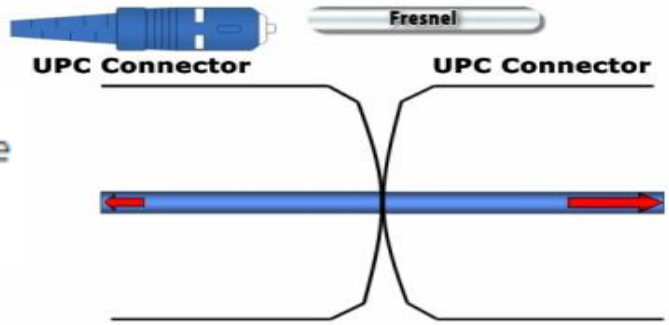
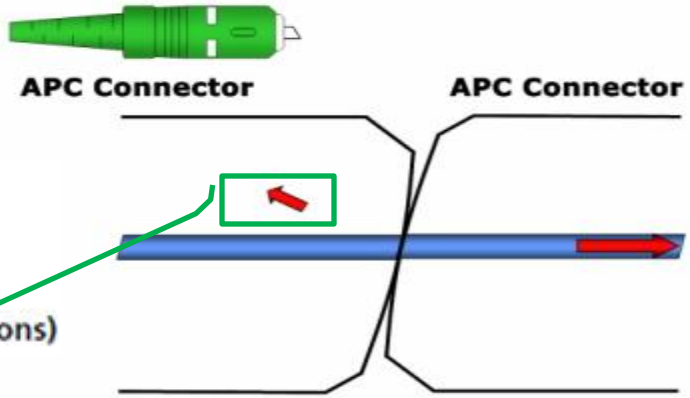
UPC or APC?

UPC Polish
Light is reflected back down to the core
Return Loss = -55 dB
(Adequate for most applications)



8° Angled Polish
Light is reflected into the cladding
Return Loss = -65 dB
(0.0001% of power reflected back)
(ideal for video and single fiber applications)



UPC

Insertion loss:

<.5 dB

Reflectance:

< -55 dB

APC

Insertion loss:

<.5 dB

Reflectance:

< -65 dB

APC connectors are a better design to reduce optical return loss, not optical loss.

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Connector Cleaning & Inspection

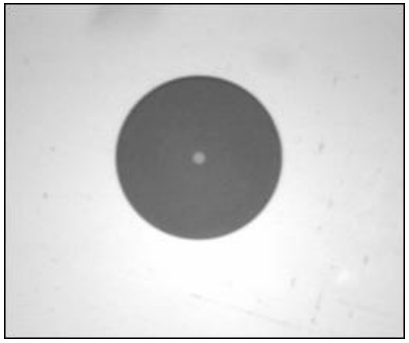
- Cleaning Techniques:
- The best way to clean connectors can be done by following three easy steps:

1. Clean the ferrule using a *wet pad* or chemical cleaner

2. Dry the connector using a *dry pad* or a *cletop reel*

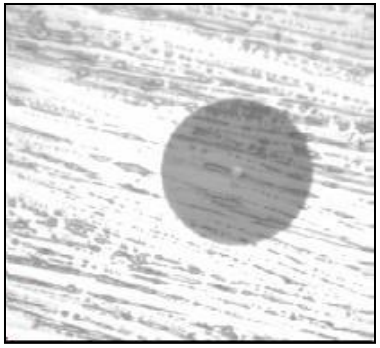
3. Inspect the connector using a video inspection fiber probe

Perfect

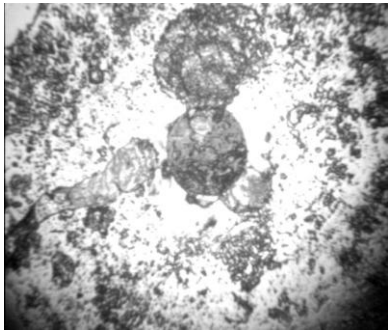


Clean Connector

Clean and Verify

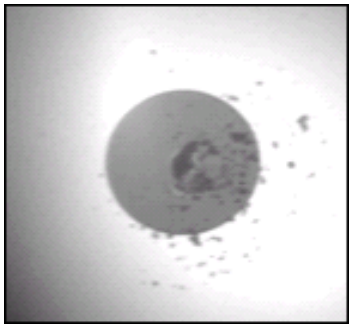


Dirty Connector



What a mess!

Replace



Damaged connector

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Terms to Know

Index of Refraction

Refractive Index = A property of optical materials that relates to the speed of light in the material versus the speed of light in a vacuum.

The **index of refraction** of a substance is a measure of the speed of light in that substance. The velocity of light travels slower any given material, or medium.
A simplified, mathematical description of refractive index is as follows:
n = velocity of light in a vacuum / velocity of light in medium Hence, the refractive index of water is 1.33, meaning that light travels 1.33 times as fast in a vacuum than it does in water.
As light exits a medium, such as air, water or glass, it may also change its propagation direction in proportion to the refractive index.
Refractive index of materials varies with the frequency of radiated light. This results in a slightly different refractive index for each color. The cited values of refractive indexes, such as 1.33 for water.

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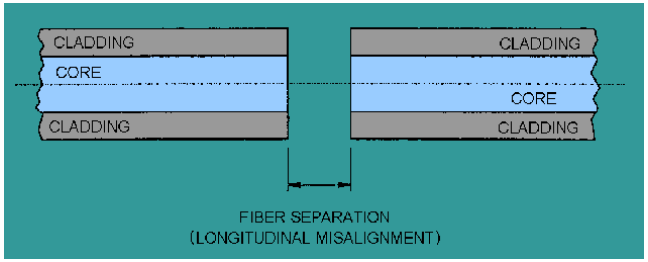
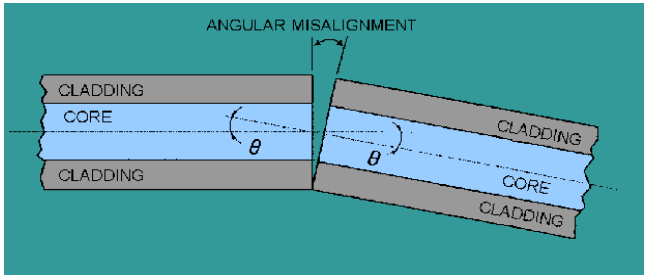
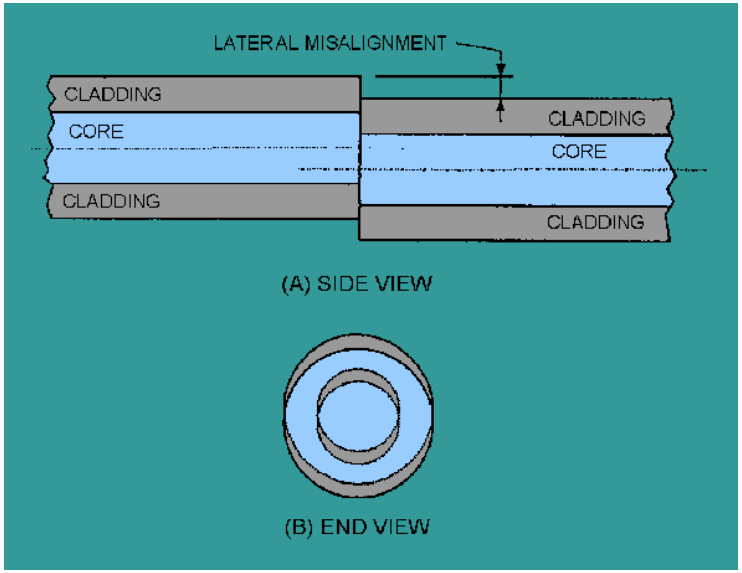
Fresnel Back Reflection

When optical fibers are connected, optical power may be reflected back into the source fiber. Light that is reflected back into the source fiber is lost. This reflection loss, called Fresnel reflection, occurs at every fiber interface. **Fresnel reflection** is caused by a step change in the refractive index that occurs at the fiber joint. In most cases, the step change in refractive index is caused by the ends of each fiber being separated by a small gap. This small gap is usually an air gap. In Fresnel reflection, a small portion of the incident light is reflected back into the source fiber at the fiber interface.







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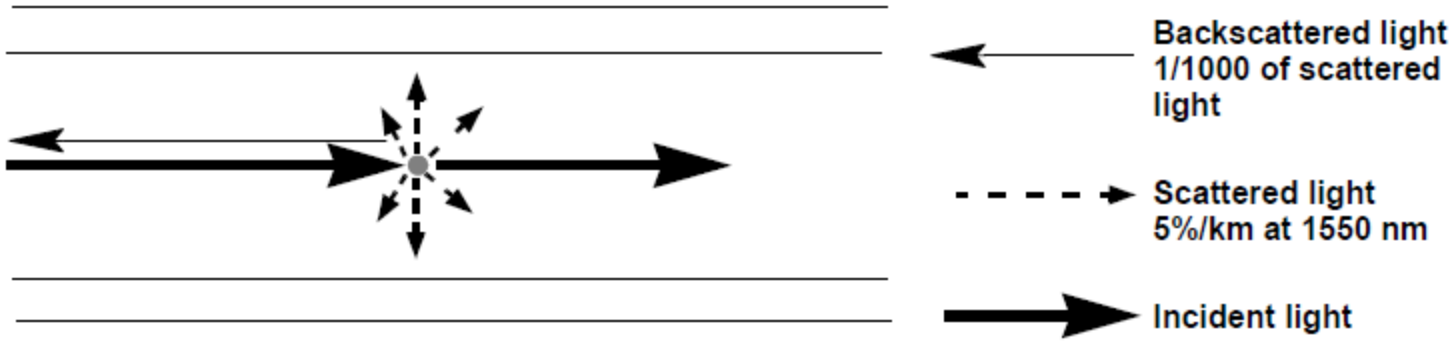
Rayleigh Scattering - Attenuation

One of the two contributing factors to optical loss is Rayleigh scattering. When a pulse of light propagates through a fiber, some of the photons of light are scattered in random directions from microscopic particles. This is a decrease in average optical power (attenuation) as the pulse travels to the receiver.



Rayleigh scattering provides amplitude information along the length of the cable to the OTDR. Without this scattering, the OTDR could not give us a trace.

Higher density of dopants in a fiber will also create more scattering and thus higher levels of attenuation. Example: flashlight in a fog at night

Typical Fiber Specifications			
Name	Attenuation (dB/km)		
Singlemode	1310 nm = 0.33	1490 nm = 0.21	1550 nm = 0.19
Multimode	850 nm = 2.74	1300 nm = 0.52	

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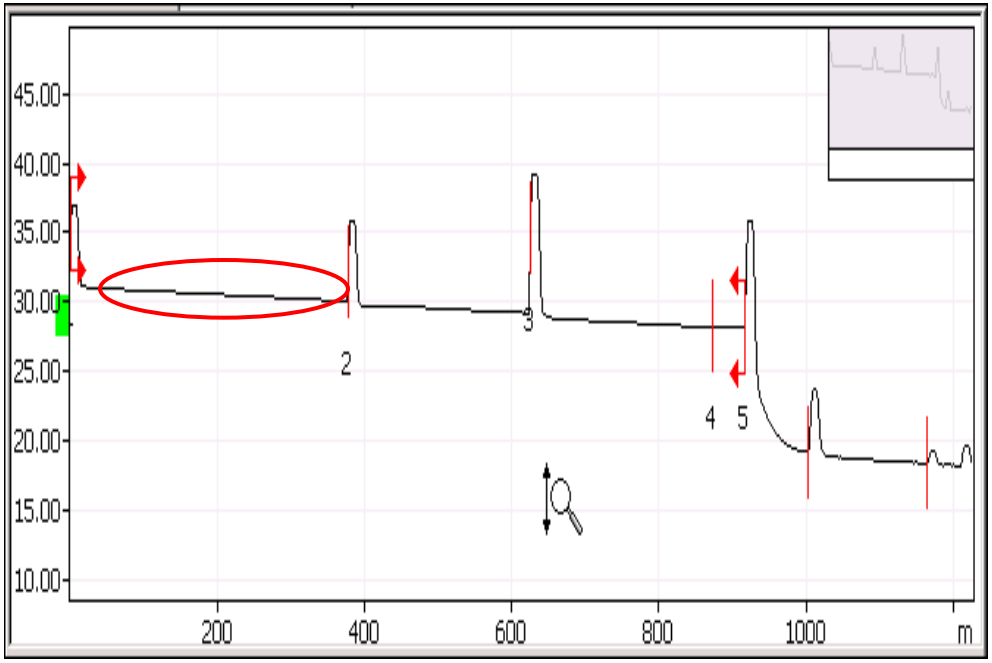
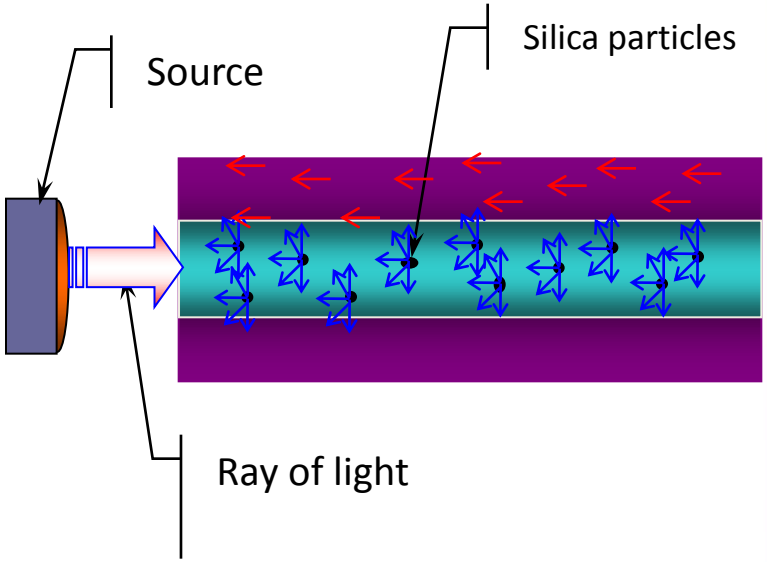
Rayleigh Backscattering

- The scattering of electromagnetic radiation by particles with dimensions much smaller than the wavelength of the radiation, resulting in angular separation of colors and responsible for the reddish color of sunset and the blue of the sky.
- Comes from the “Natural” reflection of the fiber
- The OTDR will use the Rayleigh back reflections to measure fiber’s attenuation (dB/Km)
- Higher wavelength will be less attenuated by the Rayleigh Backscatter





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Insertion Loss Versus Optical Return Loss

Why should ORL be reduced to a minimum?

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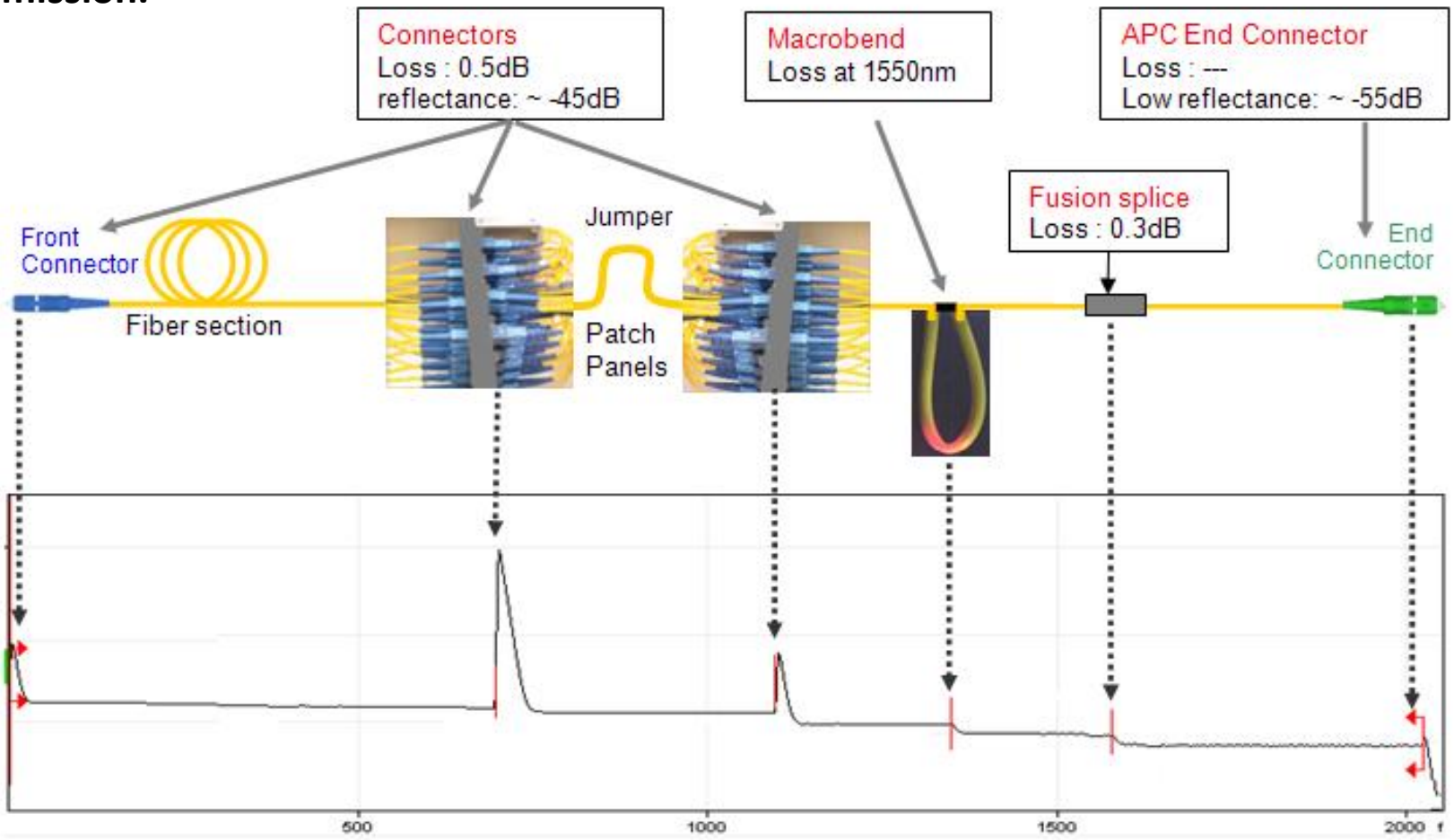
Insertion Loss

What is Insertion Loss?

Insertion loss is the loss of signal power resulting from many factors in optical transmission.



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Optical Return Loss Testing—

Ensuring High-Quality Transmission

Optical Return Loss (ORL)

What contributes to ORL?

Rayleigh backscattering: intrinsic to the fiber and cannot be completely eliminated.

Fresnel backreflections: caused by different network elements (mainly connectors and components) this can always be improved by special care or better design.

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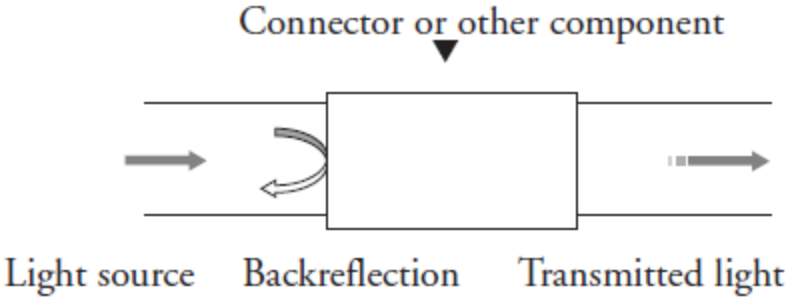
WHAT IS OPTICAL RETURN LOSS (ORL) (dB)

- We use the term « ORL » when speaking of the amount of energy returned by a section or an entire link
- ORL testing measures the difference between the amount of light a source sends out, and the amount of light that returns to the source. Optical return loss has always presented a significant challenge because it reduces the amount of light eventually transmitted.
- Simply put, ORL is amount of **energy** lost within components and fiber due to back reflections
- ORL is a measurement, from one end, of the total energy reflected back to the source by all the interfaces due to a variation of the index of refraction (IOR)
- Expressed as a positive value



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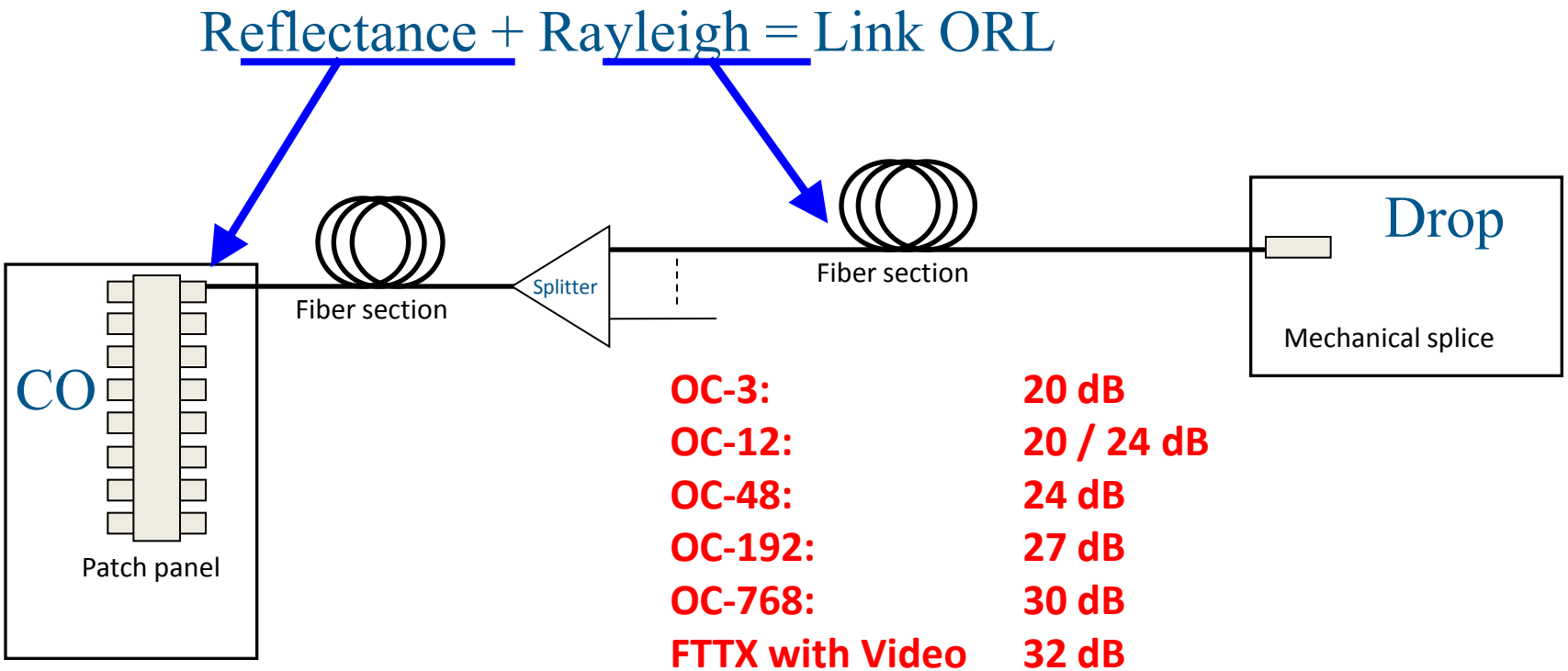
ORL (dB)
A few examples



OC-3:	**20 dB**
OC-12:	**20 / 24 dB**
OC-48:	**24 dB**
OC-192:	**27 dB**
OC-768:	**30 dB**
FTTX with Video	**32 dB**

Accepted ORL values in the telecom industry vary according to the type of connector:

- UPC (Ultra-Polish physical contact) is between 35 and 55 dB.
- APC (angle physical contact) can vary between 55 to 70 dB.

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OTDR Optical Time Domain Reflectometer

What Makes it Tick?

OTDR – Optical Time Domain Reflectometer

How does the OTDR acquire data and create a trace?
OTDRs launch short duration light pulses into a fiber and then measures the optical signal returned to the instrument.
Raleigh scattering and **Fresnel reflections** are physical causes for this behavior. By measuring the **arrival time and amplitude** of the returning light, the locations and magnitudes of faults can be determined and the fiber link can be characterized.

Pulse length	Event Dead zone
1 nsec	0.15 m (theoretically)
10 nsec	1.5 m (theoretically)
100 nsec	15 m
1 µsec	150 m
10 µsec	1.5 km
100 µsec	15 km

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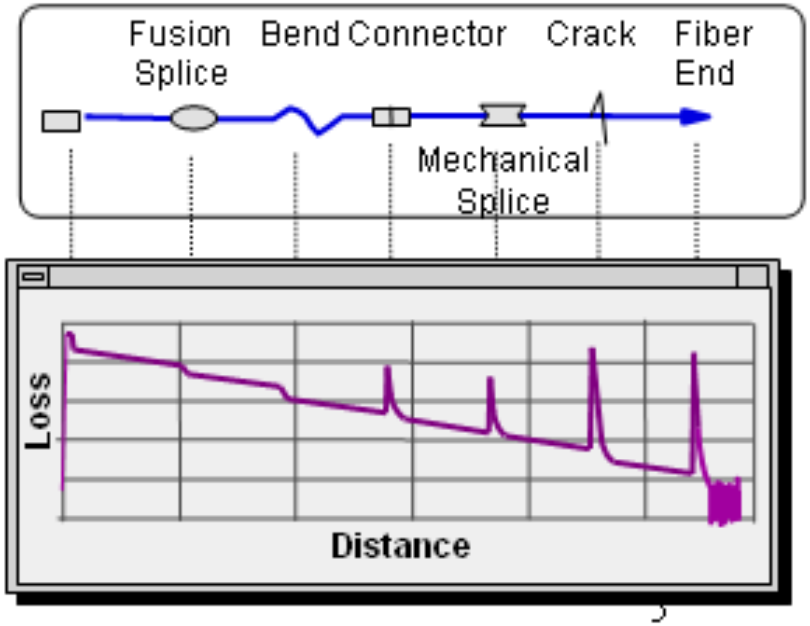
OTDR Testing—What Can an OTDR Do?

An OTDR is an optical radar that can measure:

Break points
Splice and connector losses
Point-to-point distances
Total cable length
Connector quality (return loss)
Fiber attenuation

An OTDR is used for:

Installation and commissioning
Maintenance
Emergency restoration
Fiber identification
Characterization



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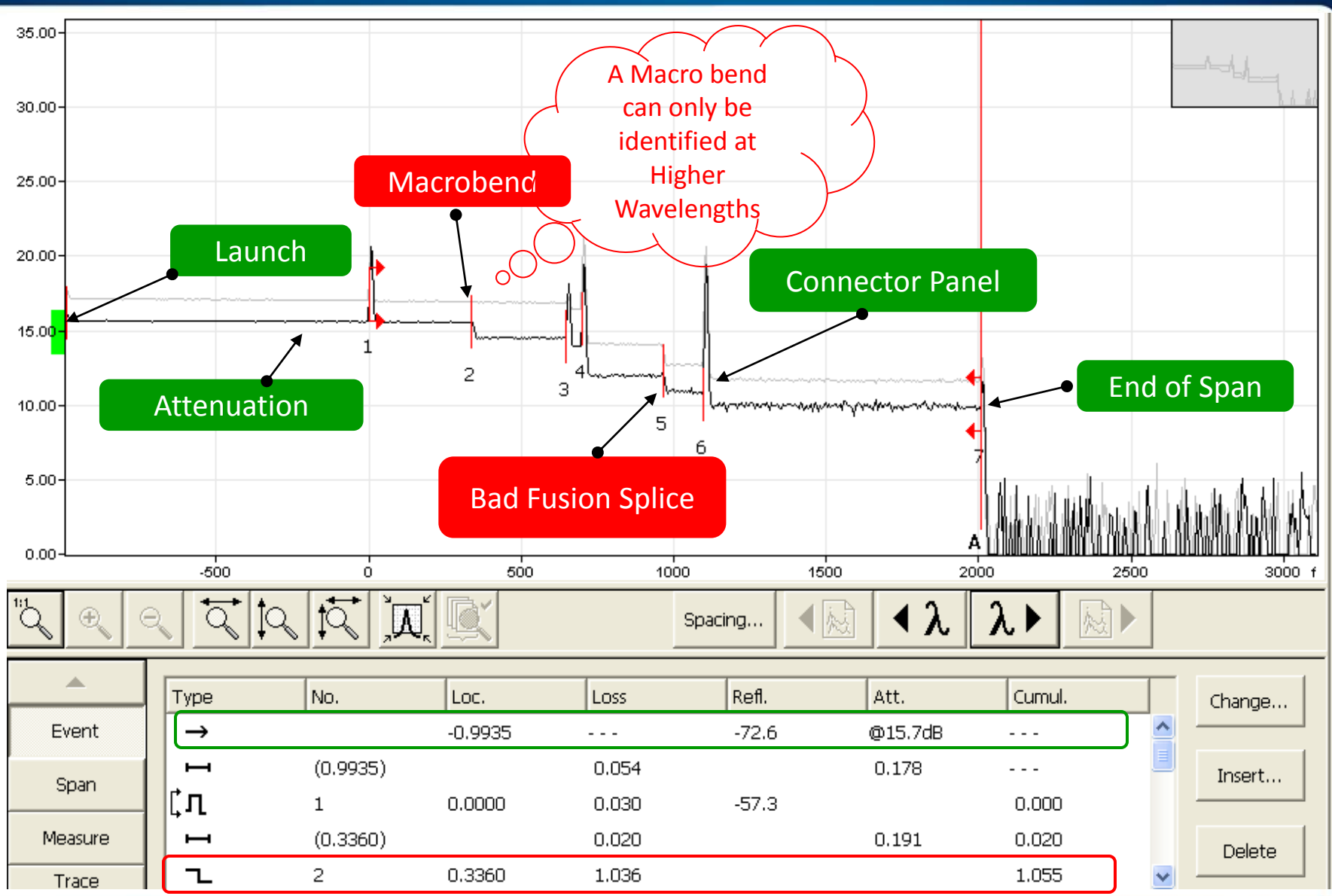
OTDR Trace - Events



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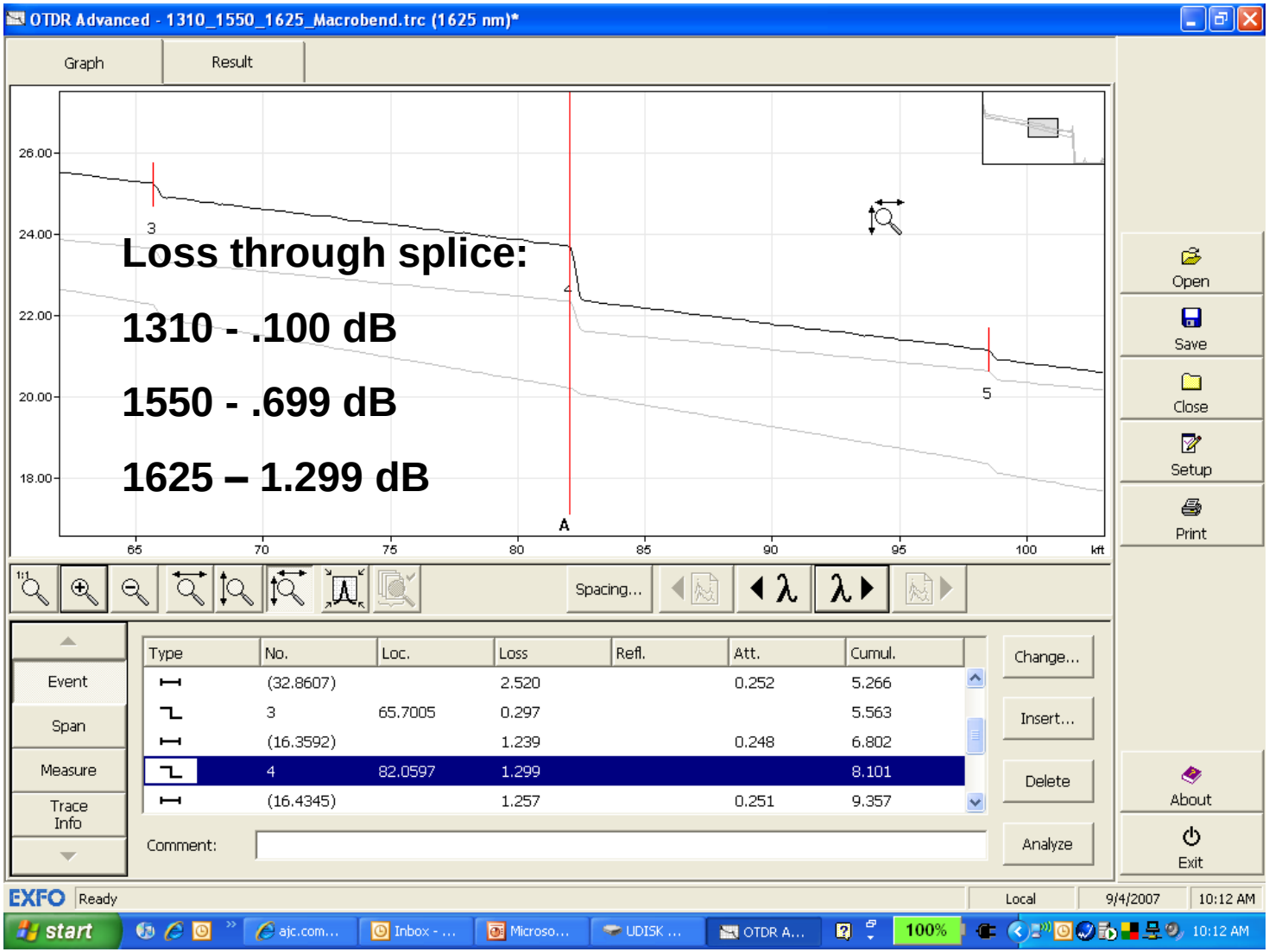
Macrobend trace



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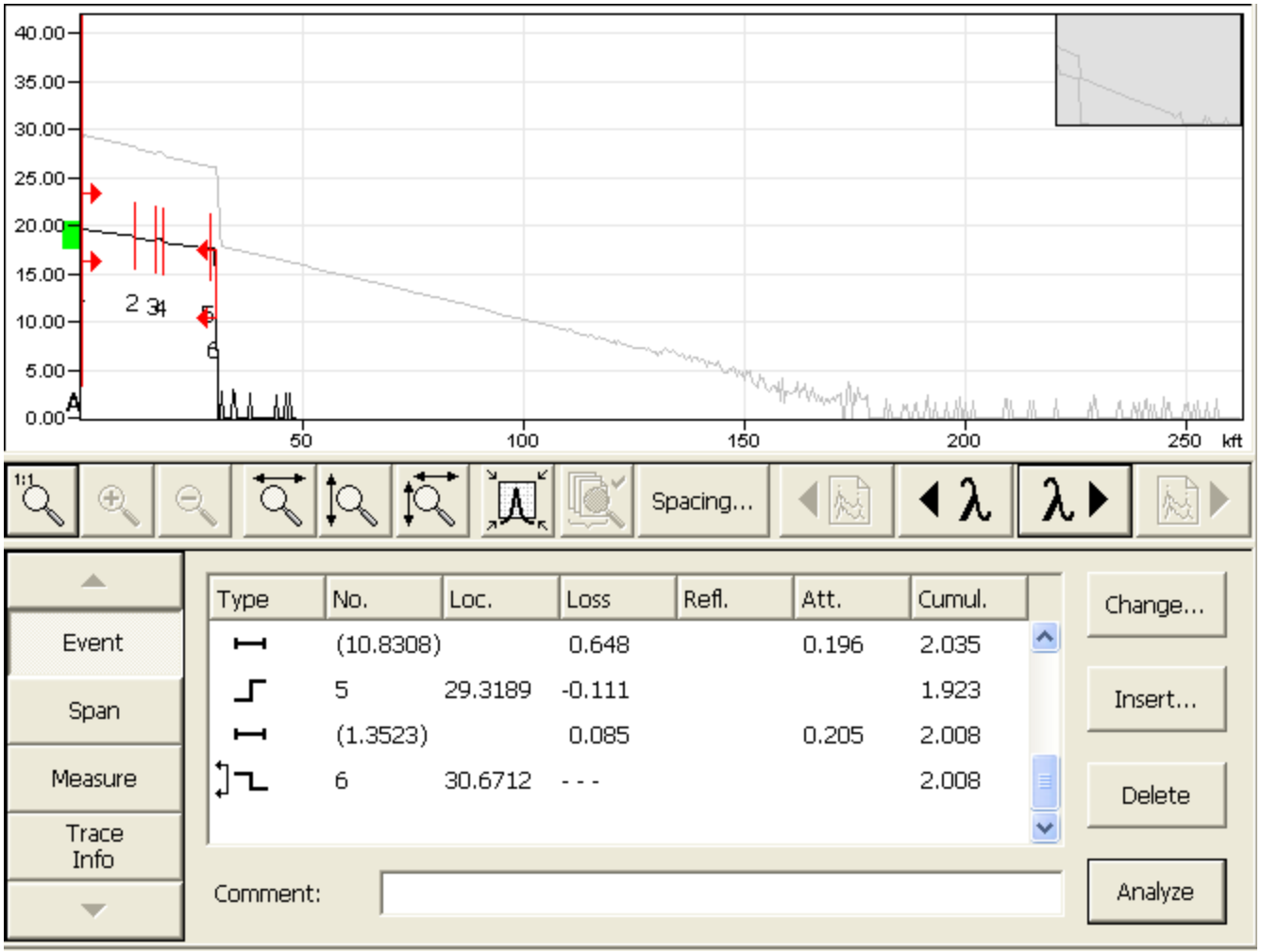
Trace Analysis - Macrobends

Macrobend at 30,671 feet from the OTDR



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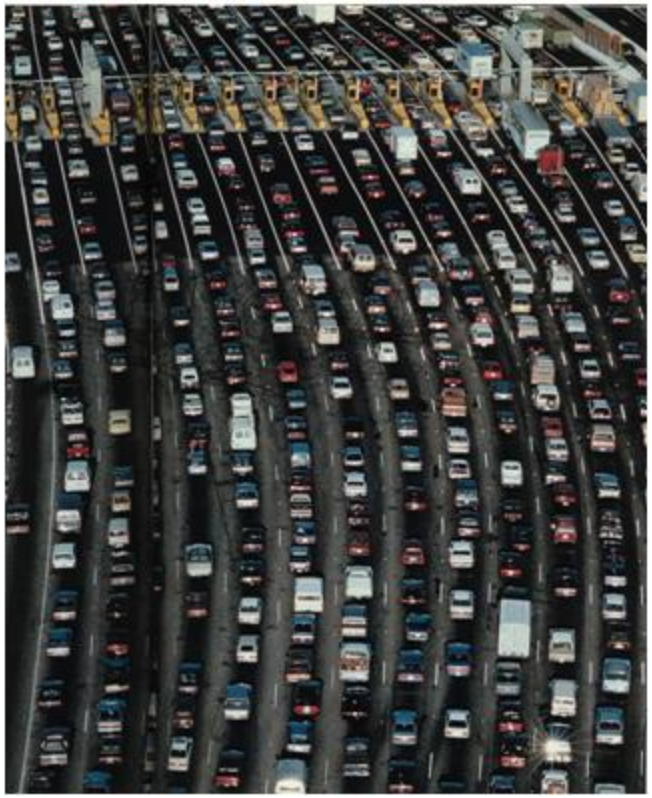
Wave Division Multiplexing

CWDM & DWDM

Addressing Bandwidth Demands - WDM

Single lane roads are built to give access to homes and businesses in a populated area. When demands for access increase, engineers look for ways to address these needs. The path is already established, how can this be done?



Adding additional lanes can be a solution to reduce the demand for access.

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CWDM and DWDM

CWDM	DWDM
Defined by wavelengths	Defined by frequencies
Short-range communications	Long-haul transmissions
Uses wide-range frequencies	Narrow frequencies
Wavelengths spread far apart	Tightly packed wavelengths
Wavelength drift is possible	Precision lasers rquired to keep channels on target
Breaks the spectrum into big chunks	Dices the spectrum into small pieces
Light signal isn't amplified	Signal amplification maybe used

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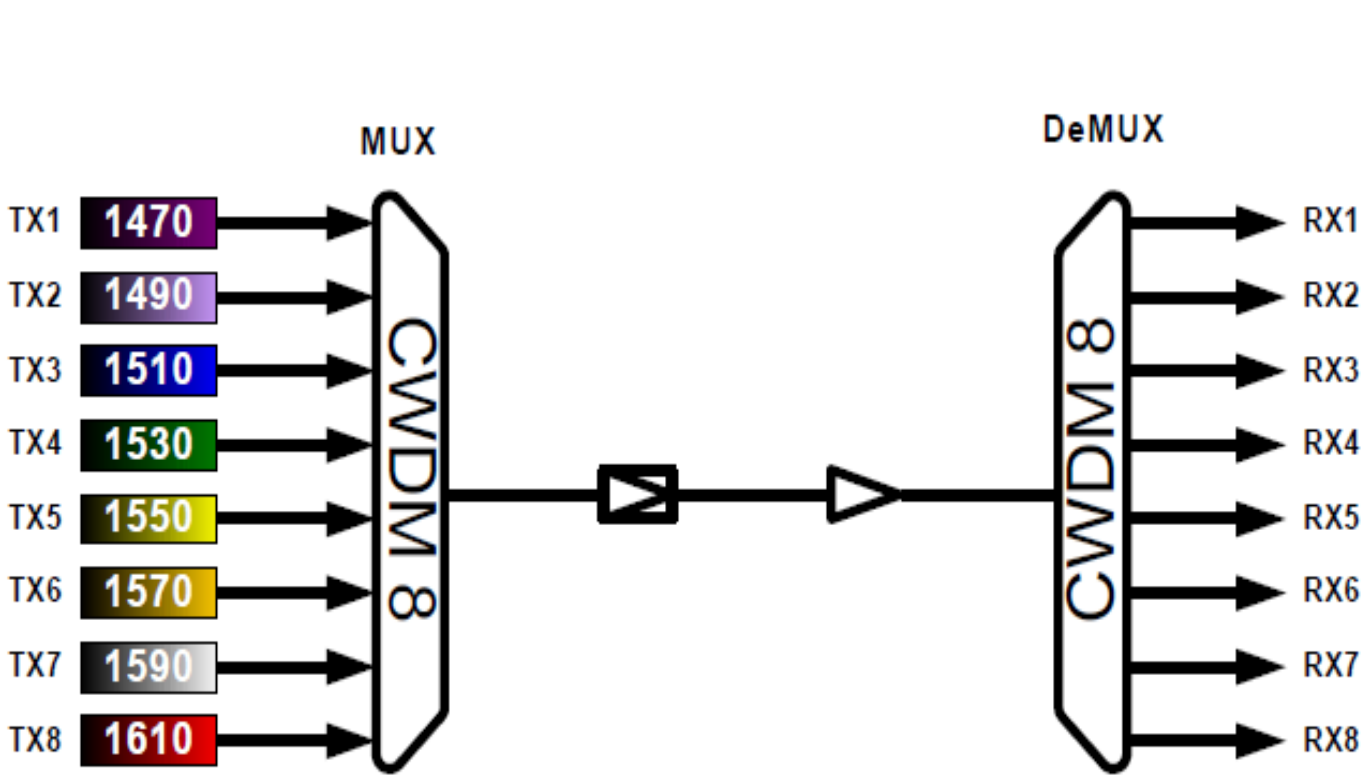
CWDM – Course Wavelength Division Multiplexing

1. 18 wavelengths in the O through L bands (typically 16 used, upper 8 most common)
2. Wide wavelength spacing: 20 nm separations
3. Uses inexpensive uncooled laser diode sources
4. Wider spectral drift tolerances for sources: +/- 6.5 nm



Nominal central wavelengths (nm) for spacing of 20 nm

1271
1291
1311
1331
1351
1371
1391
1411
1431
1451
1471
1491
1511
1531
1551
1571
1591
1611

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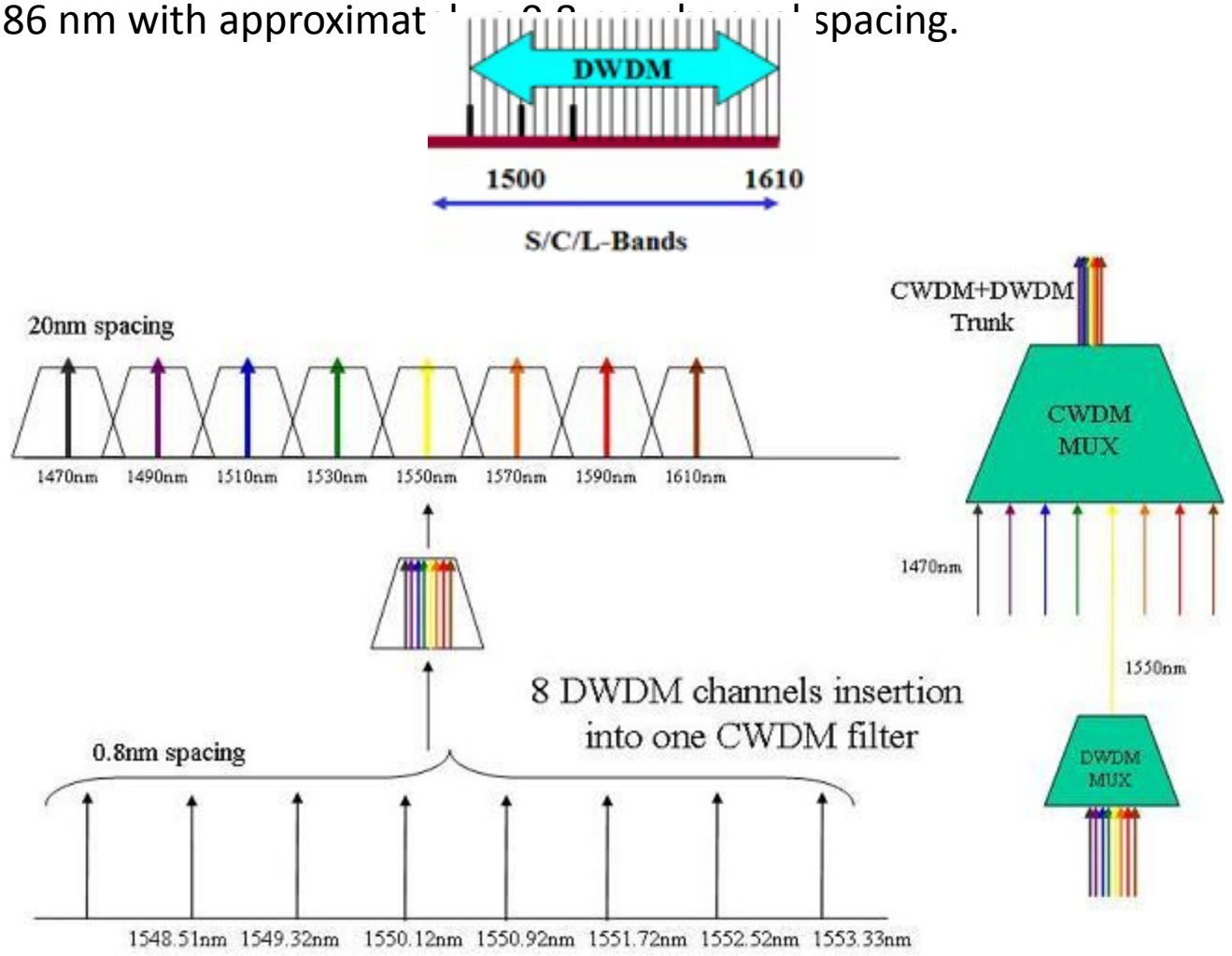
DWDM – Dense Wavelength Division Multiplexing

The grid is defined relative to 193.1THz and extends from 191.7 THz to 196.1 THz with 100 GHz spacing. While defined in frequency the grid is often expressed in terms of wavelength in which case it covers the wavelength range of 1528.77 nm to 1563.86 nm with approximat[illegible] spacing.



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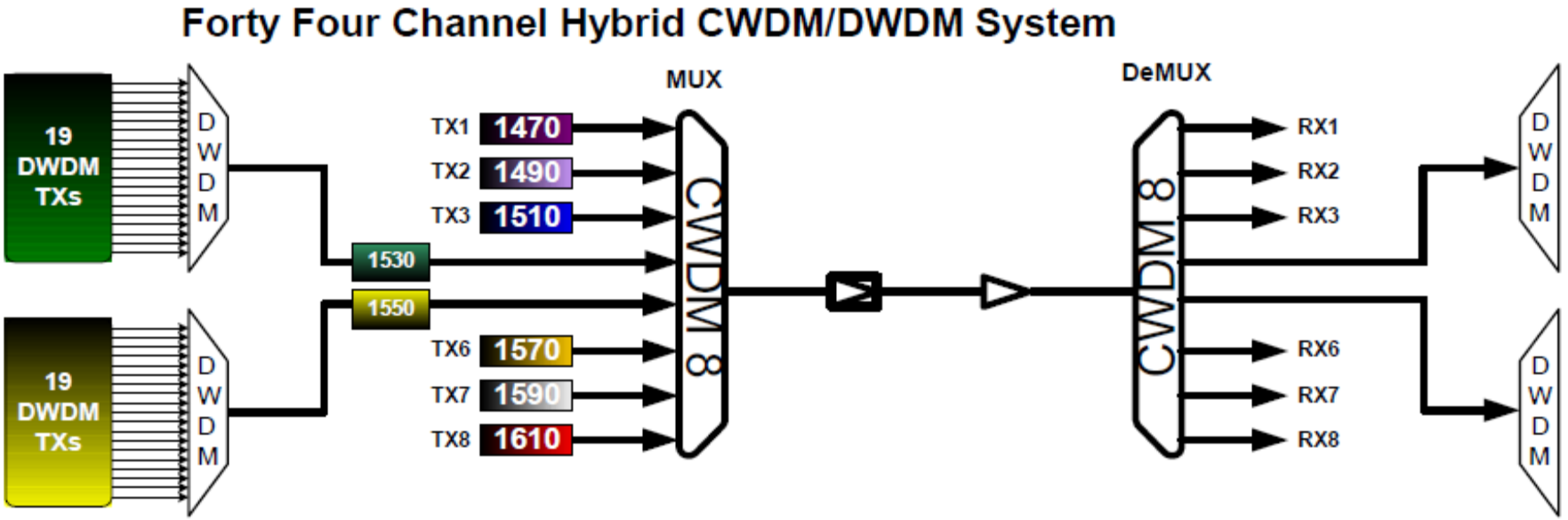
And There's MORE!

Hybrid CWDM/DWDM Optical Networks

CWDM is an excellent, cost effective, first step solution for metro networks.
If capacity needs grow beyond the normal 8 CWDM channels, merging DWDM and CWDM can be a solution.
This allows carriers to add many channels (38 DWDM) to networks originally designed for the more limited CWDM capacity and reach.



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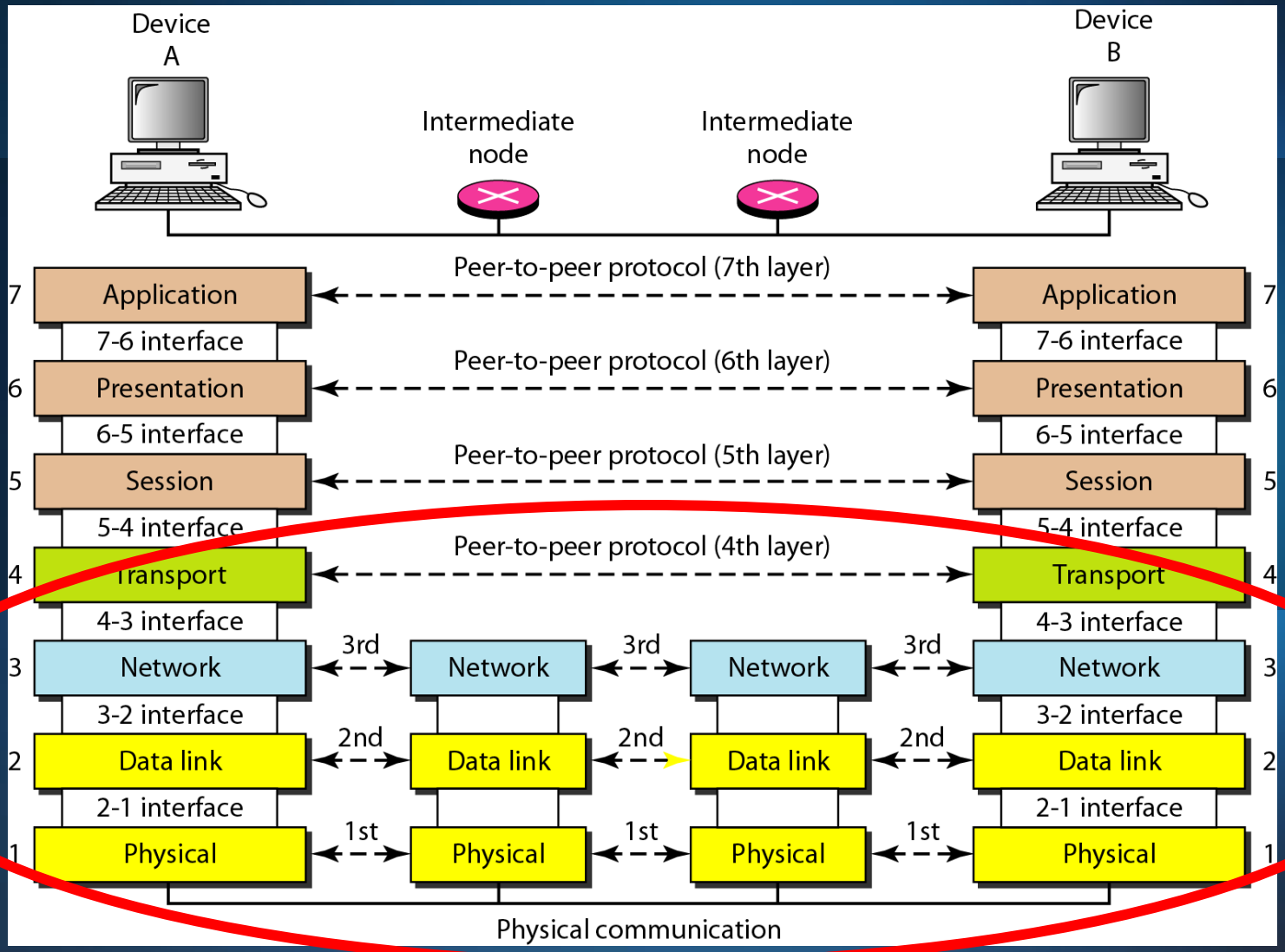
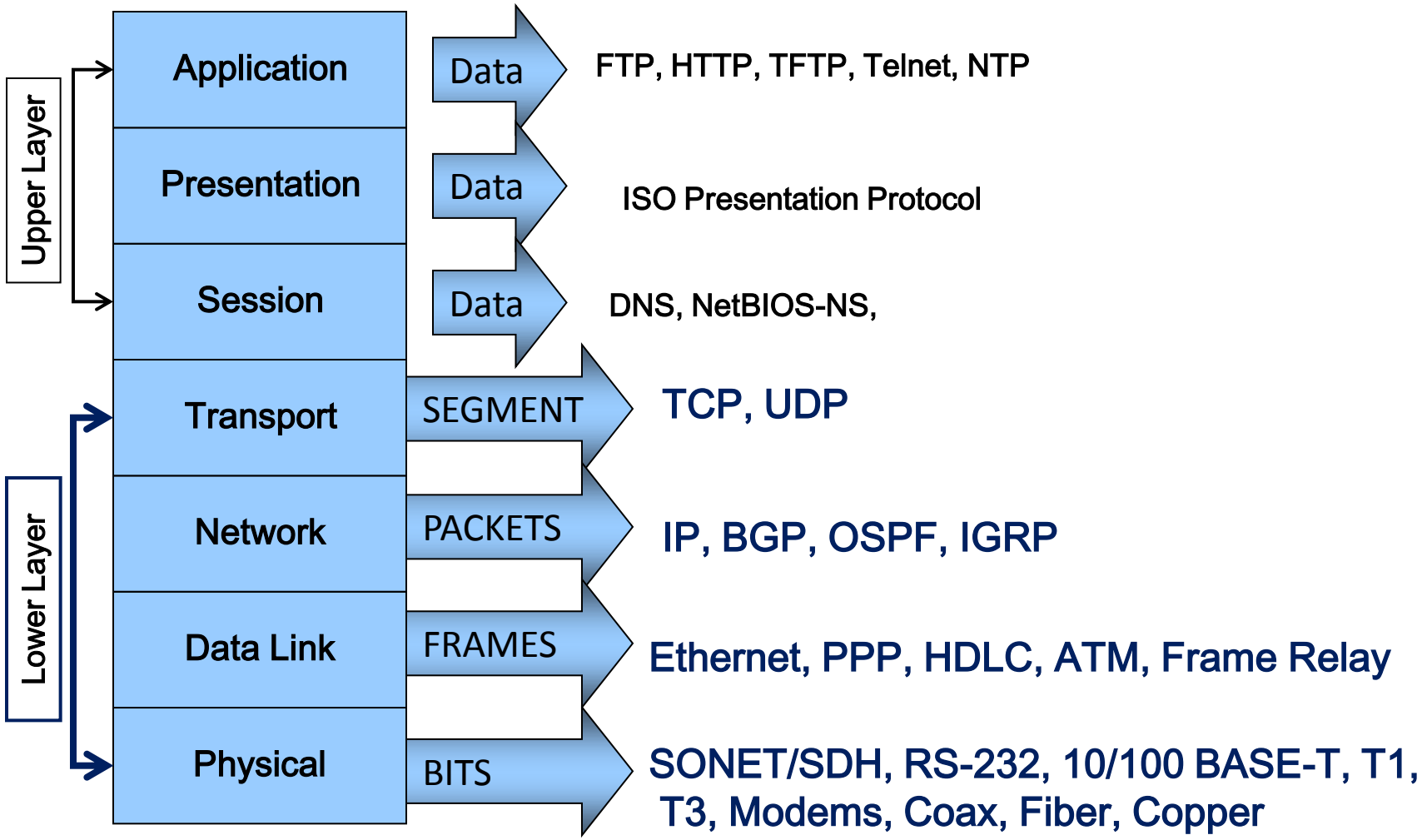
Welcome to the 7 Layers of the OSI Model



OSI Reference Model Popular Protocols



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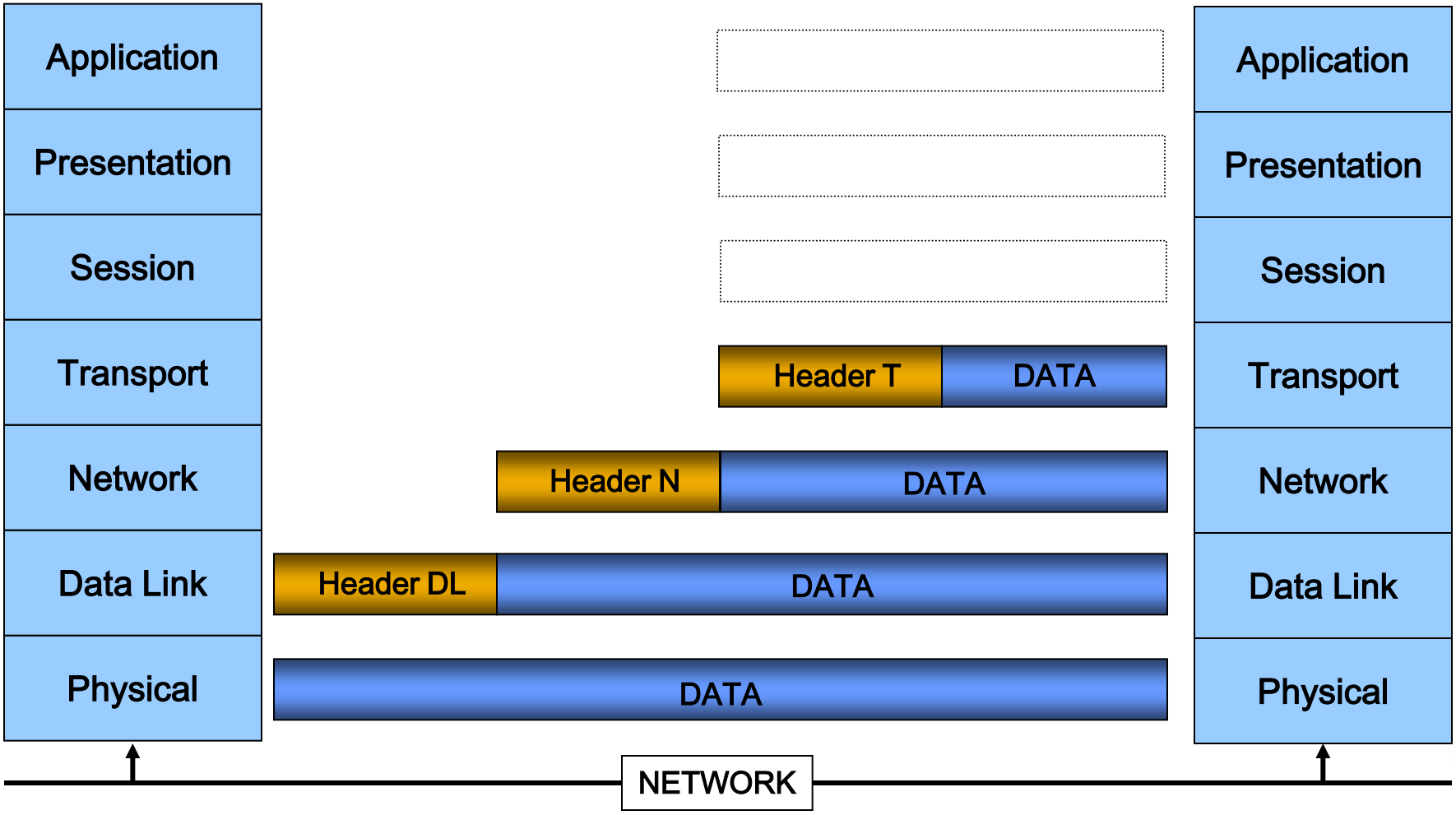
Encapsulation of Data



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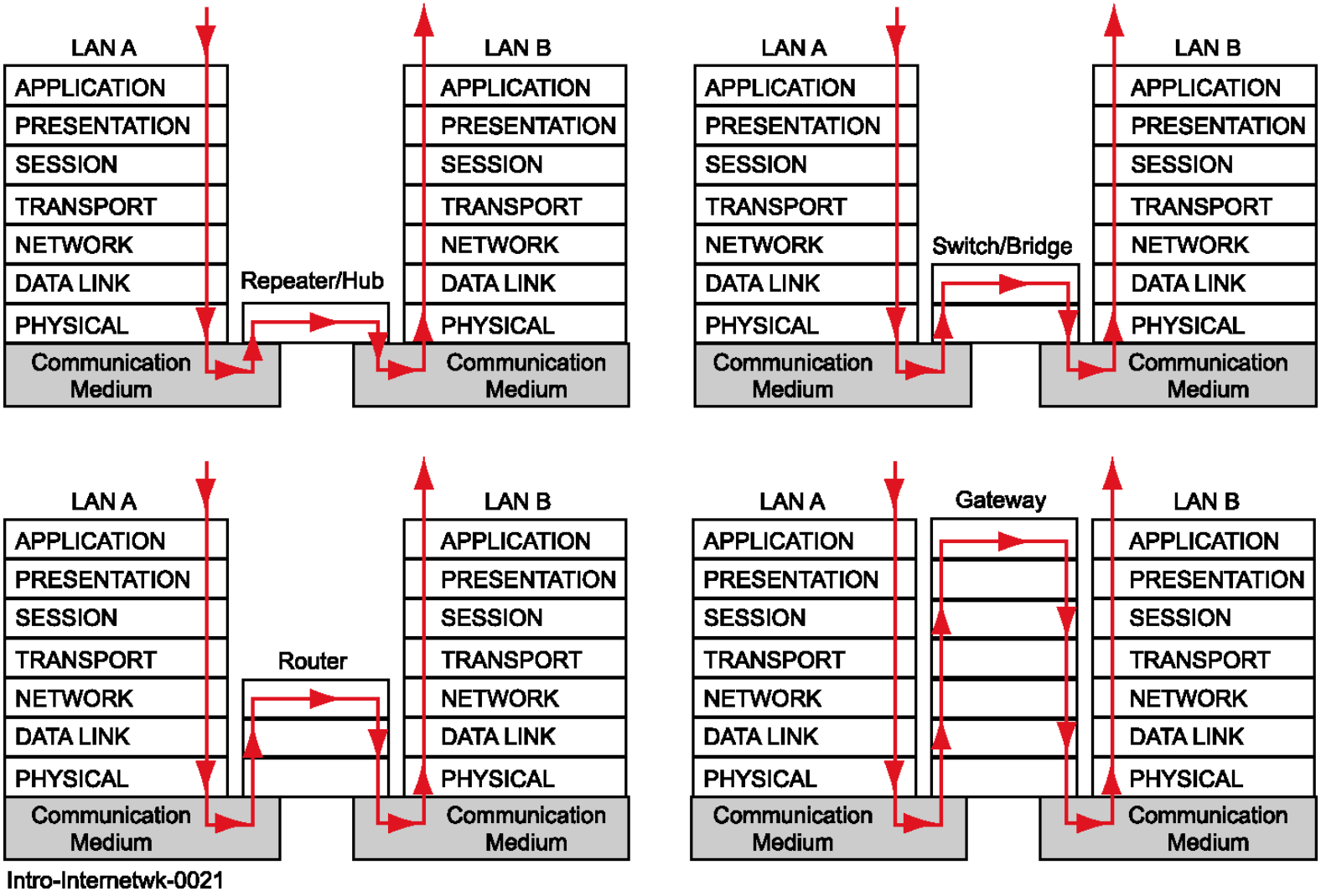
Internetworking Devices



Intro-Internetwk-0021

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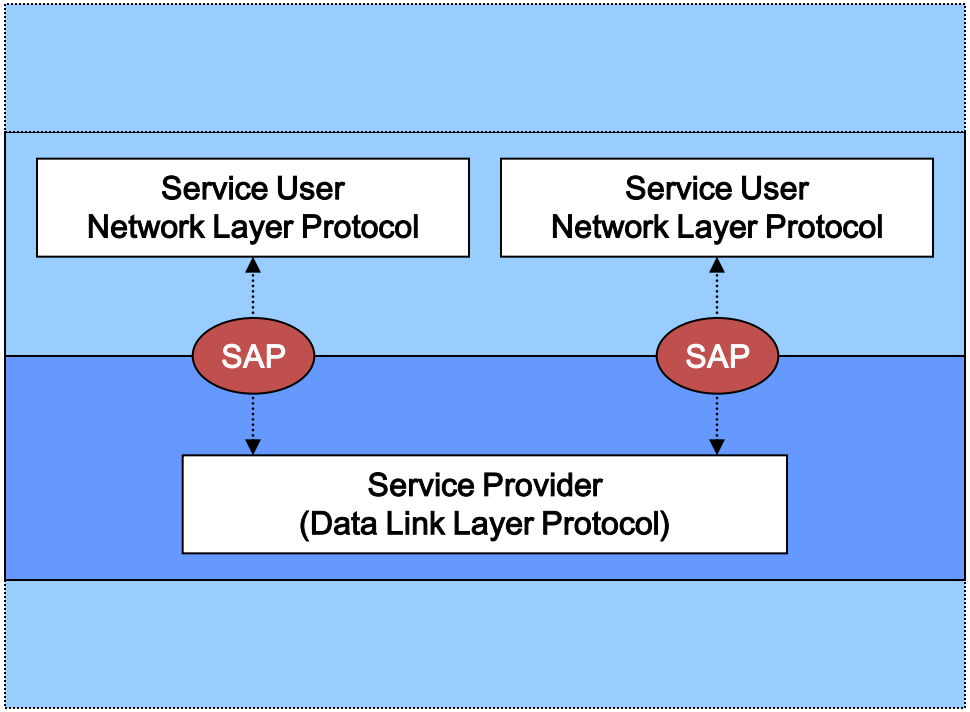
Interaction Between OSI Layers



Transport Layer

Network Layer

Data Link Layer

Physical Layer

Service Access Points (SAP) are also know as Port numbers

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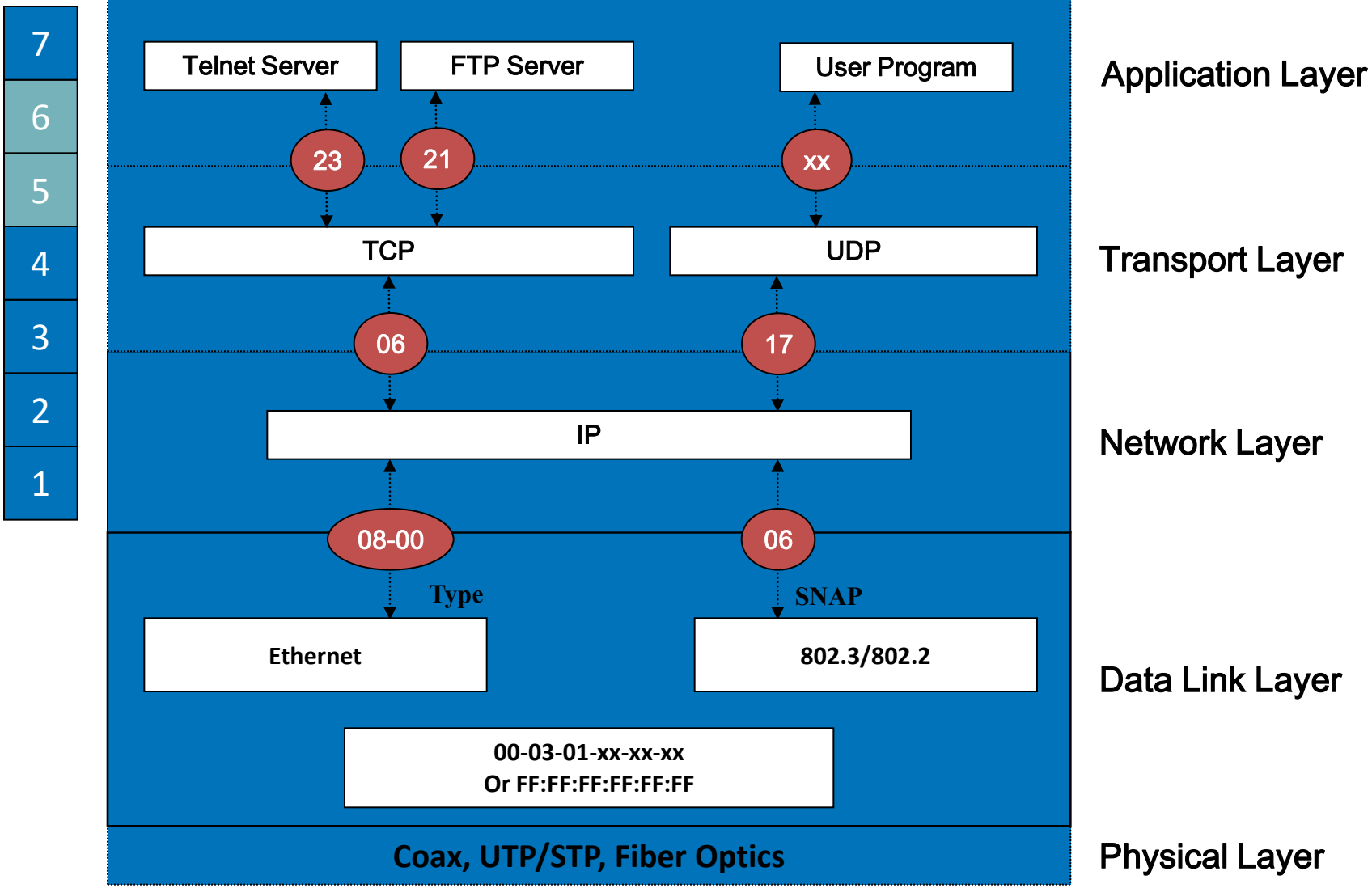
Ethernet, IP, TCP and UDP Protocols

TCP and UDP port numbers.pdf



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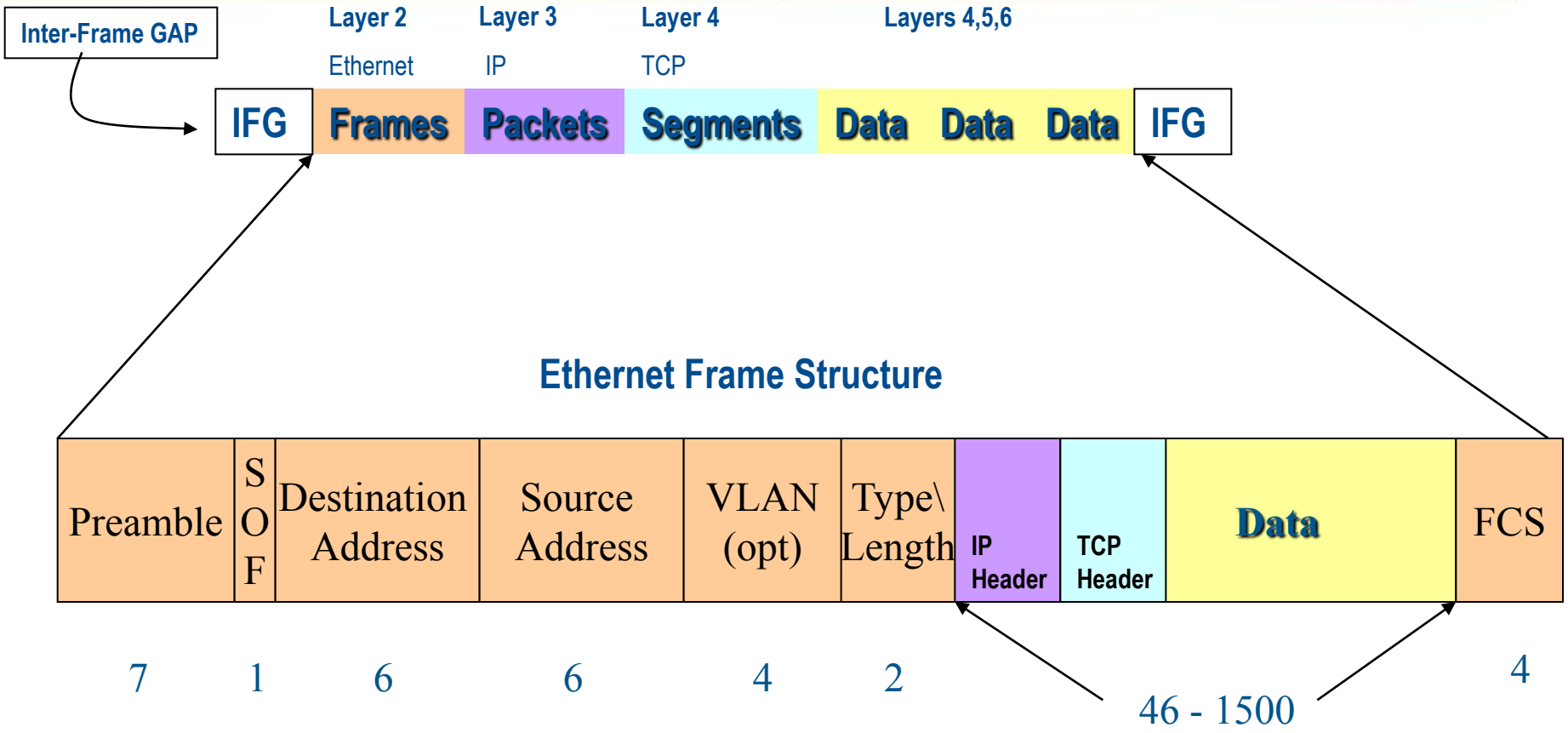
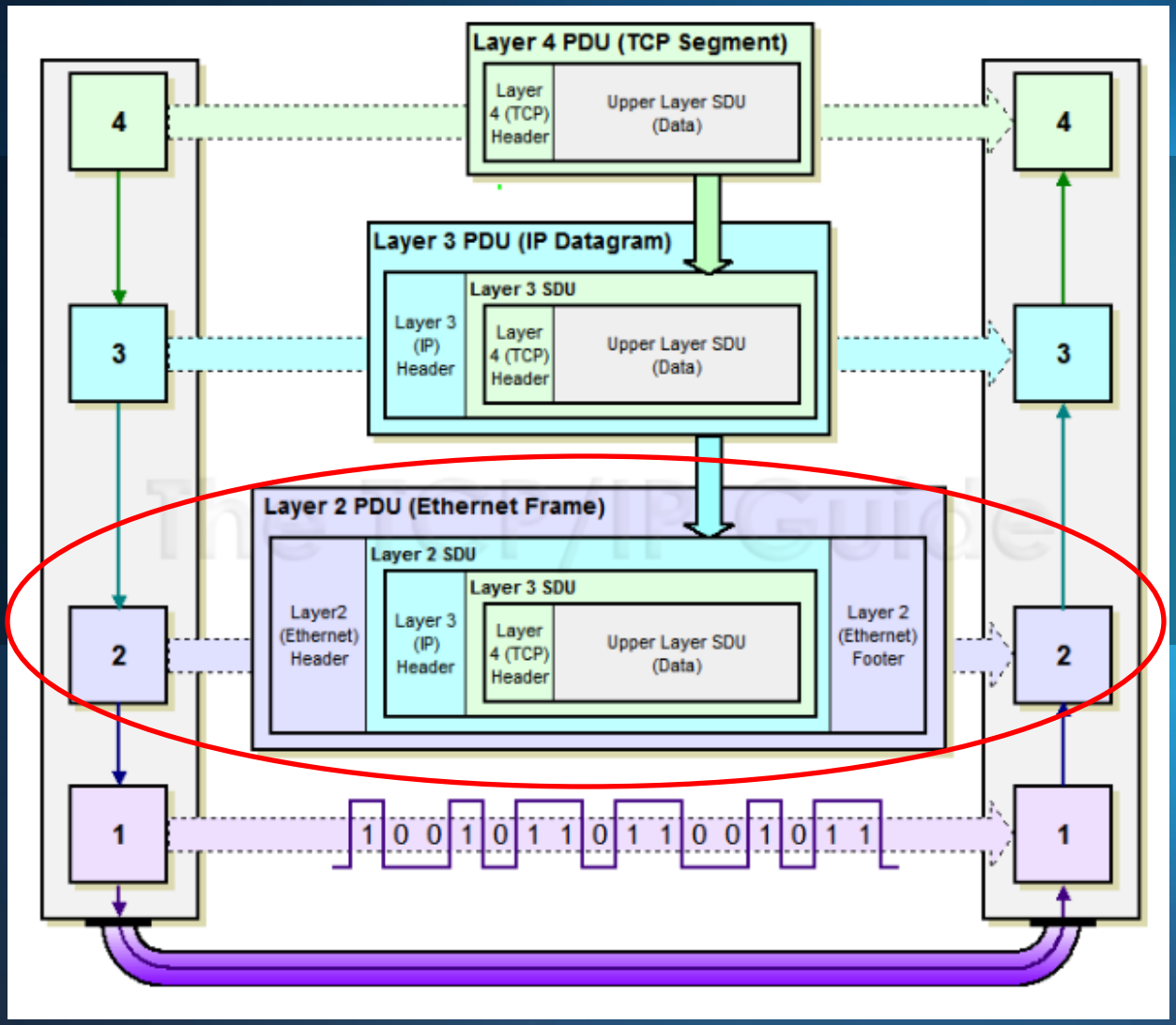
Encapsulation & Terminology



Ethernet Frame Sizes as defined by IEEE 802.3:

Non-VLAN 64 Bytes to 1518 Bytes
With VLAN 68 Bytes to 1522 Bytes

OSI Layers 2
Open Systems Interconnect Model

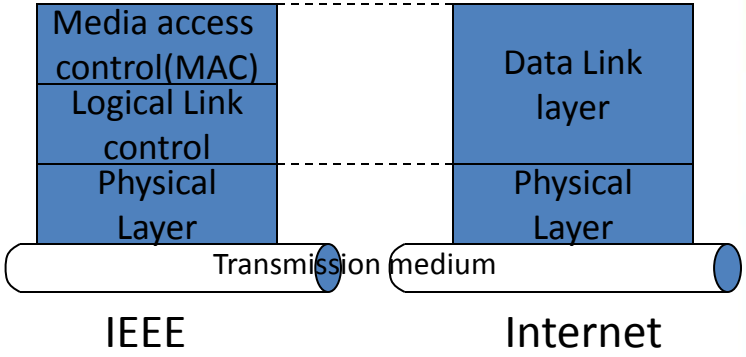


Data Link Layer- Switches

Provides reliable transit of data across a physical network link. It defines different network and protocol characteristics including physical addressing, network topology, etc…

Introduction
Layer 2 - Data Link Layer

- Receives service from physical layer and provides service to the network layer.
- Two models
  - Internet model and IEEE model
- Responsible for carrying data from one hop to the next hop.
- Packet integrity.
- Flow control.
- Access control.
- Examples of LL protocol
  - Ethernet, token ring, FDDI, ATM



- Services Provided to the Network Layer
- Framing
- Error Control
- Flow Control

data link layer

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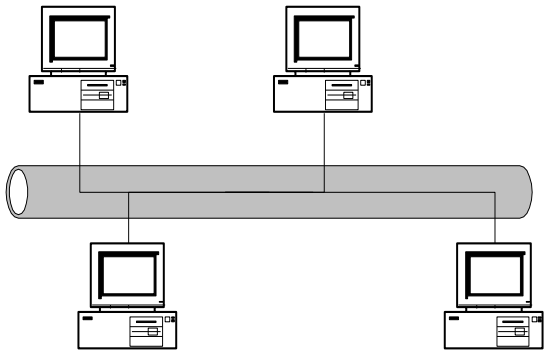
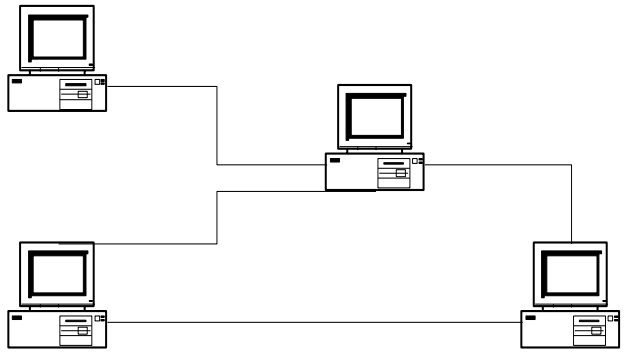
Two types of networks
Layer 2 - Data Link Layer

- Broadcast Networks: All stations share a single communication channel
- Point-to-Point Networks: Pairs of hosts (or routers) are directly connected



Broadcast Network



Point-to-Point Network

- Typically, local area networks (LANs) are broadcast and wide area networks (WANs) are point-to-point

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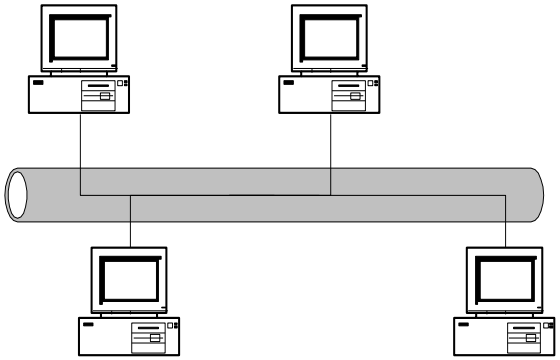
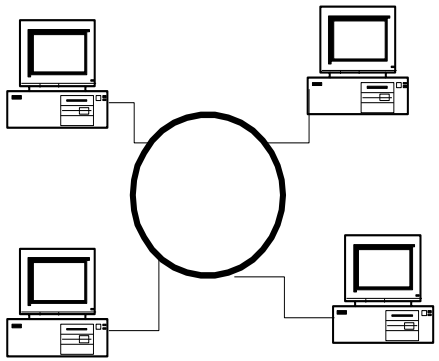
Local Area Networks
Layer 2 - Data Link Layer

- Local area networks (LANs) connect computers within a building or a enterprise network
- Almost all LANs are broadcast networks
- Typical topologies of LANs are **bus** or **ring** or **star**
- We will work with Ethernet LANs. Ethernet has a bus or star topology.



Bus LAN



Ring LAN

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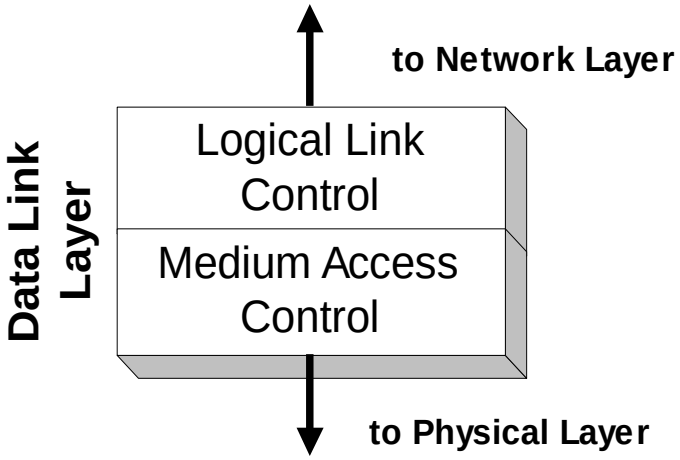
MAC and LLC
Layer 2 - Data Link Layer

- In any broadcast network, the stations must ensure that only one station transmits at a time on the shared communication channel
- The protocol that determines who can transmit on a broadcast channel are called Medium Access Control (MAC) protocol
- The MAC protocol are implemented in the MAC sublayer which is the lower sublayer of the data link layer
- The higher portion of the data link layer is often called Logical Link Control (LLC)



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Ethernet
Layer 2 - Data Link Layer

- Speed: 10Mbps -10 Gbps
- Standard: 802.3, Ethernet II (DIX)
- Most popular physical layers for Ethernet:

RATE	Spec:	Media:
10 Mbps	10Base-T Ethernet (IEEE 802.3)	Electrical
100 Mbps	Fast Ethernet (IEEE 802.u	Electrical/Optical/Wireless
1000 Mbps	Gigabit Ethernet (IEEE 802.3z)	Electrical/Optical/Wireless
10 Gbps	10 Gig Ethernet (IEEE 802.3ae)	Electrical/Optical
40/100 Gbps	40 / 100 Gigabit- (IEEE 802.3ba)	Optical

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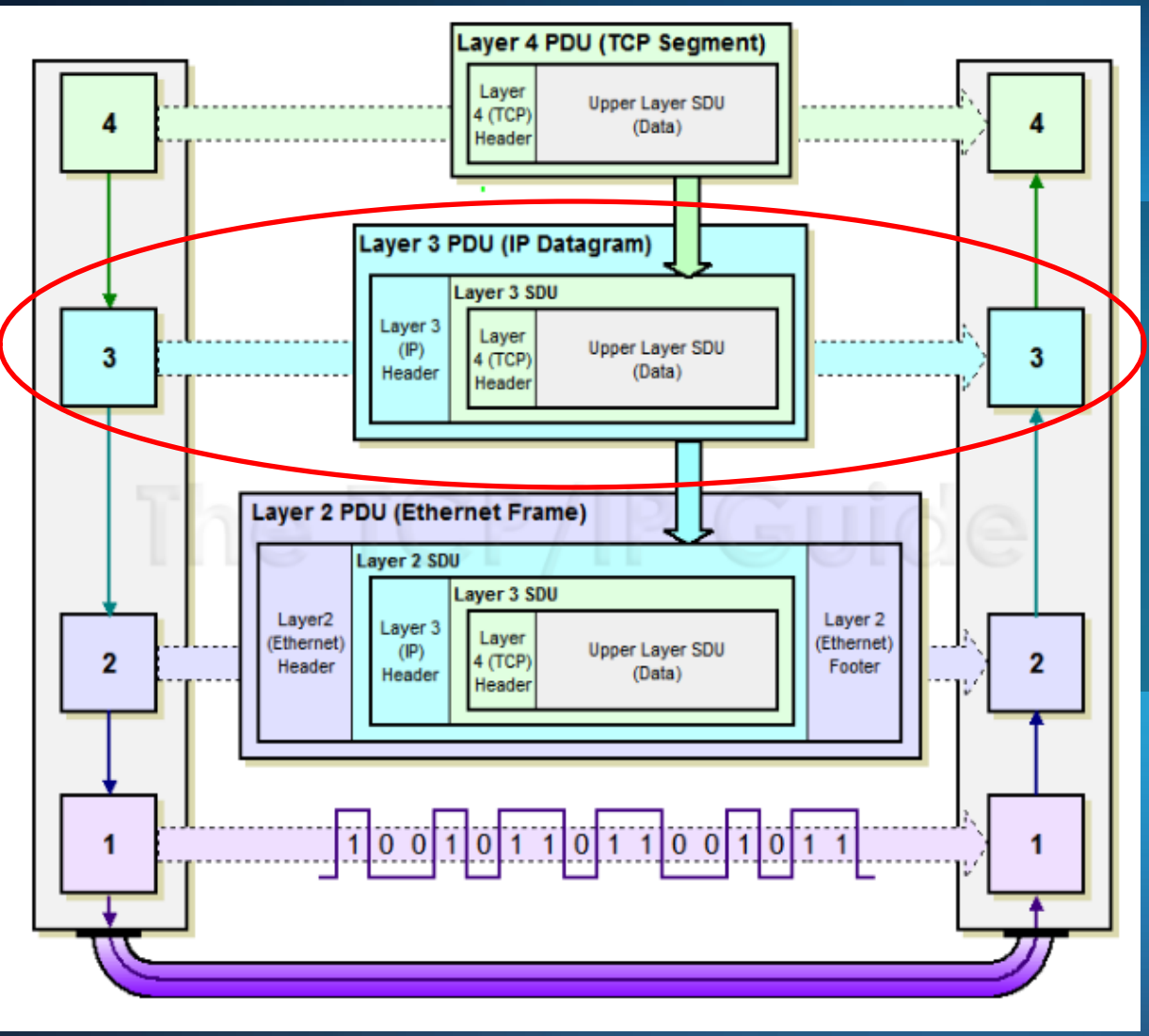
Layer 3 – The Network Layer



Network Layer – Routers

Provides routing and related functions to connect Data Links to into networks. This is achieve by the logical addressing of devices.

Network Layer
Layer 3

Goals:

- Understand Internet network layer concepts
- Understand Internet routing
- Understand Internet network layer protocols

Content:

- IP addressing
- Getting datagram from source to destination
- Internet Protocol (IP)
- ICMP
- Intra- & Inter-AS routing
- Multicast routing

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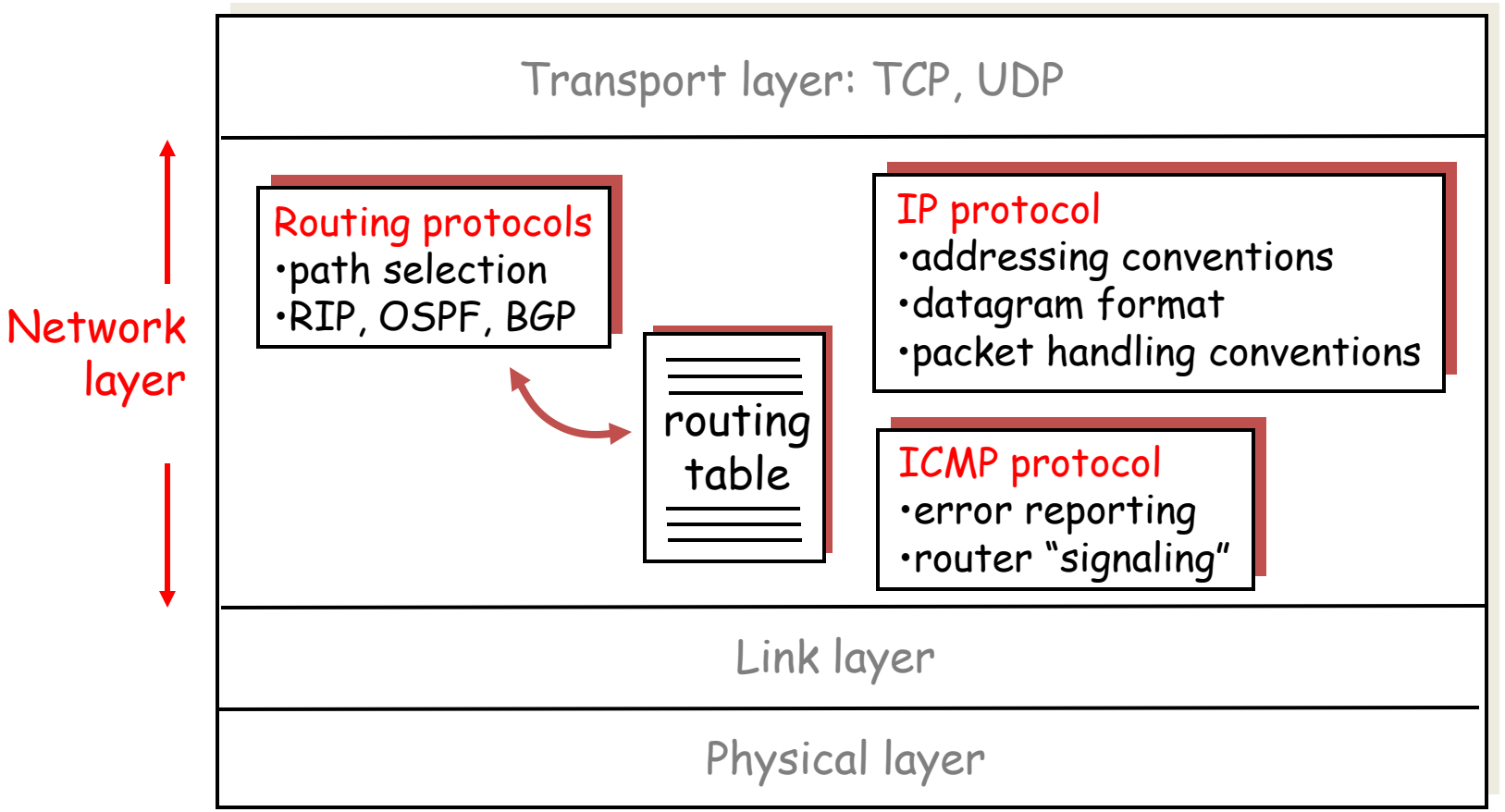
Layer 3
The Network Layer

Host, router network layer functions:



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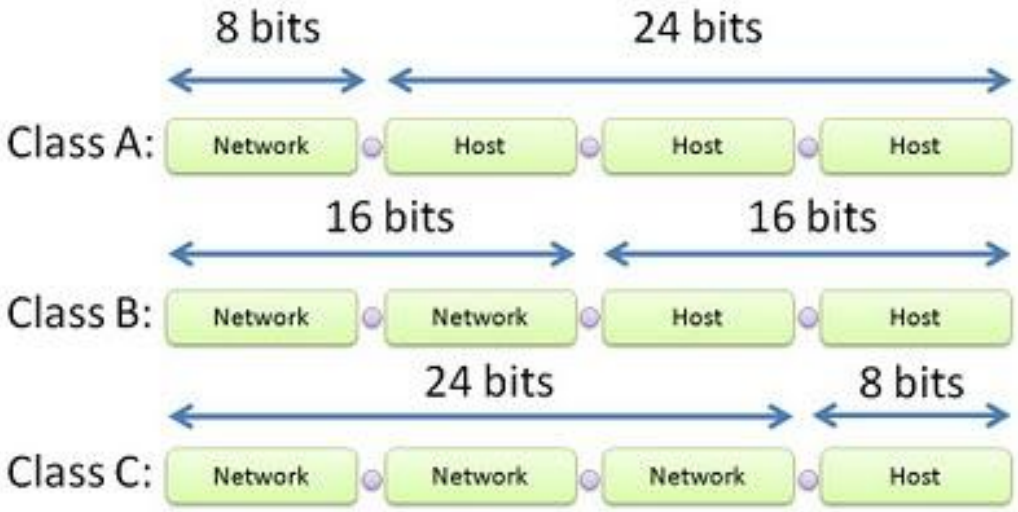
Commonly used classes of IPv4 addresses

Layer 3 – The Network Layer

Class	Range	Default Subnet mask	Default Network ID	Default Broadcast Address	Max number of host per network
A	0.x.x.x to 127.x.x.x Eg: 14.3.4.5	255.0.0.0	x.0.0.0 Eg: 14.0.0.0	x.255.255.255 Eg: 14.255.255.255	About 16 millions
B	128.x.x.x to 191.x.x.x Eg:132.2.2.3	255.255.0.0	x.x.0.0 Eg: 132.2.0.0	x.x.255.255 Eg:132.2.255.255	About 65000
C	192.x.x.x to 223.x.x.x Eg:202.3.2.4	255.255.255.0	x.x.x.0 Eg: 202.3.2.0	x.x.x.255 Eg: 202.3.2.255	254



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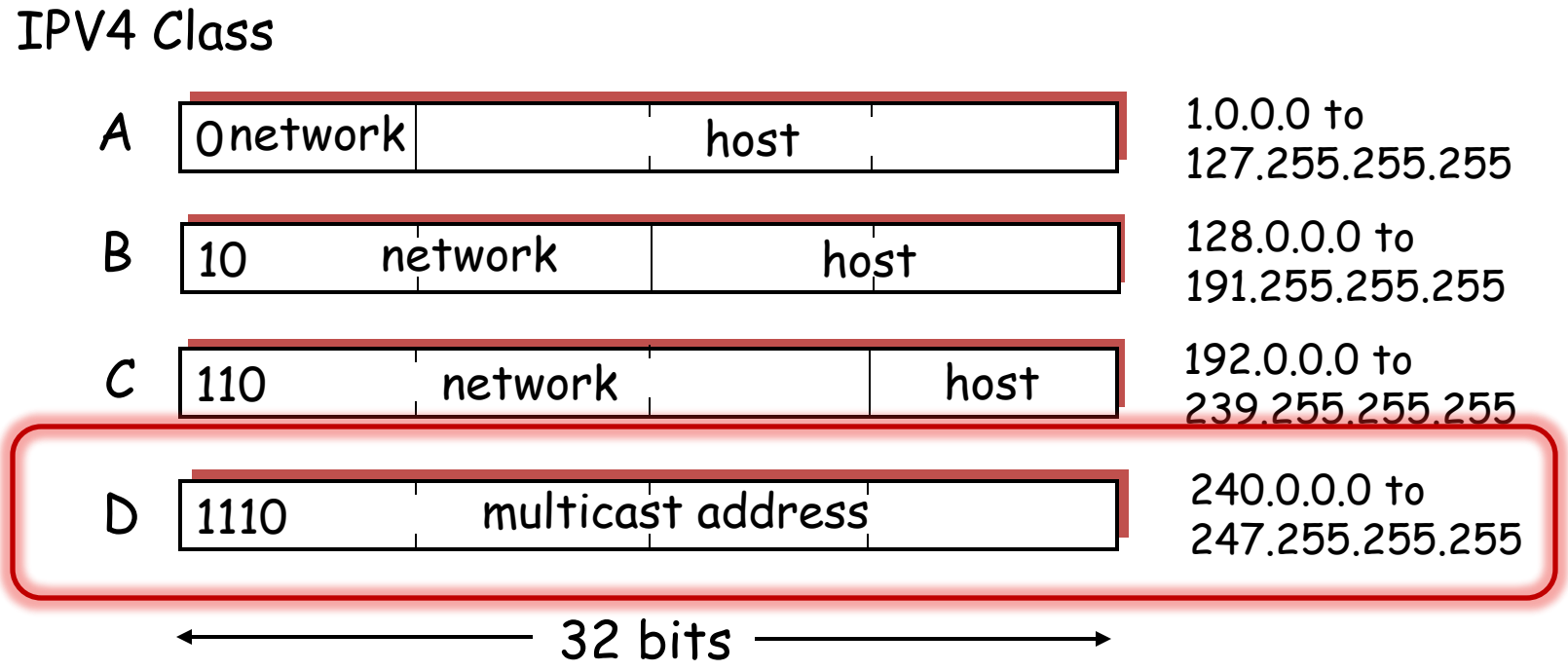
IP Addresses
Layer 3 – The Network Layer



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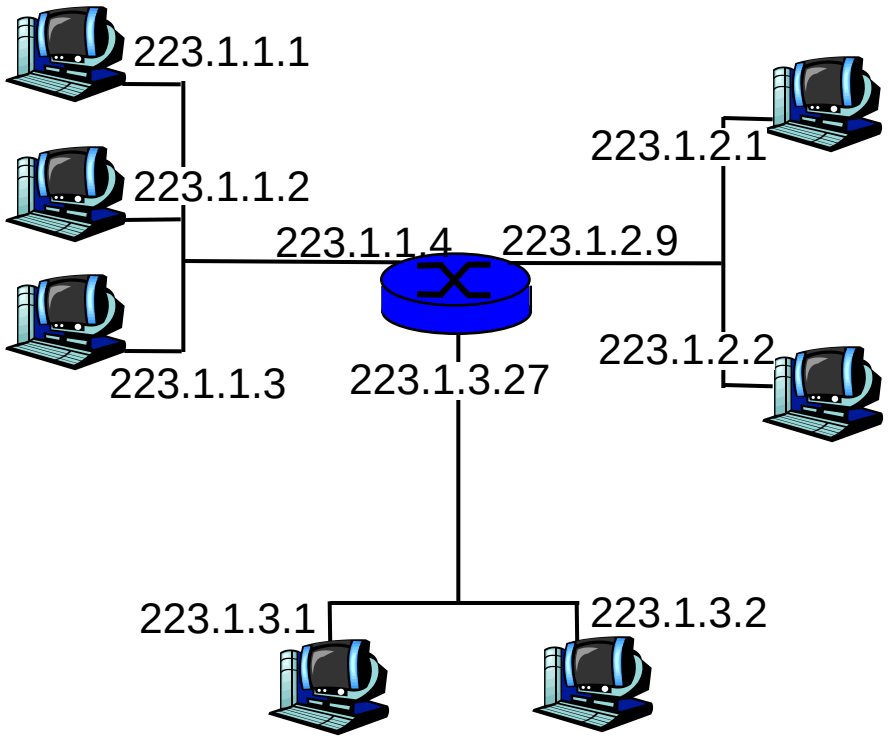
IP Addressing
Layer 3 – The Network Layer

- IP address: 32-bit identifier for host, router *interface*
- *interface:* connection between host/router and physical link
  - routers typically have multiple interfaces
  - host may have multiple interfaces
  - IP addresses associated with interface, not host or router



223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

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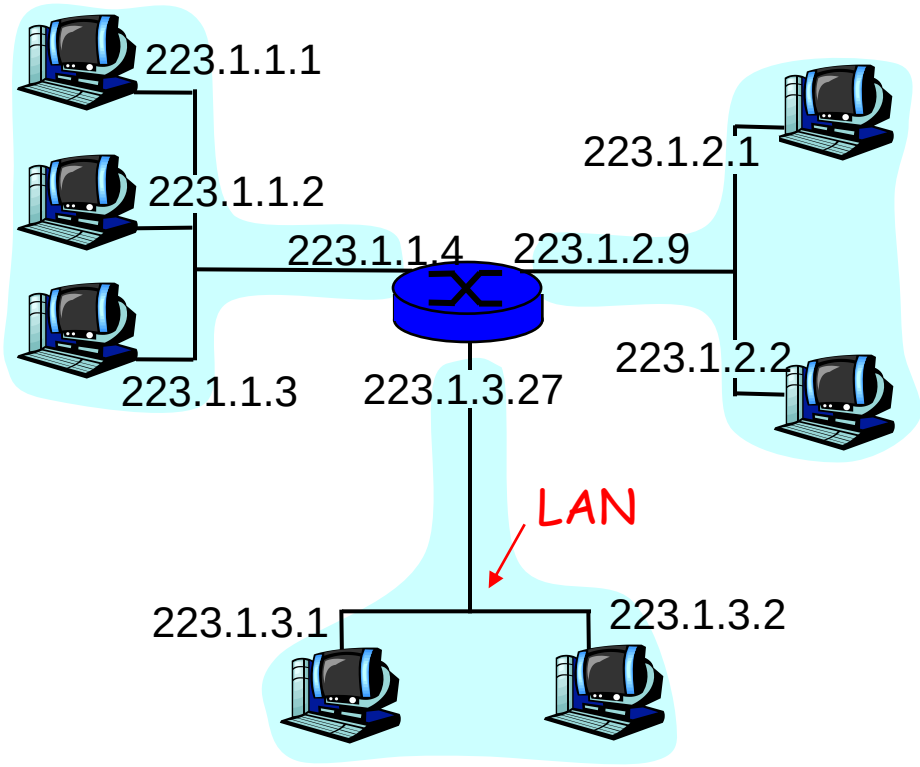
- IP address:
  - network part (high order bits)
  - host part (low order bits)

- ***What's a network ?***

  (from IP address perspective)
  - device interfaces with same network part of IP address
  - can physically reach each other without intervening router



network consisting of 3 IP networks (for IP addresses starting with 223, first 24 bits are network address)

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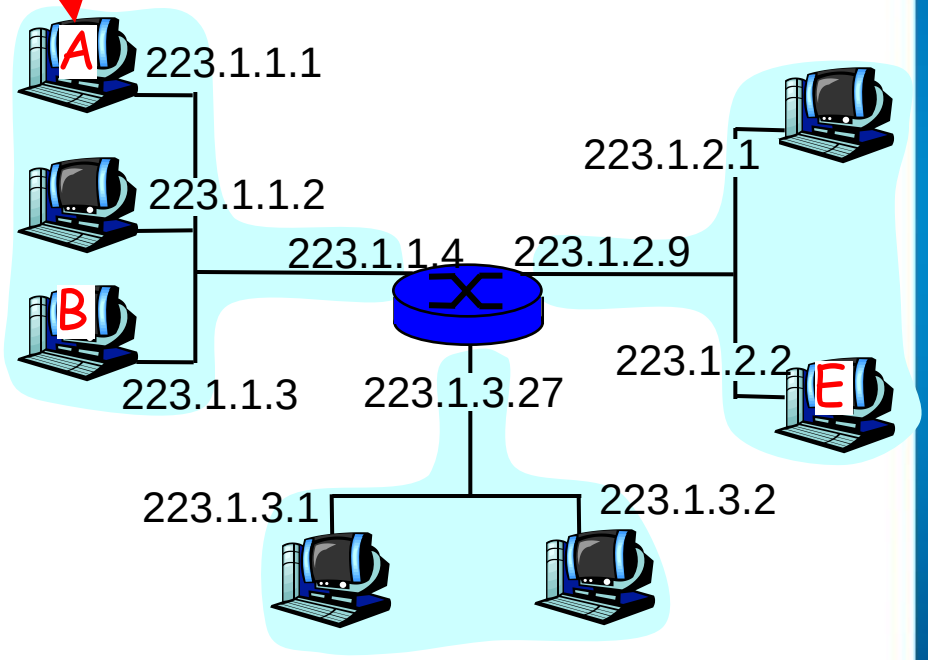
IP datagram:

header fields	source IP addr	dest IP addr	data

- datagram remains unchanged, as it travels source to destination
- addr fields of interest here

routing table in A

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2



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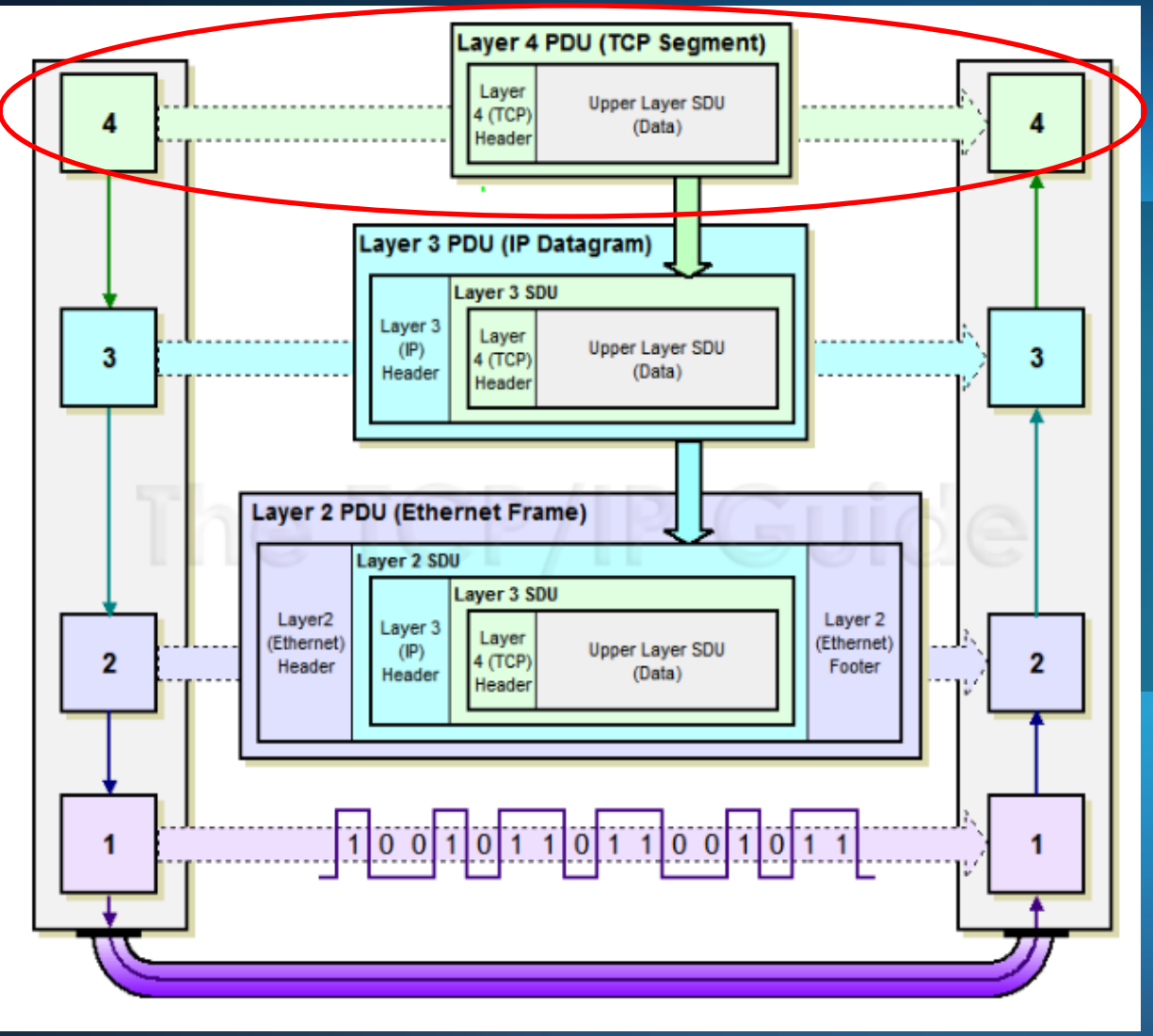
Layer 4 – The Transport Layer Layer



Transport Layer - Implements reliable data transport services that are transparent to upper layers. Transport-layer functions typically include flow control, multiplexing and error checking and recovery.

Transport Layer Over View
Layer 4

Goals:

- understand principles behind transport layer services and protocols:
  - UDP
  - TCP

Overview:

- transport layer services
- multiplexing/demultiplexing
- connectionless transport: UDP
- connection-oriented transport: TCP
  - reliable transfer
  - flow control
  - connection management

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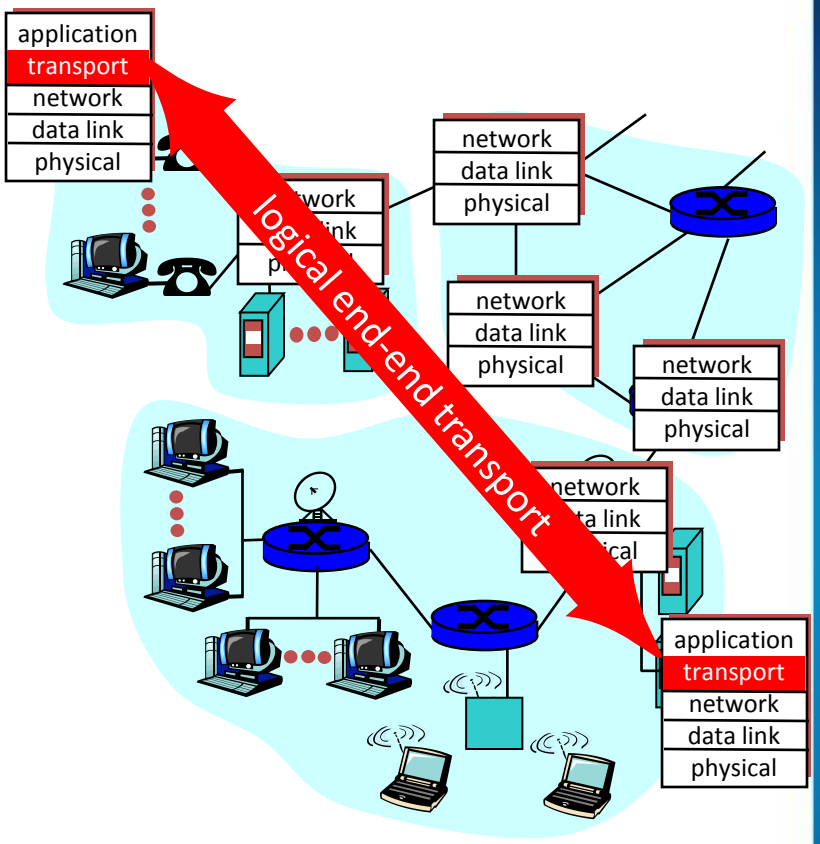
Transport services and protocols
Layer 4

- provide *logical communication* between app' processes running on different hosts
- transport protocols run in end systems (exception – L4, L7 switches)

transport vs network layer services:

- *network layer:* data transfer between end systems
- *transport layer:* data transfer between processes
  - relies on, enhances, network layer services



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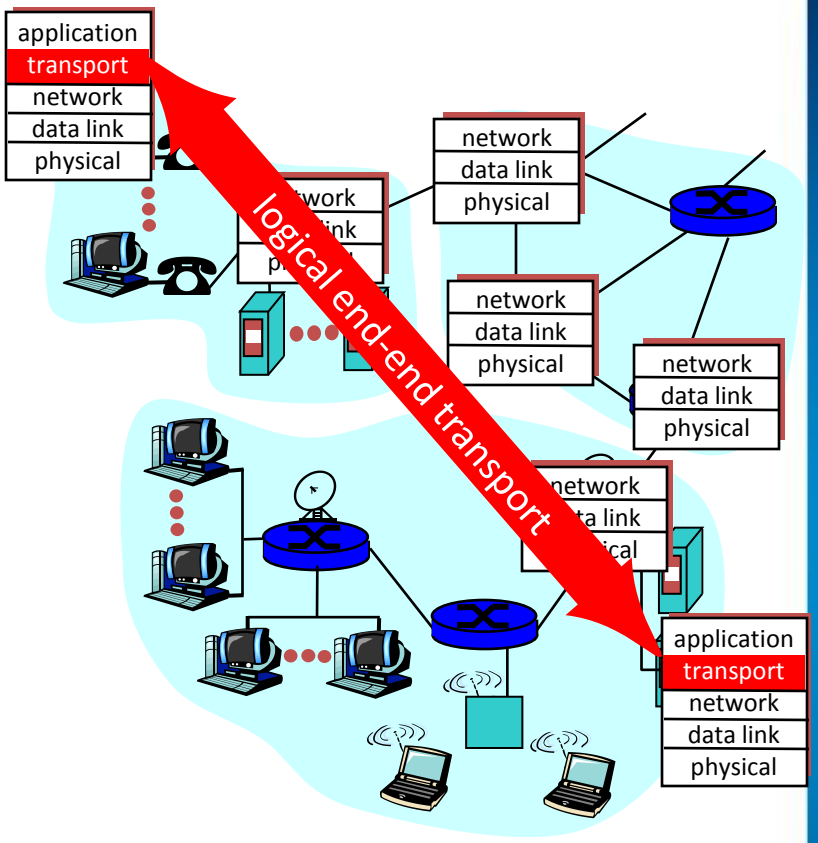
Transport-layer protocols
Layer 4

Internet transport services:

- reliable, in-order unicast delivery (TCP)
  - congestion
  - flow control
  - connection setup
- unreliable (“best-effort”), unordered unicast or multicast delivery: UDP
- services not available:
  - real-time
  - bandwidth guarantees
  - reliable multicast



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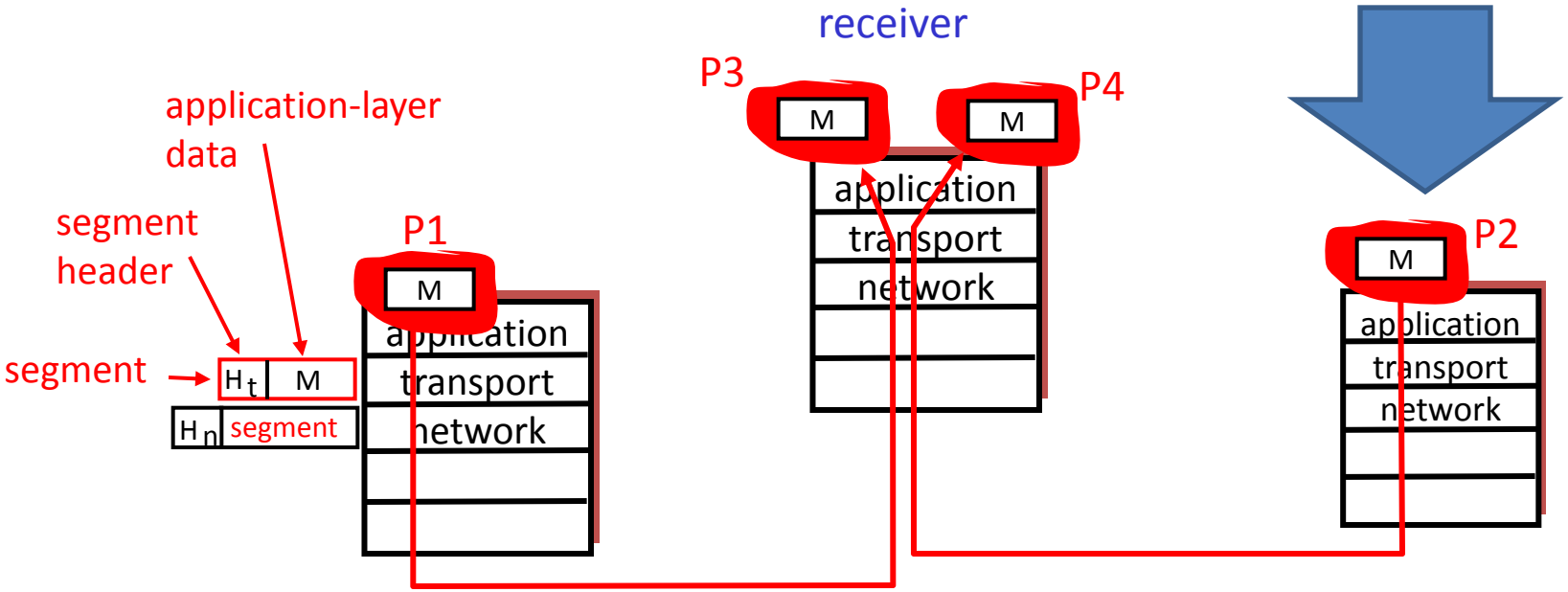
Multiplexing/Demultiplexing
Transport Layer 4

segment - unit of data exchanged between transport layer entities

– aka TPDU: transport protocol data unit

Demultiplexing: delivering received segments (TPDUs)to correct app layer processes



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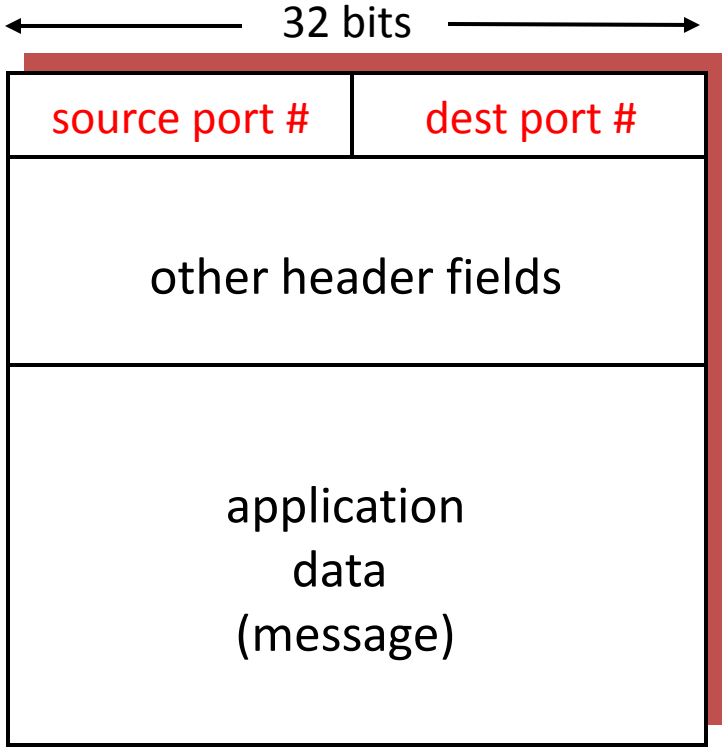
Multiplexing/Demultiplexing
Transport – Layer 4

Multiplexing:
gathering data from multiple app processes, enveloping data with header (later used for demultiplexing)

multiplexing/demultiplexing:

- based on sender, receiver IP addresses & port numbers
  - source, dest port #s in each segment
  - "well-known" port numbers for specific applications



TCP/UDP segment format

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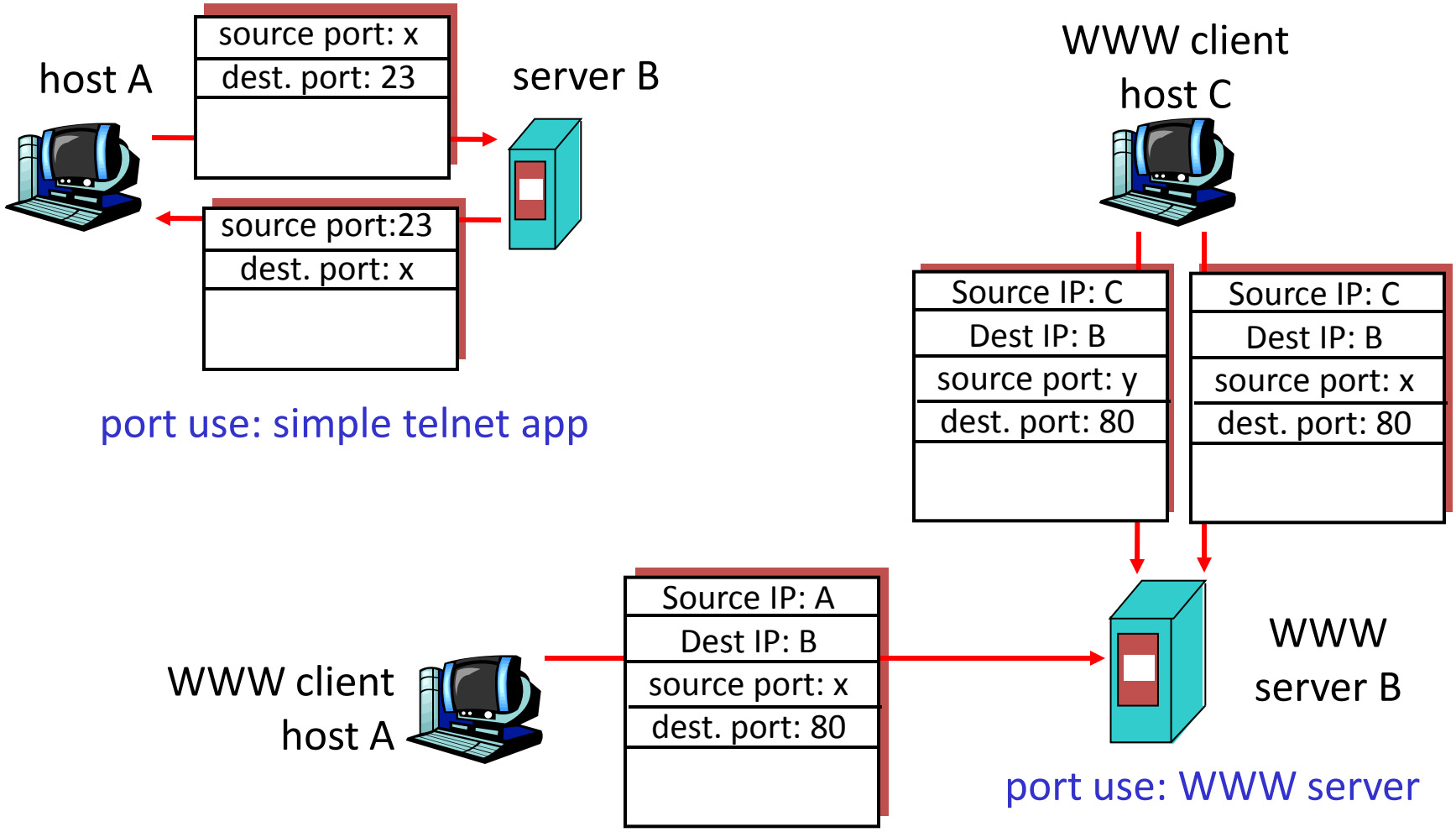
Multiplexing/Demultiplexing: examples
Transport Layer 4



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UDP: User Datagram Protocol [RFC 768]
Transport Layer 4

- "no frills", "bare bones" Internet transport protocol
- "best effort" service, UDP segments may be:
  - lost
  - delivered out of order to app
- *connectionless:*
  - no handshaking between UDP sender & receiver
  - each UDP segment handled independently of others

Why is there a UDP?

- no connection establishment (which can add delay, less resource required)
- simple: no connection state at sender, receiver
- small segment header
- no congestion control: UDP can blast away as fast as desired

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TCP: Overview
Transport Layer 4

- full duplex data:
  - bi-directional data flow in same connection
  - MSS: maximum segment size
- connection-oriented:
  - handshaking (exchange of control msgs) init's sender, receiver state before data exchange
- flow controlled:
  - sender will not overwhelm receiver
- point-to-point:
  - one sender, one receiver
- reliable, in-order *byte steam:*
  - no "message boundaries"
- pipelined:
  - TCP congestion and flow control set window size

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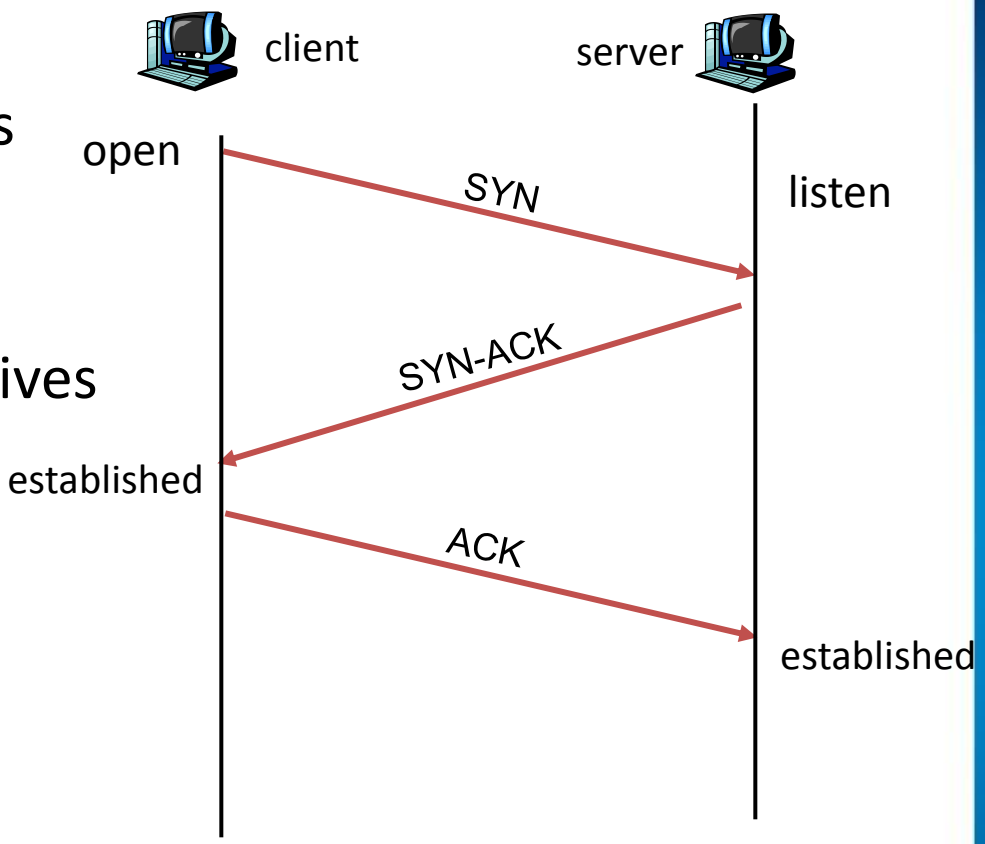
TCP Connection Management (cont'd)
Transport Layer 4

Opening a connection
(3-way handshake)

Step 1: client end system sends TCP SYN control segment to server

Step 2: server end system receives SYN, replies with SYN-ACK
- allocates buffers
- ACKs received SYN

Step 3: client rcvs SYN-ACK
- connection is now set up
- client starts the "real work"



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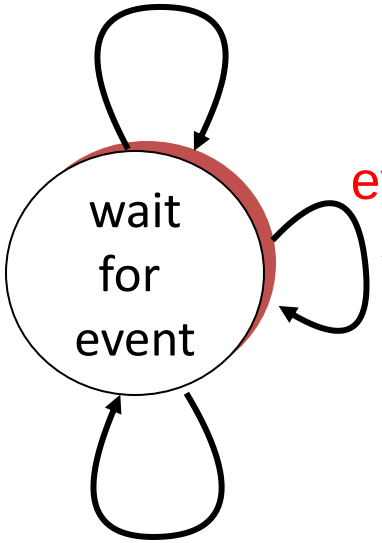
TCP: reliable data transfer
Transport Layer 4

event: data received
from application above
create, send segment



event: timer timeout for
segment with seq # y
retransmit segment

event: ACK received,
with ACK # y
ACK processing

simplified sender, assuming

- one way data transfer
- no flow, congestion control

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TCP Connection Management
Transport Layer 4

Recall: TCP sender, receiver establish a "connection" before exchanging data segments

- initialize TCP variables:
  - seq. #s
  - buffers, flow control info (e.g., **`RcvWindow`**)
- *client:* connection initiator
- *server:* contacted by client

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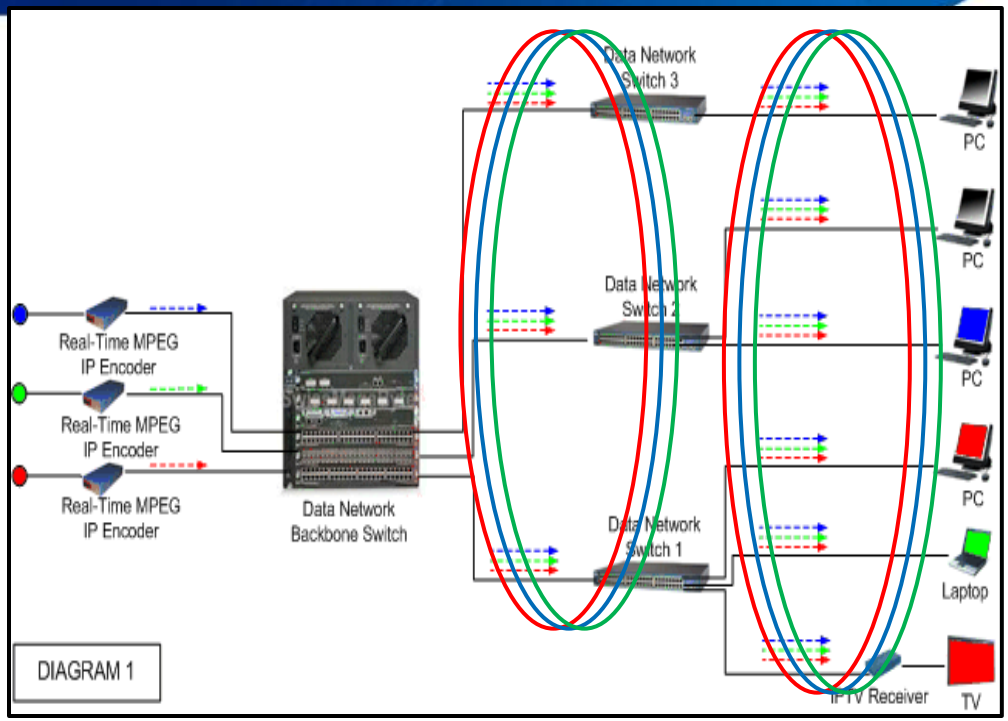
IPTV
without Multicasting

Internet Protocol (IP) multicast is a bandwidth-conserving mechanism for reducing data network traffic by simultaneously delivering a single stream of information to thousands of recipients.

None of the network switches have IGMP snooping or querying turned on and so the network is not multicast enabled.

The backbone switch has all the streaming traffic coming into it from the MPEG IP Encoders

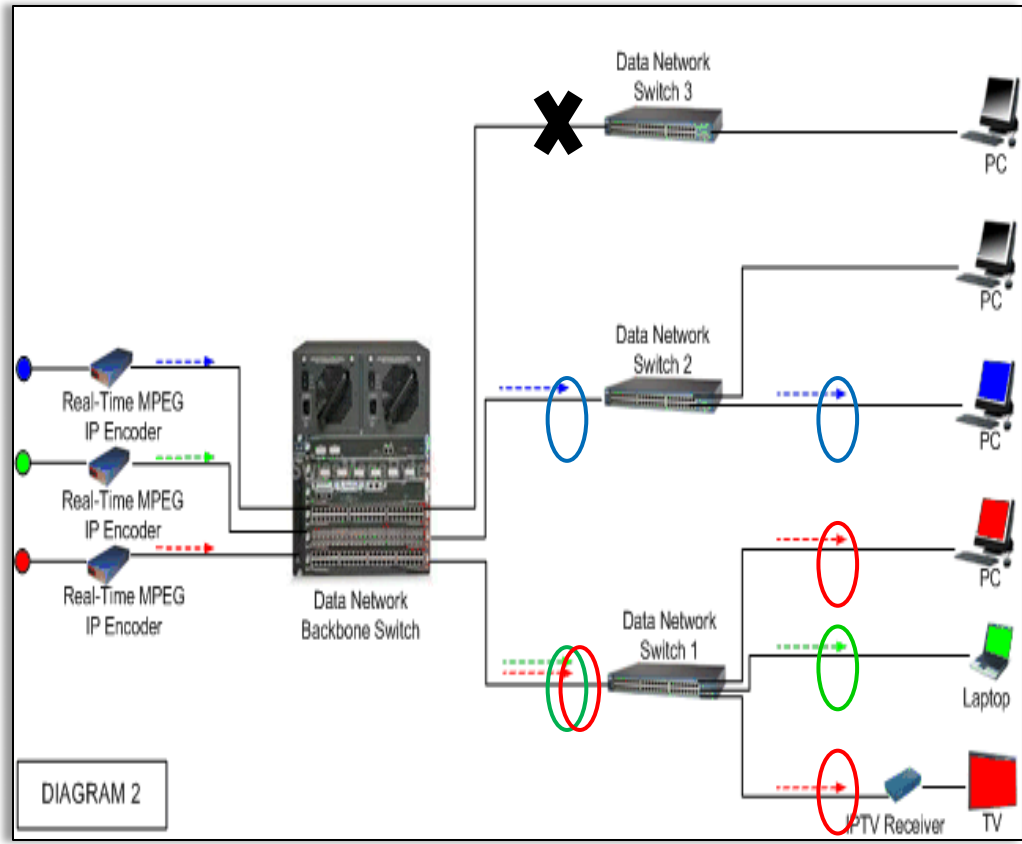


IPTV Multicast

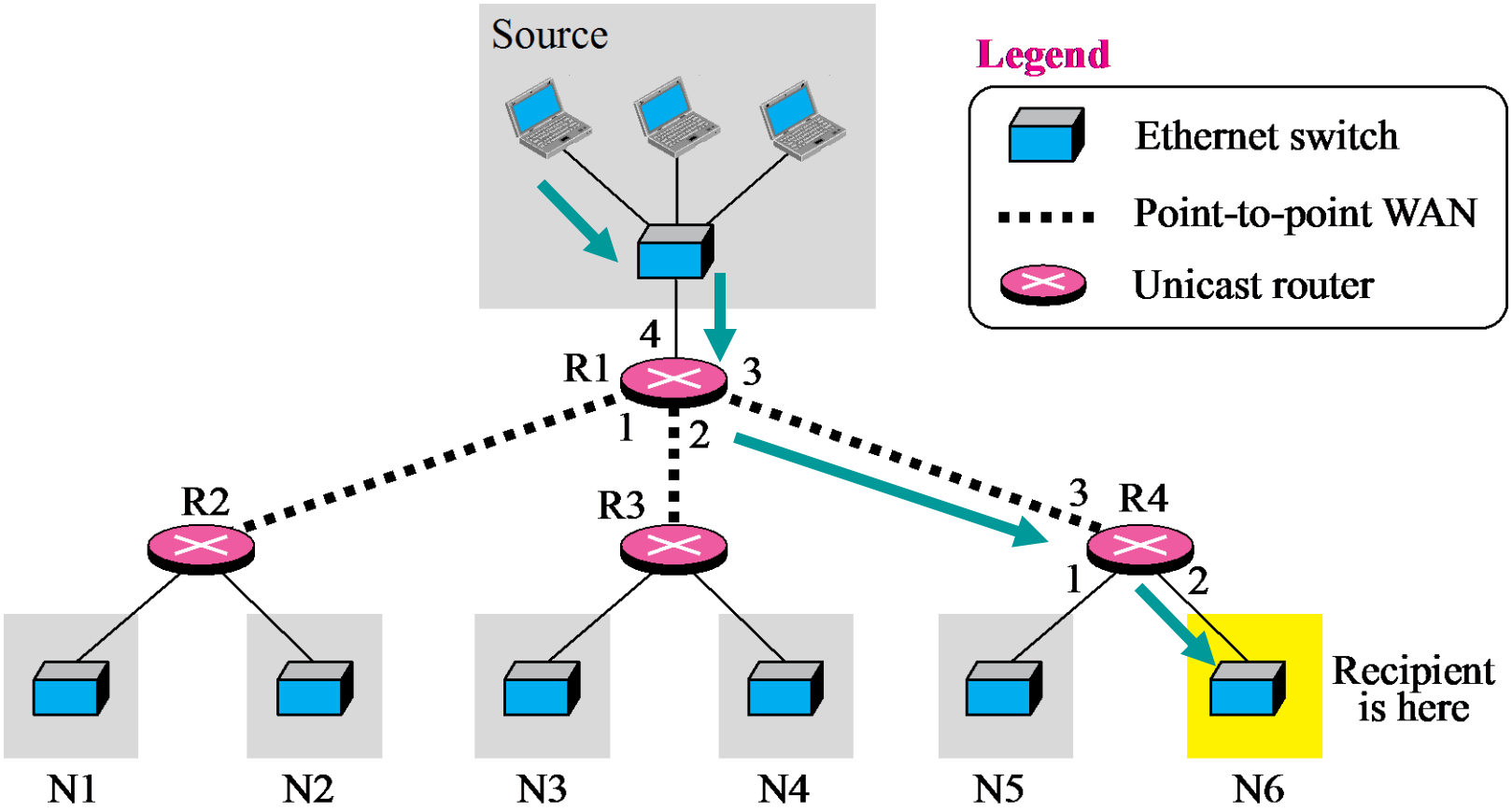
Multicasting is fundamental to the implementation of IPTV.

IGMP snooping turned on and the backbone switch has IGMP query turned on.

*** IGMP snooping** is the process of listening to Internet Group Management Protocol (IGMP) network traffic. IGMP snooping is a feature that allows a network switch to listen in on the IGMP conversation between hosts and routers. By listening to these conversations the switch maintains a map of which links need which IP multicast streams. Multicasts may be filtered from the links which do not need them.

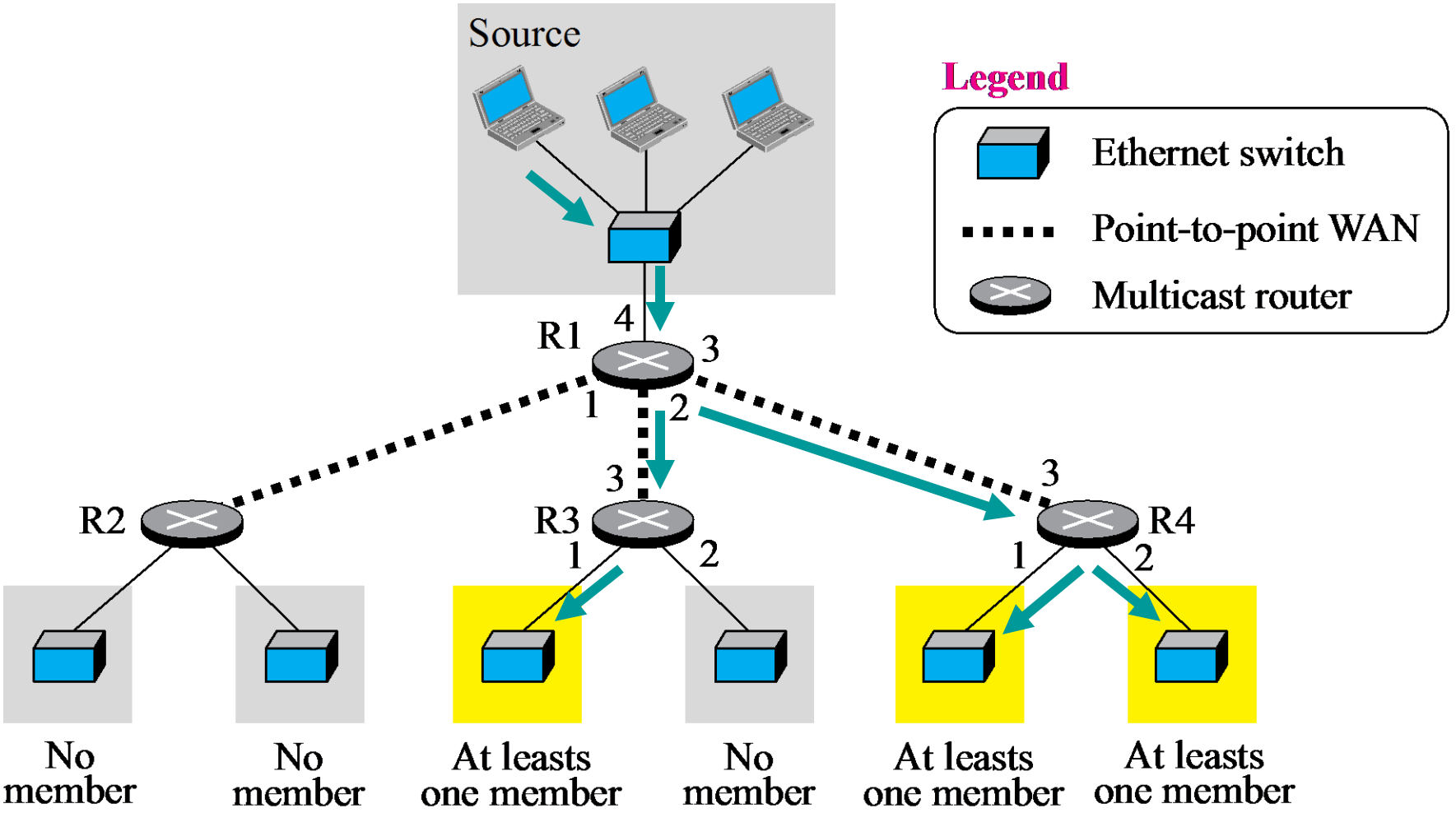


Unicasting


Source
Legend
Ethernet switch
Point-to-point WAN
Unicast router
4
R1
3
1
2
R2
R3
3
R4
1
2
N1
N2
N3
N4
N5
N6
Recipient is here

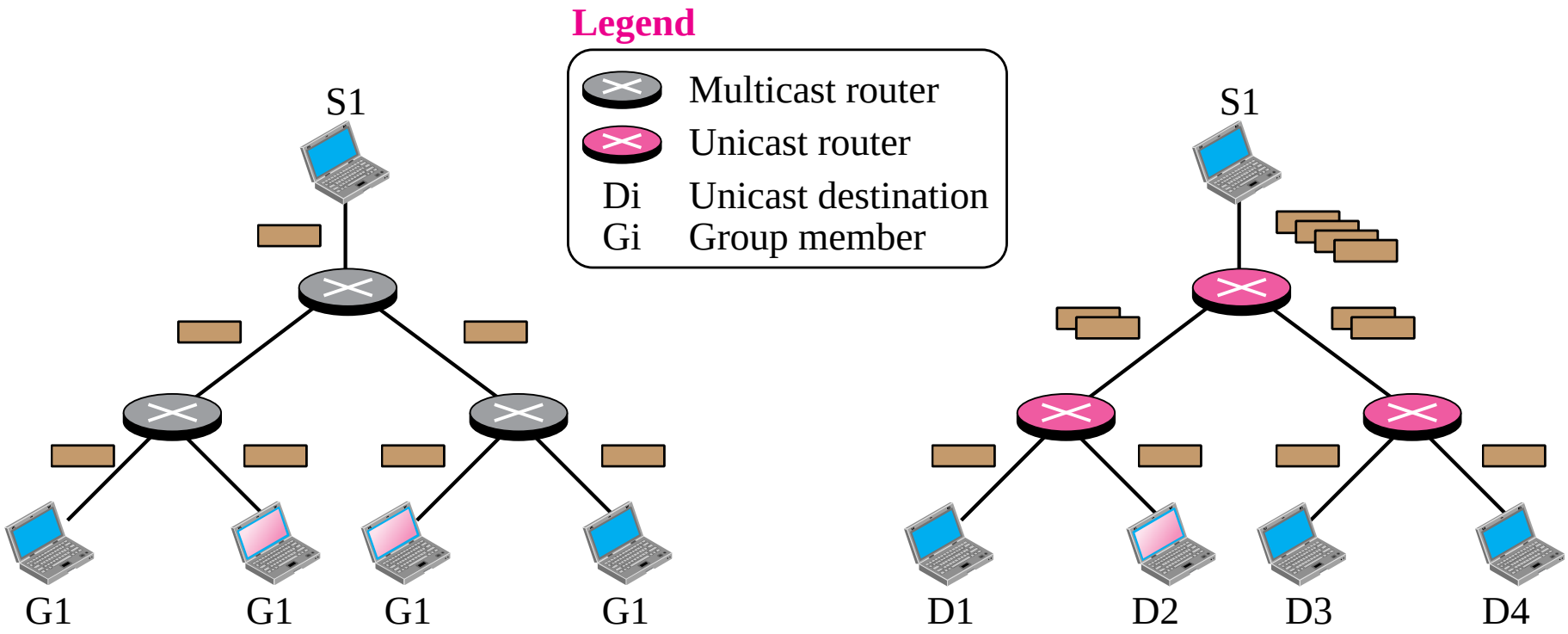
In unicasting, the router forwards the received datagram through only one of its interfaces.

Multicasting



In multicasting, the router may forward the received datagram through several of its interfaces.

Multicasting versus multiple unicasting

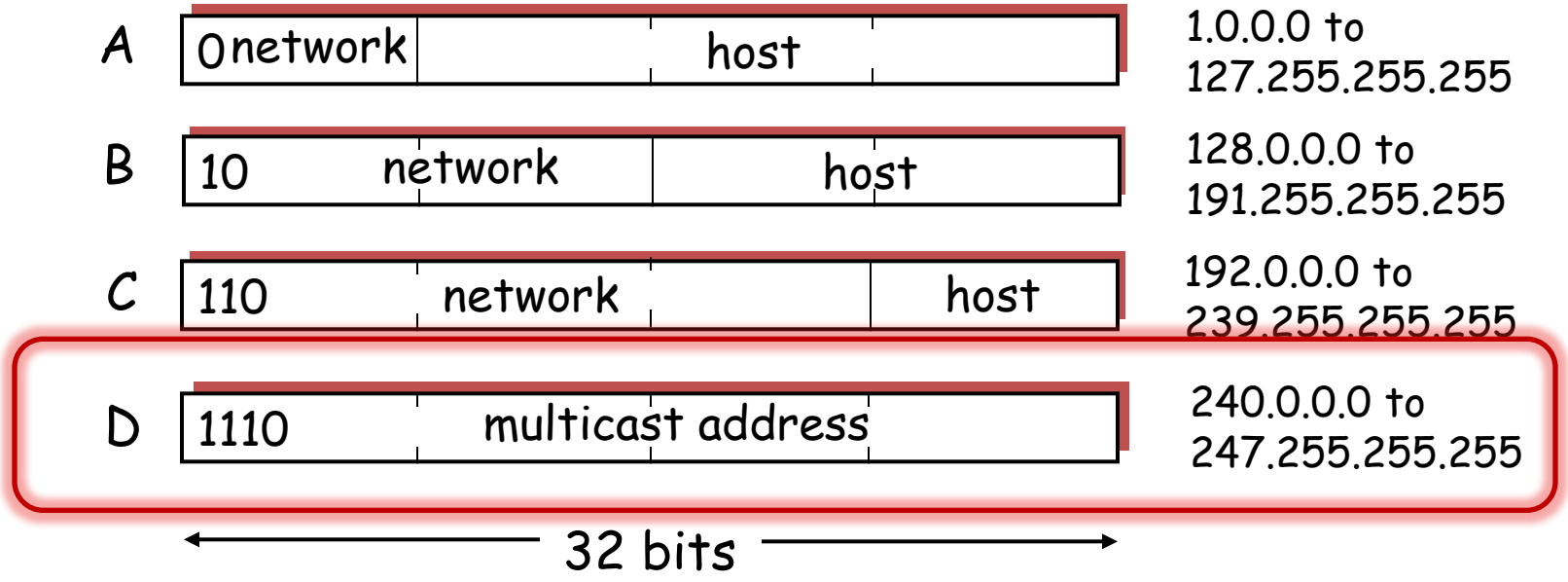


a. Multicasting

b. Multiple unicasting

IP V4 Address Class
Layer 3 – The Network Layer

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network	Start address	End address
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	0.0.0.0	127.255.255.255
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	128.0.0.0	191.255.255.255
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	192.0.0.0	223.255.255.255
Class D (multicast)	1110	not defined	not defined	not defined	not defined	224.0.0.0	239.255.255.255
Class E (reserved)	1111	not defined	not defined	not defined	not defined	240.0.0.0	255.255.255.255



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Summary
Transport Layer 4

- transport layer services
- multiplexing/demultiplexing
- connectionless transport: UDP
- connection-oriented transport: TCP

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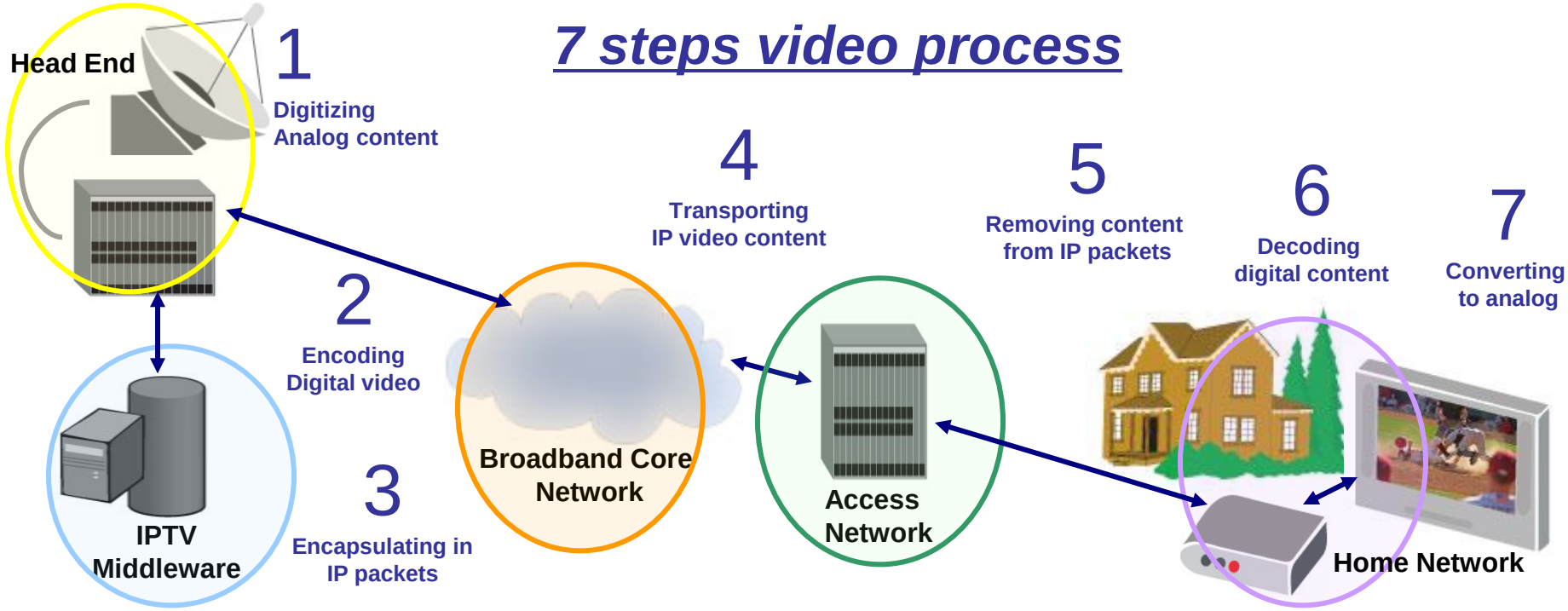
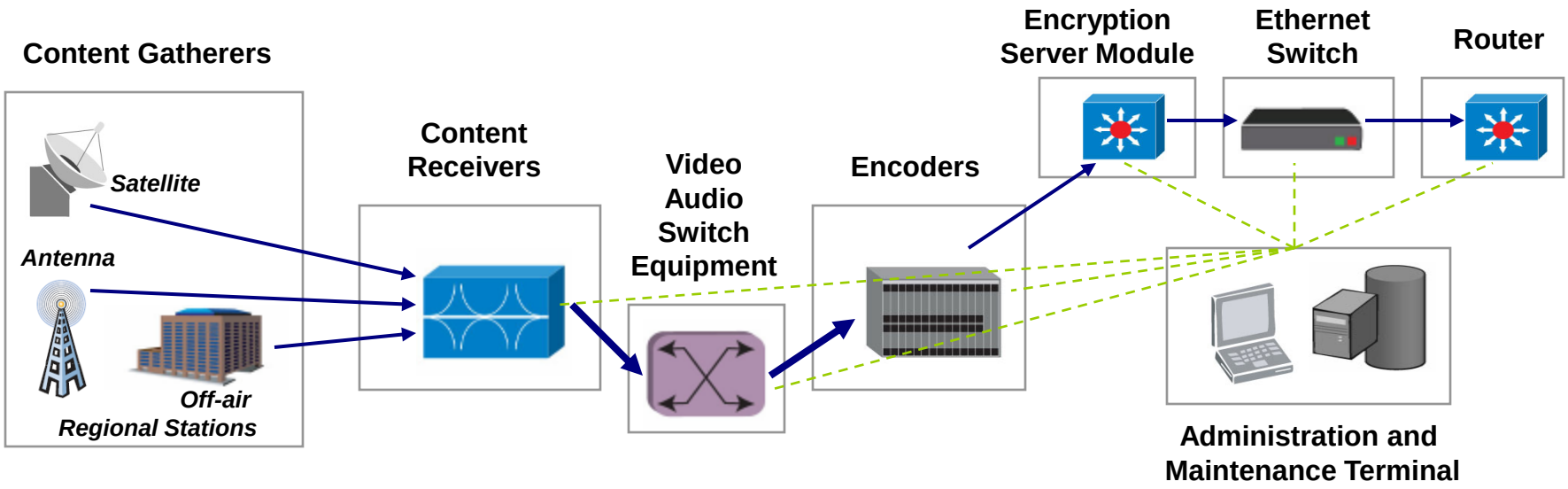
IPTV & Troubleshooting Overview

IPTV Ecosystem : Technical Architecture



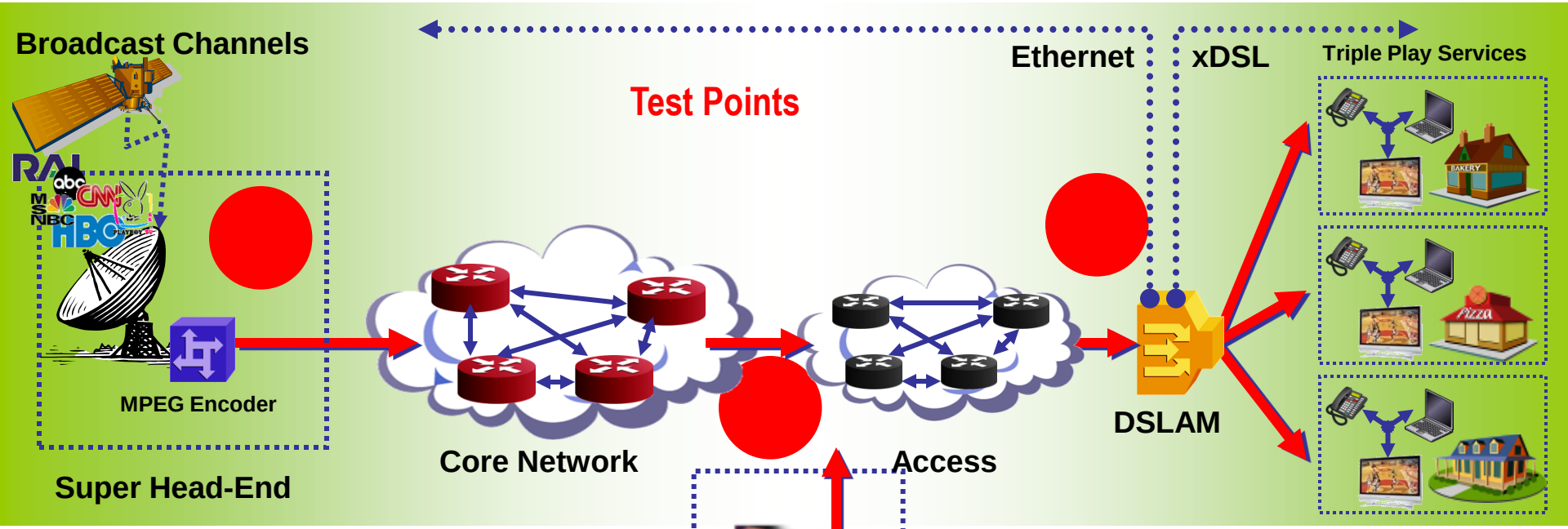
5 major technical components in an IPTV network:	3- IP Broadcast Core Network
1- IPTV Middleware / servers (VoD, etc.)	4- Broadband Access Network
2- Head End / Video (broadcast sources)	5- Broadband Home Network

Head End Architecture



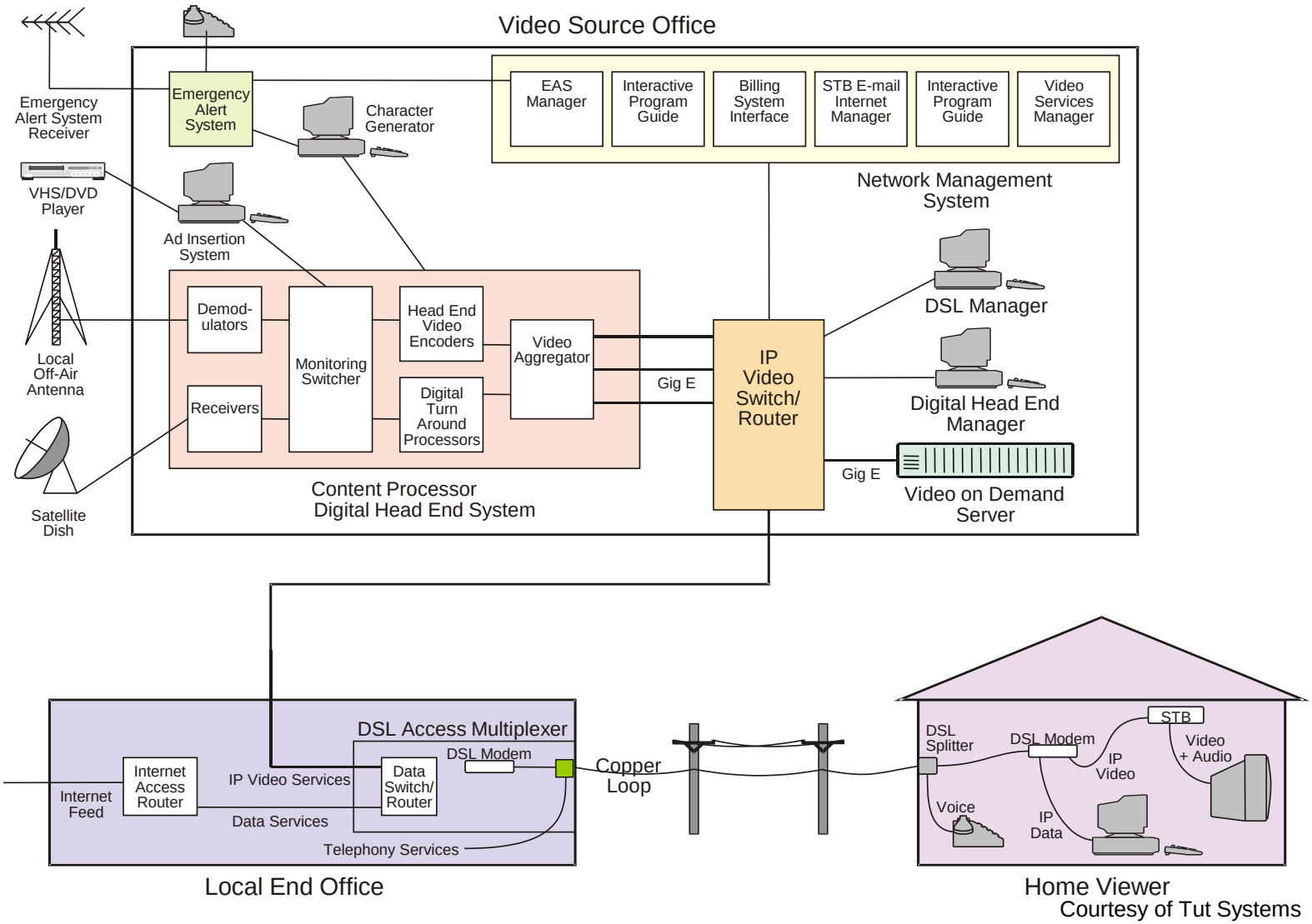
Content Gatherers Various sources: CDs, Digital servers, Off-air regional stations, Digital program feeds or Satellites (analog or digital channels)	**Encryption Server Module** Encrypts content, parts of the Conditional Access (CA) system that ensures video content can be viewed only by authorized subscribers
Content Receivers Definition of the video format (NTSC – PAL – SECAM) and removal of any noise or distortions acquired through transmission	**Ethernet Switch** Assigns a unique IP address to each video and audio stream. The set top box will call on the unique IP address assigned to the channel.
Video-audio Switch Equipment Acts as interfaces with the content receivers and encoders to provide access to all channels for testing and maintenance procedures	**Router** The router allows the transportation of the IP packets to the core network.
Encoders Conversion of the content from analog to digital formatted content and encoding into an appropriate format (MPEG2 – MPEG4 – VC-1)	**Administration and Maintenance Terminals** Each of these devices have network management access (status events and alarms) for remote maintenance and troubleshooting.

IPTV Topology



- The IPTV network must be tested upon introduction of new services to characterize the network
- IPTV testing and monitoring should occur at every major routing point
- Critical measurement points are where media content enters the network
  - Super head-end, local content and link leading to the DSLAM
- More testing points allows for easier fault isolation

IPTV Topology



Courtesy of Tut Systems

Issues Affective IPTV Quality

QoS Problem	Probable Reason
Channel and service availability	System / network availability
Slow channel change time	IGMP / network performance / middleware
Content quality	Packet loss / jitter / A-server / D-server, STB
Bandwidth efficiency	IGMP performance / fast channel change (middleware)
Video / audio synch	Network performance / system configuration

Transport (IP)	Signalling (IGMP)	Content (Video/Audio)	Service (IPTV)
Latency Packet loss Jitter, buffer delay Hop count	IGMP • Join/leave times • Join/leave gap • Join/leave overlap HTTP/SIP • Service access time	MOS, bandwidth Picture/frame loss Frame rate Freeze/skip frame events Black screens	Channel availability Channel start time Channel change time Channel join time Channel change failure DRM response time

- The majority of video quality problems are network (transport) related
- Exfo is focusing its IPTV testing strategy in the transport layer of the IPTV service delivery chain

Common QoE (Quality of Experience) Cause and Effects

Jitter Effect

Picture viewing problems because the buffer does not fill fast enough, and the feed to the decoder does not happen at a constant rate.

The stream of IP packets is flowing too quickly. Thus, the IPTV consumer device buffer overflows, and packets are lost.

0% Packet Loss

0.5% Packet Loss

5% Packet Loss

Packet Loss Effect

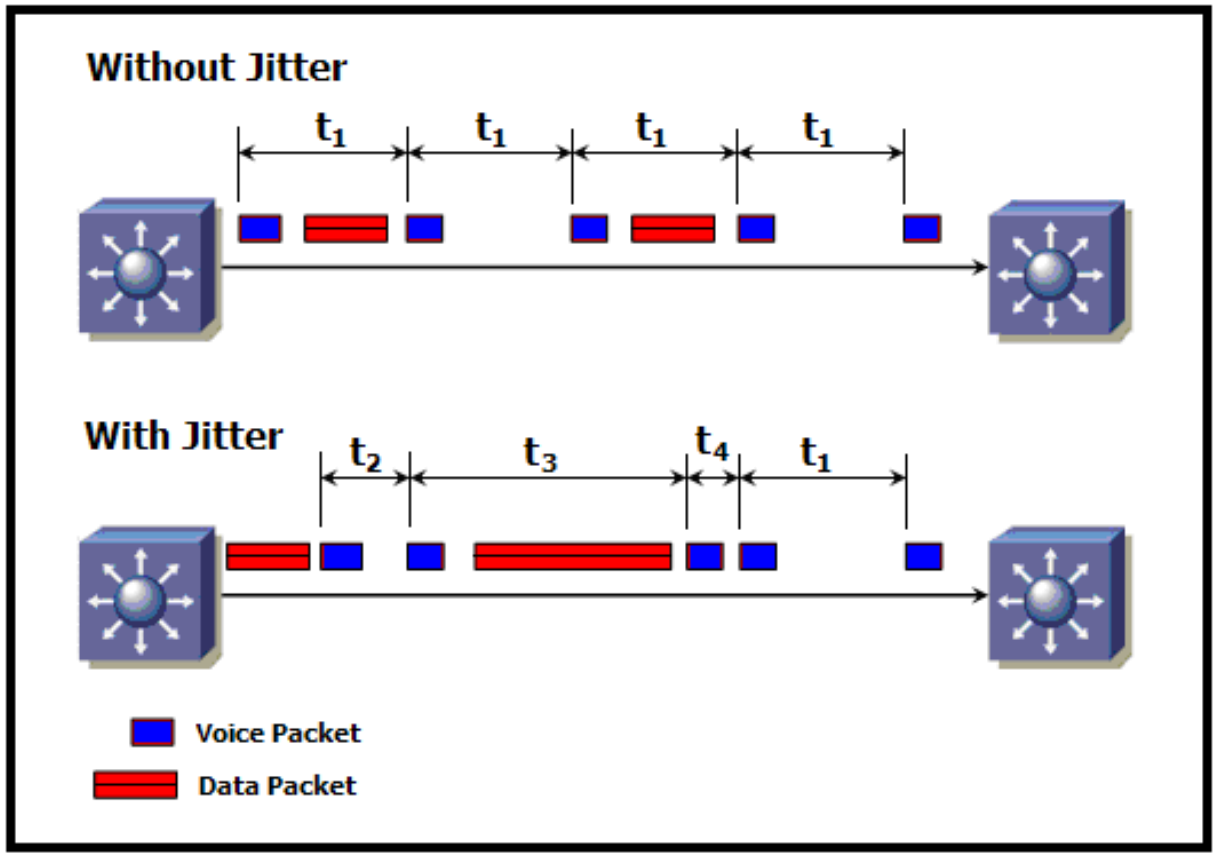
Packet loss occurs when one or more packets of data traveling across the access network fail to reach their destination. If the missing packets were related to the reconstruction of the I Frames, there is a good chance of losing the video signal for a short period of time.

Out-of-order Effect

Buffering issues on the output ports of network routers can cause packet loss. If a router at a network aggregation point gets near its maximum input capacity, there may be packet losses at the output interface as the routers buffers reach overflow.

Frame Delay Variation- PACKET JITTER

Packet jitter refers to the variability in arrival time between consecutive packets



Testing Term's & Definitions

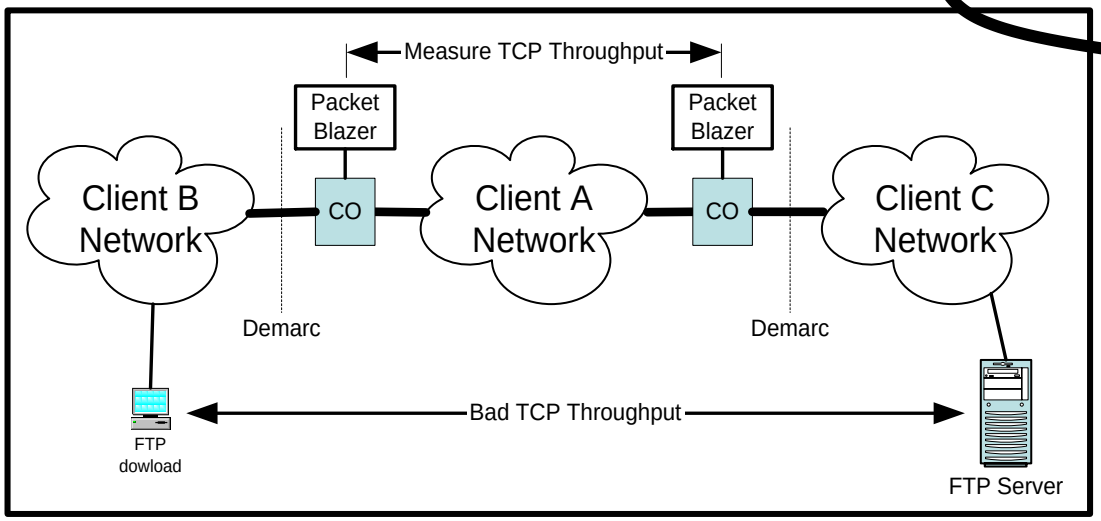
RFC - 2544

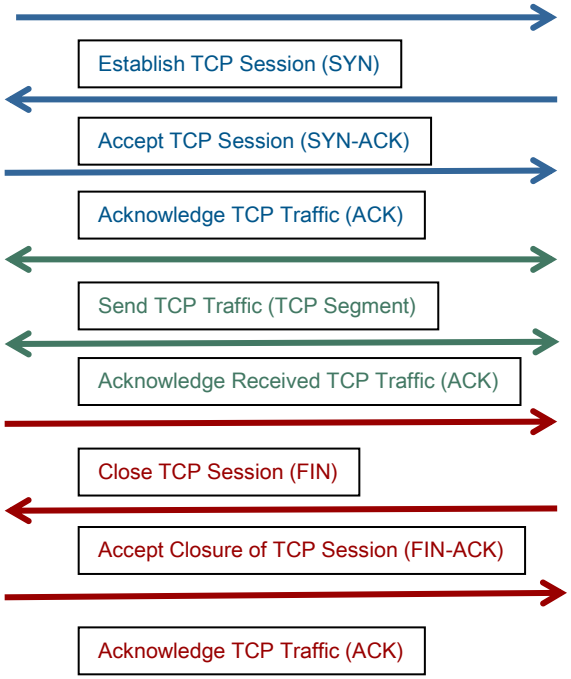
Throughput-	Maximum rate of transmitted frames through the network (Bandwidth Verification)
Back to Back-	Burstability Bandwidth- maximum burst of traffic through network where Burst = the max # of bytes at full line rate before a packet is dropped
Frame Loss-	Measure network ability to handle overload
Latency-	Round Trip delay of frames through network

RFC-2544 Report.pdf

TCP Throughput

Verification of network performance with connection oriented stateful TCP traffic.





High-Level View of EtherSAM

EtherSAM (ITU-T Y.156sam)

Phase 1 – Network Configuration Test (Ramp Test)

Objective: Validate the network configuration of each defined services (rate limiting, traffic shaping, QoS)

Methodology: For each service, a ramp test is used to gradually reach and exceed the CIR . All KPIs are measured against a threshold

Phase 2 – Service Test

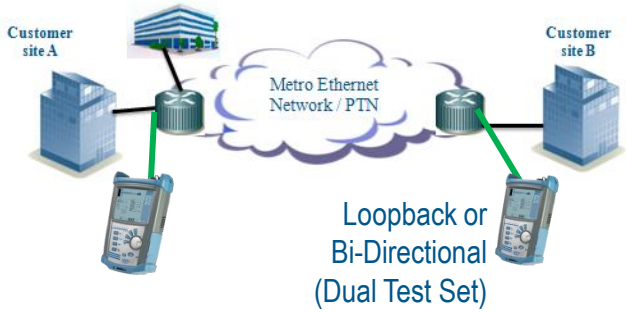
Objective: Validate the quality of service of each defined service and prove SLA conformance

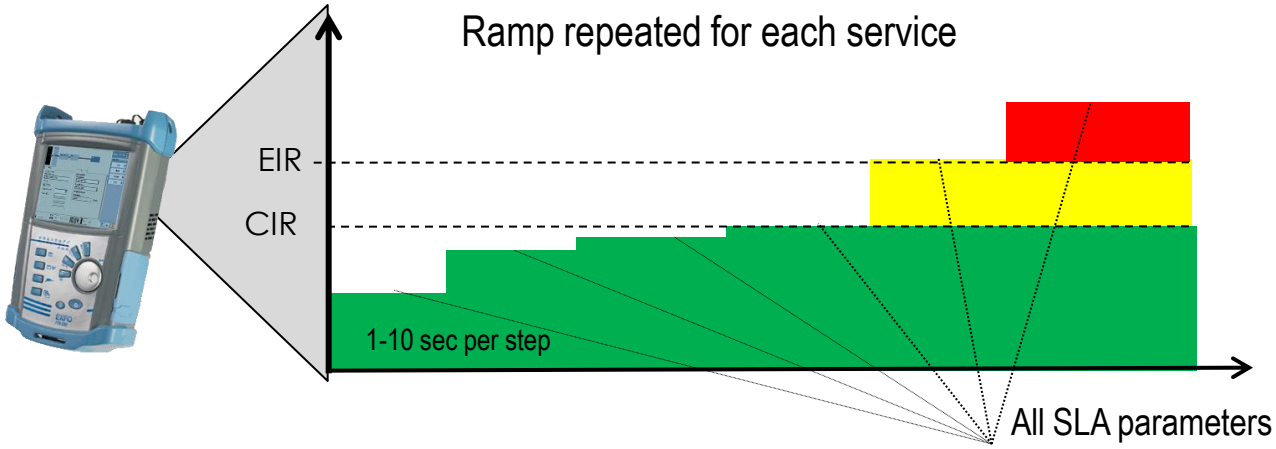
Methodology: All services are generated at once to their CIR and all KPIs are measured for all services

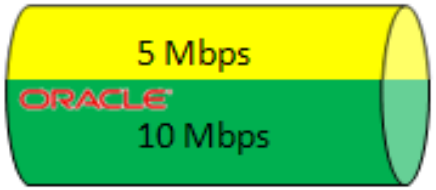
Phase 1 – Network Configuration Test

Phase 1 – **Network Configuration Test (Ramp Test)**

Objective: Validate the network configuration of each defined services (rate limiting, traffic shaping, QoS)	**Methodology:** For each service, a ramp test is used to gradually reach and exceed the CIR . All KPIs are measured against a threshold







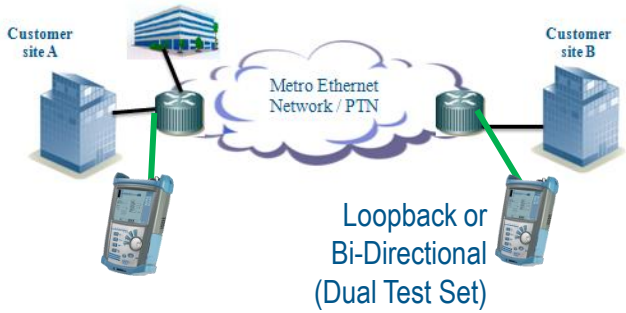
All SLA parameters measured at each step (Throuhput, Latency, Frame Loss, Jitter, OOS), Pass/Fail result

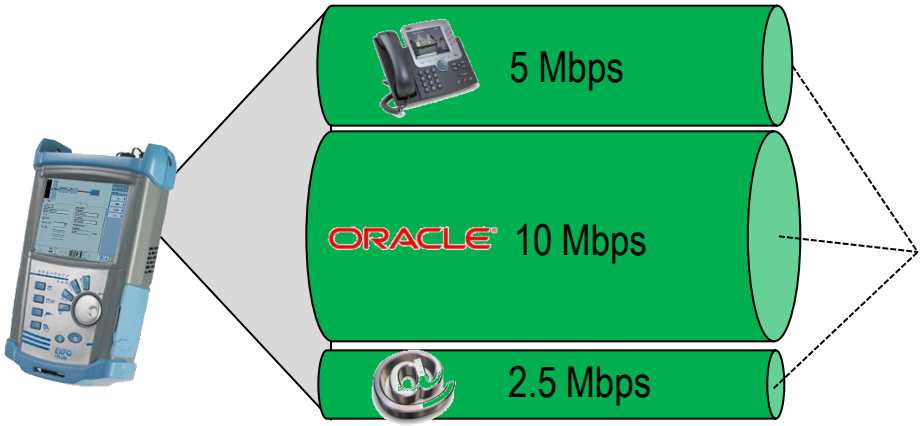
- For each service sequentially, generate a traffic ramp, first up to CIR and then up to EIR (if applicable) and then over EIR
- Verify that CIR and EIR are properly configured
- Verify all SLA parameters at each ramp step (Pass/Fail thresholds for each parameters)
- Approximate Test time: 1 minute per service

EtherSAM

Phase 2 – Service Test

Phase 2 – **Service Test**	
Objective: Validate the quality of service of each defined service and prove SLA conformance	**Methodology:** All services are generated at once to their CIR and all KPIs are measured for all services





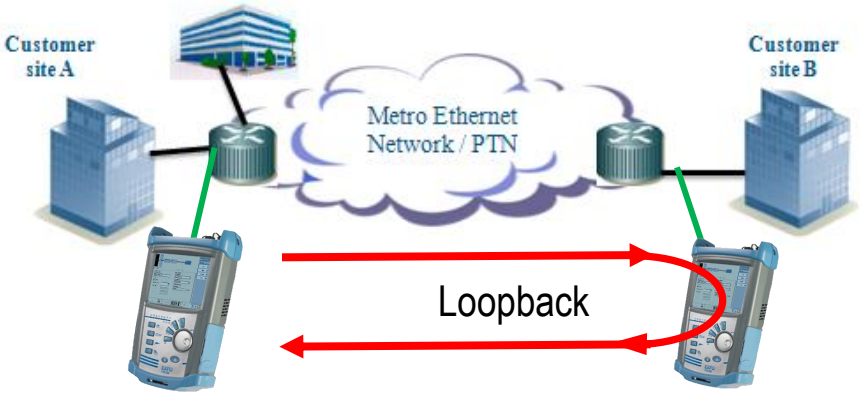
All SLA parameters measured throughout the test (Throuhput, Latency, Frame Loss, Jitter, OOS), Pass/Fail result

- Generate all Services simultaneously at CIR and measure all parameters simultaneously (Throughput, Latency, Frame Loss and Packet Jitter) – Similar to “Per Stream Statistics”
- Pass/Fail threshold for each parameter (in each direction)
- Suggested Test time: 2 hours (dependent on customers, could be as low as 2 minutes)
- Can be scaled to longer term test (ex. 24 hours).

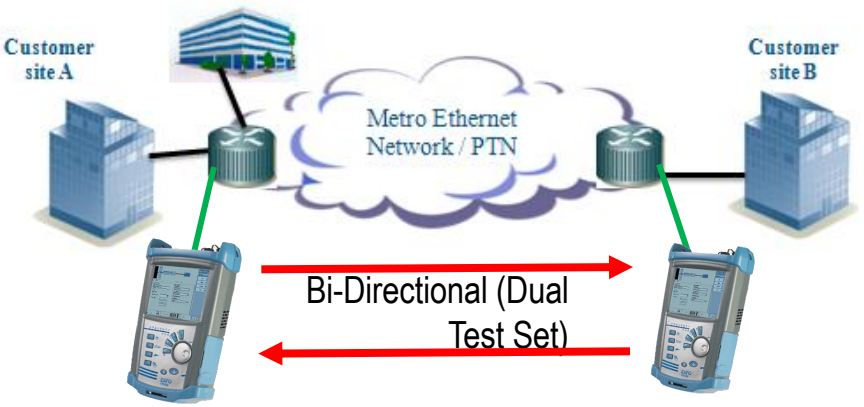
EtherSAM

Bi-directional (Dual Test Set)

EtherSAM can be performed in Dual Test Set and obtain Bi-Directional Results



Round-trip results only

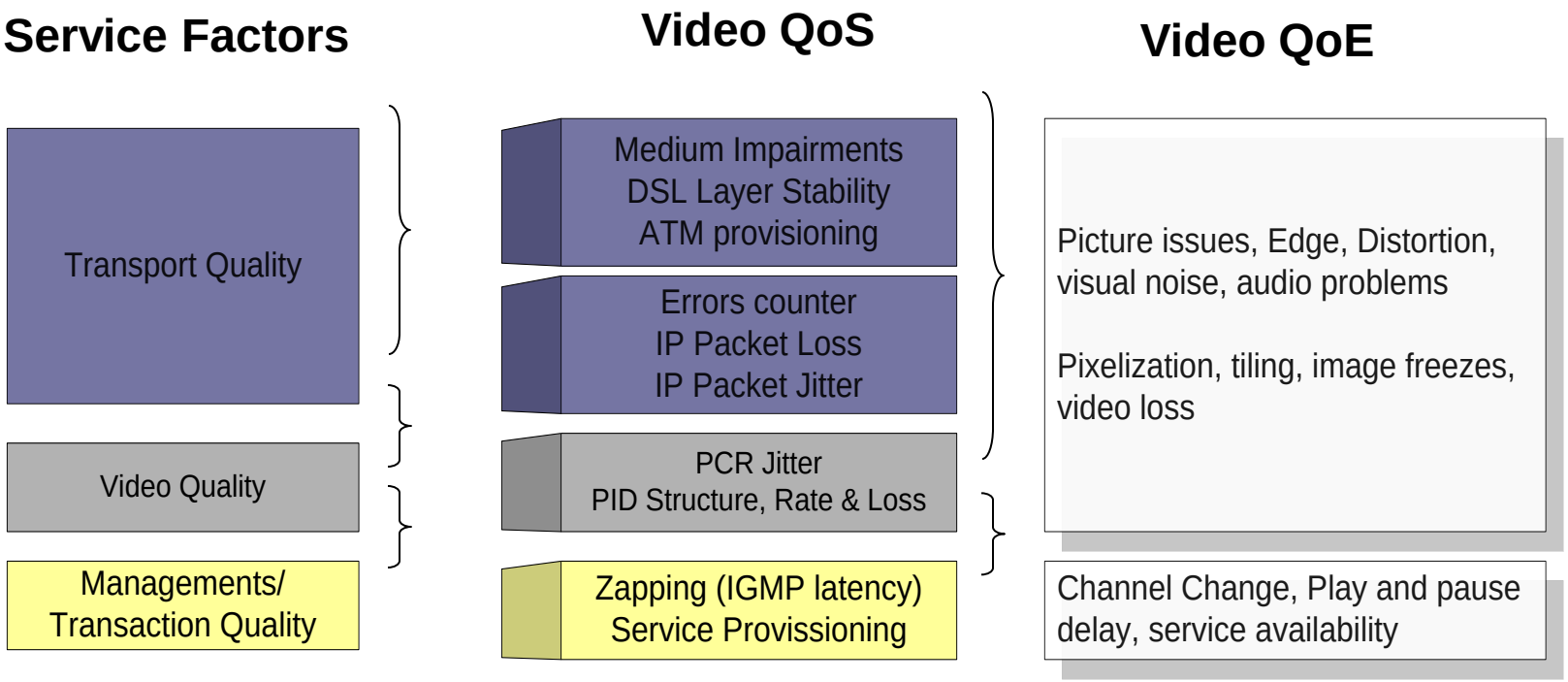


Independent Results for each test direction for each individual service

- Only Bi-directional results can uncover all configuration errors and test assymmetrical services

EtherSAM

Video Analysis – IPTV

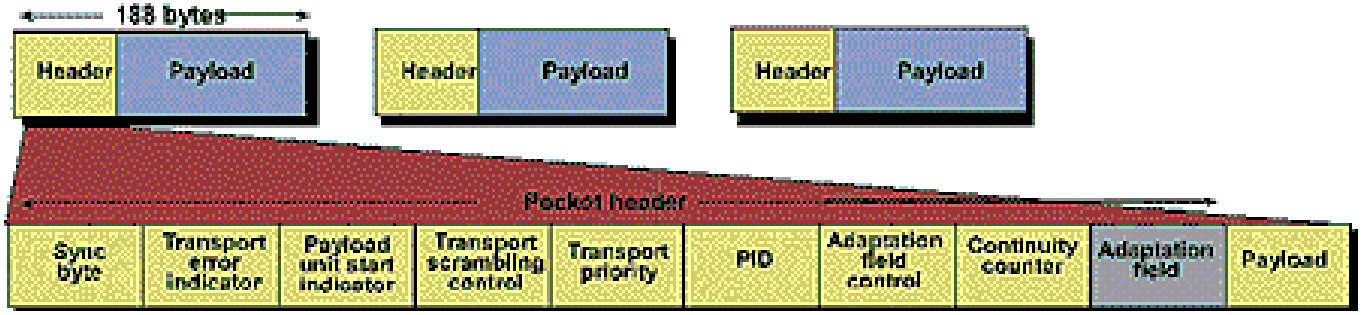


Advanced IPTV testing application

PID

PID

The PID is part of that 4-byte Transport Stream header and represents a unique address identifier for the type of packet or payload carried by the TS



- ✓ **STB uses the PID to process audio, video and other MPEG info packets accordingly**
- ✓ **Correct PID assignment and minimal packet loss are required by STB for the correct decoding of a video stream**
- ✓ **Service Providers need visibility of PID configuration, rates and packet loss for isolation and troubleshooting IPTV disturbances**

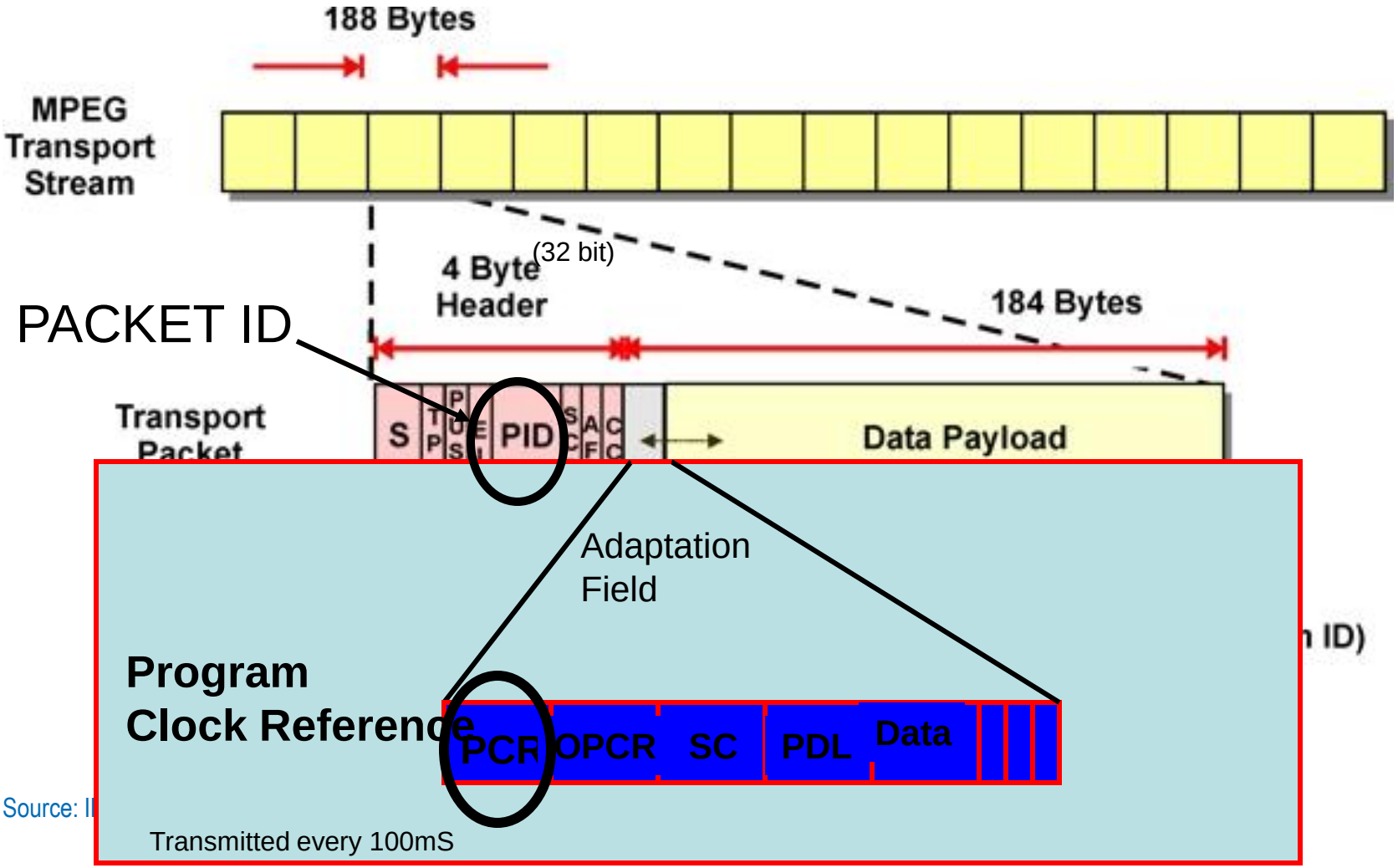
MPEG-4 Part 10 (H.264) versus MPEG-2

- **The improved efficiency of MPEG-4 Part 10 versus MPEG-2 translates into three main benefits:**
- **Higher video quality at a given bit-rate:** reduction in artifacts such as blockiness, color bands etc.
- **Higher resolution:** as the video world transitions to High Definition, a mechanism is needed to deliver it.
- **Lower storage requirements:** lower storage requirements will allow for large amounts of content to be delivered on a single disc.

Source: ATI

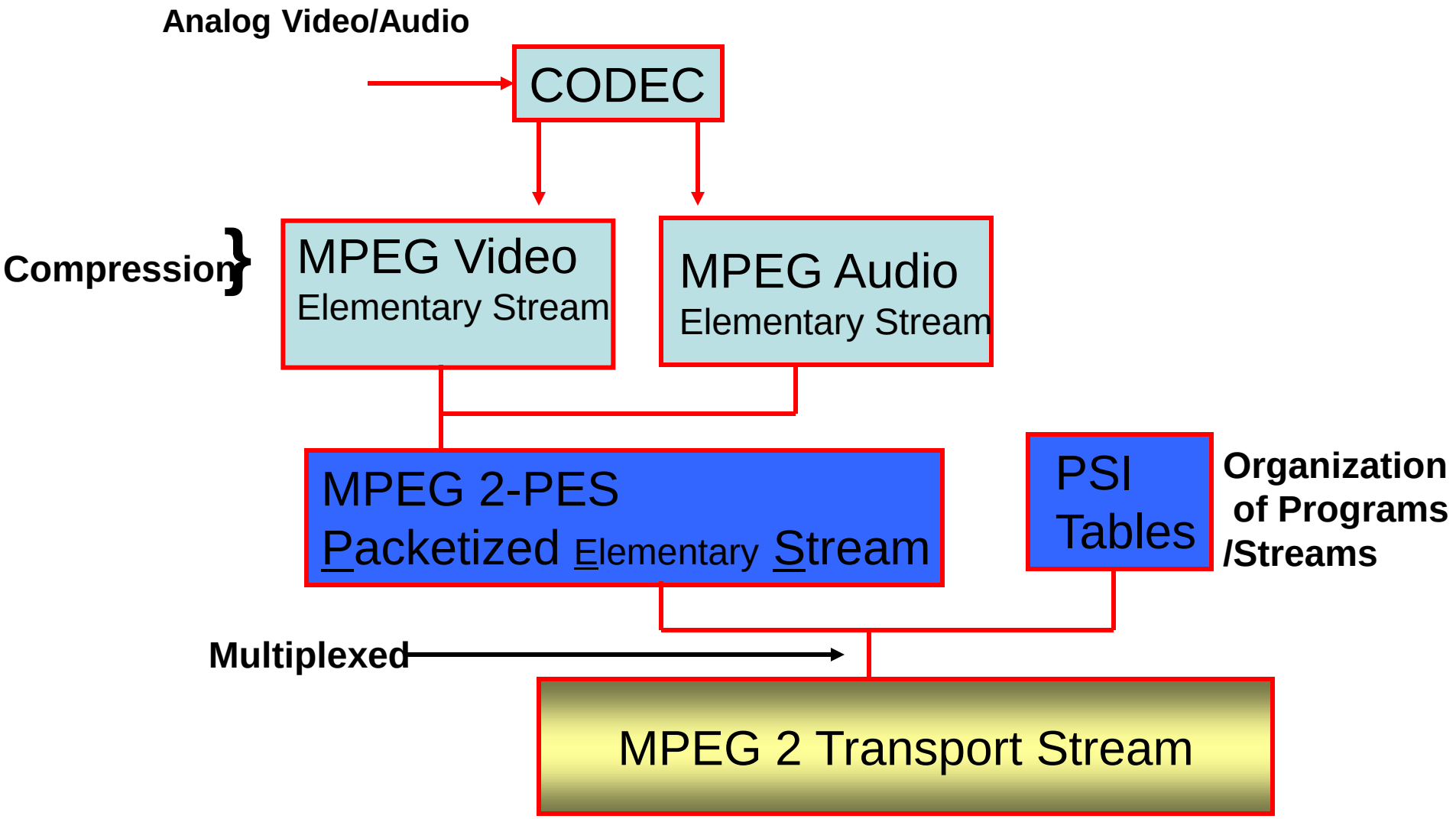
Header (4 bytes / 32 bits)

MPEG Transport Stream structure



- Source: I

MPEG 2 STRUCTURE



Zapping time - IGMP in Action

FOX MPEG

IGMP Leave FOX

IGMP Query

IGMP Join CNN

CNN MPEG

IGMP CONTROL POINT

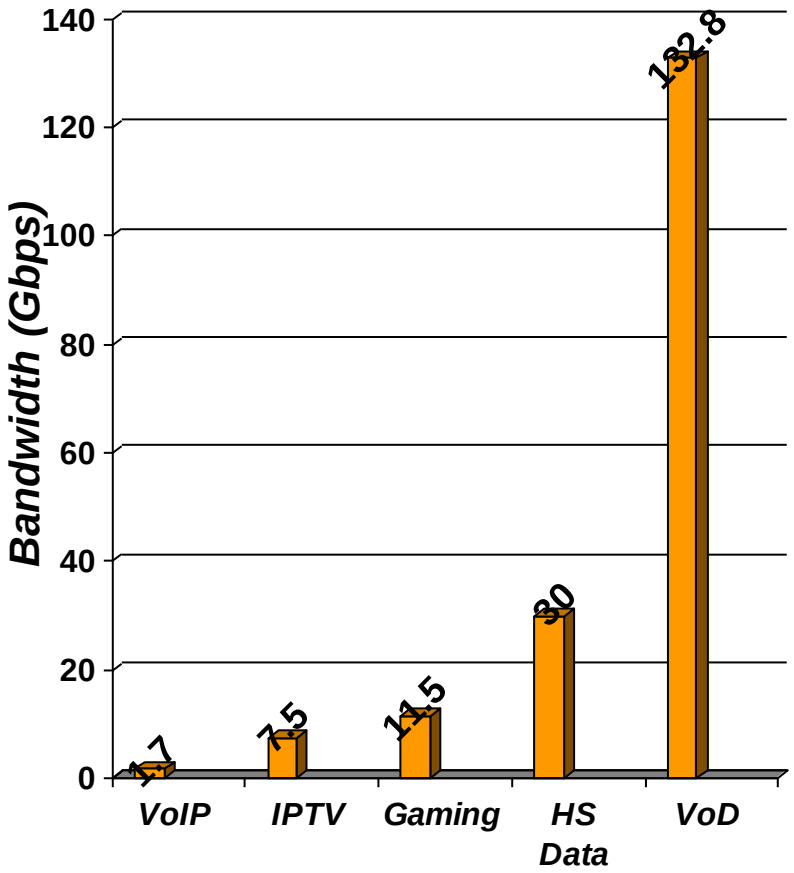
NETWORK

HBO

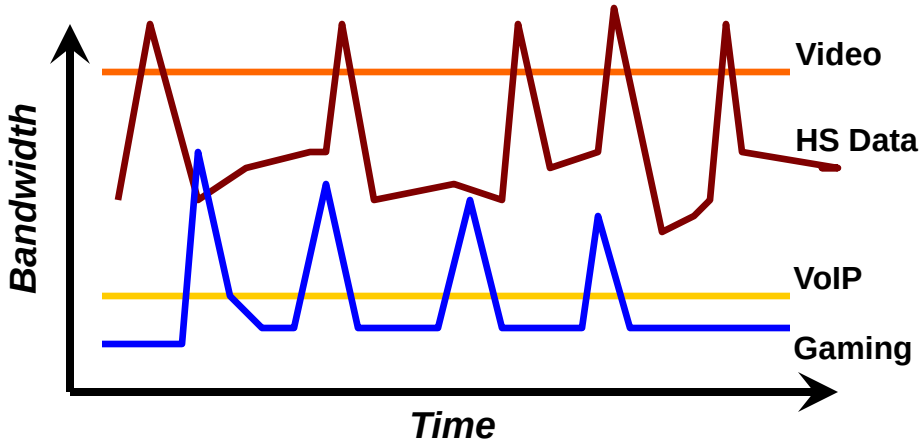
CNN

FOX

Multi-Service Network Challenges



Note: Bandwidth requirement based on 100,000 subscribers
Source: Heavy Reading



	Latency	Jitter
IPTV	*Med*	*High*
VoD	*Med*	*High*
VoIP	*High*	*High*
HS Data	*Med*	*Low*
Gaming	*High*	*High*

Where do IPTV Problems Come From?

	% of problems 2007	2010
Video Head End • Poor content quality • PCR jitter • PID mappings errors • Lip synch problems	~5 to 10%	~10 to 15%
Transport Layer • Packet loss • Error correction performance • Miss-provisioning	~10%	~20 to 25%
Network Transition & VoIP/ISP Peering • Signaling • VOD service capacity / availability • Local channel feed errors	~10%	~10%
Aggregation & Last Mile • Miss provisioning • IGMP performance • Policy management	~25%	~20 to 25%
Customer Premise • Impulse events • Residential gateway problems • Security • Performance	~50%	~30 to 40%

QUESTIONS?

THANK YOU FOR YOUR ATTENTION!

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