# Networking 101 …. in 10 Easy Lessons

ProLiant Network Connectivity
Working with Ethernet, Protocols, and Switches

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HP WORLD 2003
Solutions and Technology Conference & Expo

# Overview

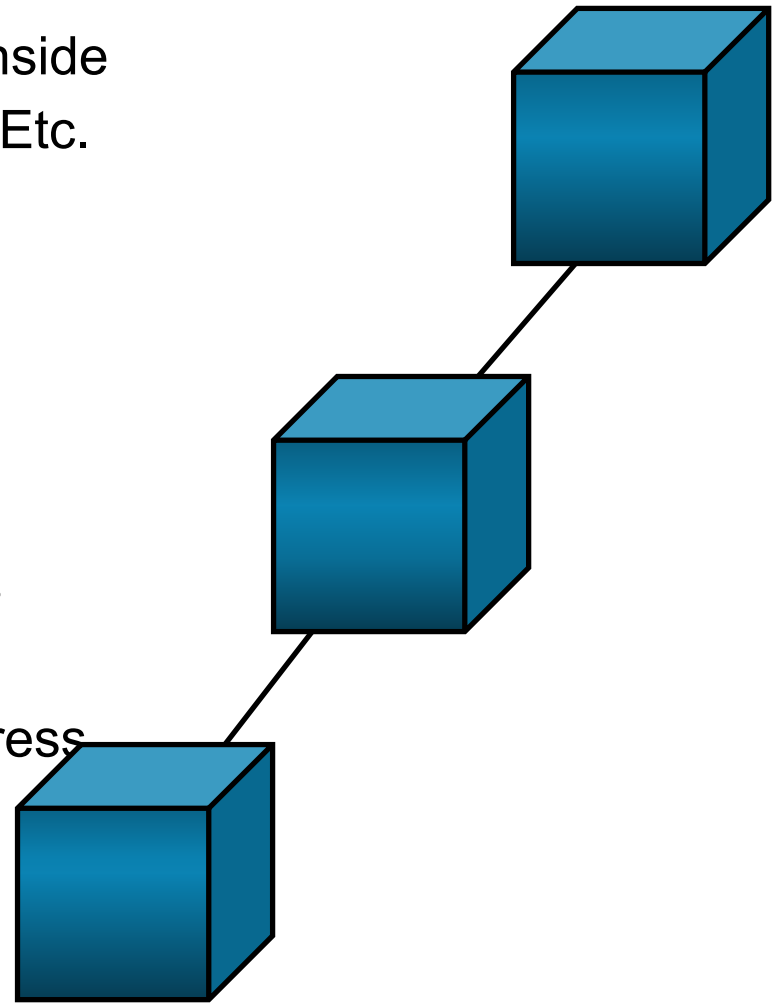
1. Introduction
2. OSI Model
3. TCP/IP
4. Addresses, VLANs
5. L2 Switches
6. L3 Routers
7. L4-7 Content Switches
8. ProLiant Teaming
9. ProLiant Blade Switches
10. Other Things to Know

# Lesson 1
# Information Technology - Networking

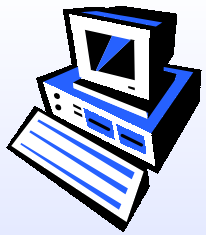
**Through a combination of hardware and software, networks permit services, data and equipment to be shared efficiently and economically by multiple users and applications.**

# Lesson 1
# "Four simple elements ...."

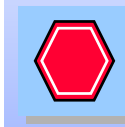
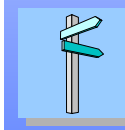
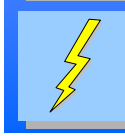
- The Node or Element
  - Generally has a computer/processor inside
  - A PC, Server, Printer, Router, Switch, Etc.
- The Transmission Media
  - Has a data transmitter - receiver
  - CAT5, Fiber, Radio Waves
- The Protocol
  - Rules with formatted messages
  - End User or Application data payloads
- Addresses
  - Ports, Sockets, IP Address, MAC Address



# Lesson 2
# The Seven Layers of the OSI Model



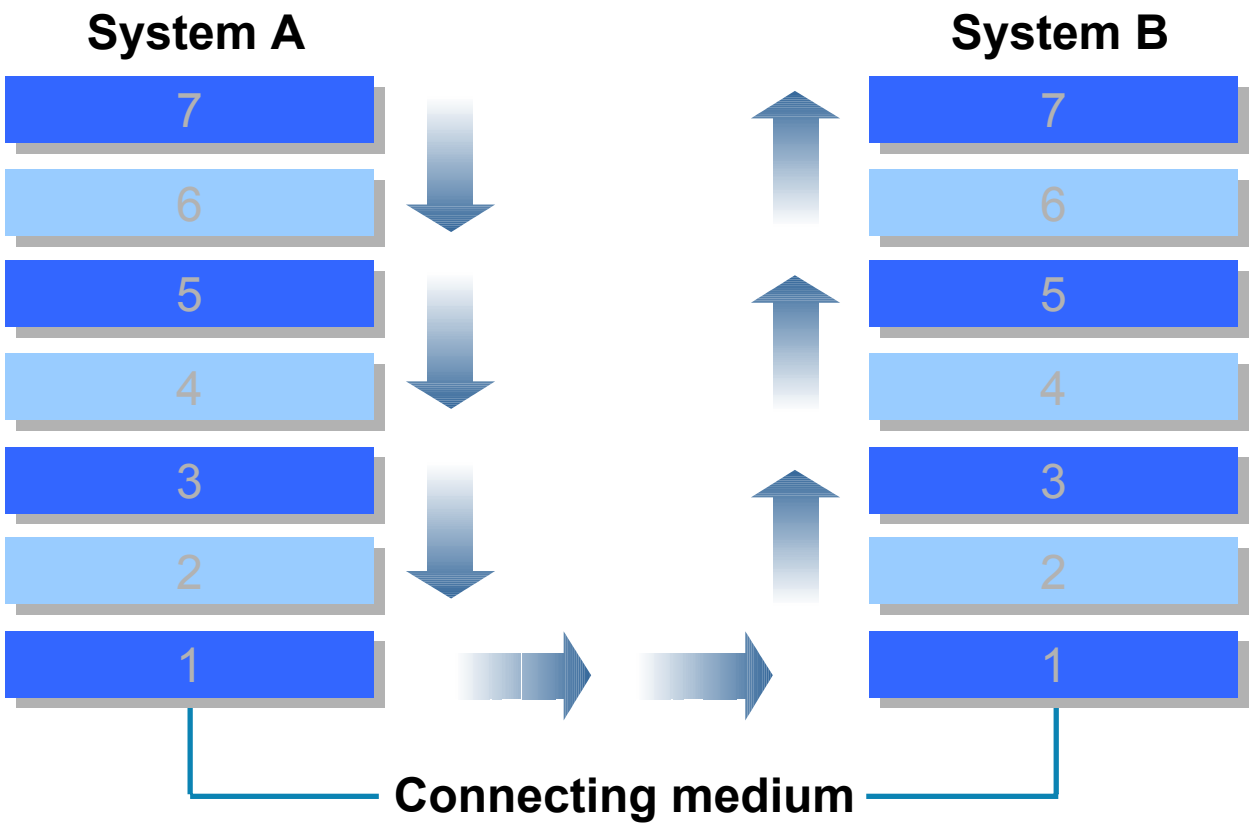
Network User

| OSI MODEL | | | |
|---|---|---|---|
| 7 |  | **Application layer** | Provides services to the application. |
| 6 |  | **Presentation layer** | Converts, encrypts data. |
| 5 |  | **Session layer** | Starts, stops session. Maintains order. |
| 4 |  | **Transport layer** | Ensures delivery of entire file or message. |
| 3 |  | **Network layer** | Routes packets to LANs and WANs |
| 2 |  | **Data Link (MAC) layer** | Transmits frames from node to node. Error checks. |
| 1 |  | **Physical layer** | Passes information in bits across the connection medium. |

# Lesson 2
# OSI Model

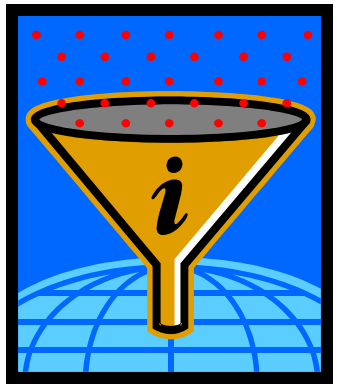
- Developed by the International Organization for Standardization in 1974
- Consists of seven layers: Abstract, theoretical framework
- Each layer has a different but specific processing function.
- Each layer provides functions for the layer directly adjacent to it.
- Modules (layers) may be replaced with one of equal type (that is, transport layer may not be replaced with the network layer).
- General approach developed to explain protocols that were already in place.
- Divides general problem of how to transmit information over a network into 7 sub problems.

# Lesson 2
# Information Path in the OSI Model



# Lesson 2
# Why is the model important for the industry?

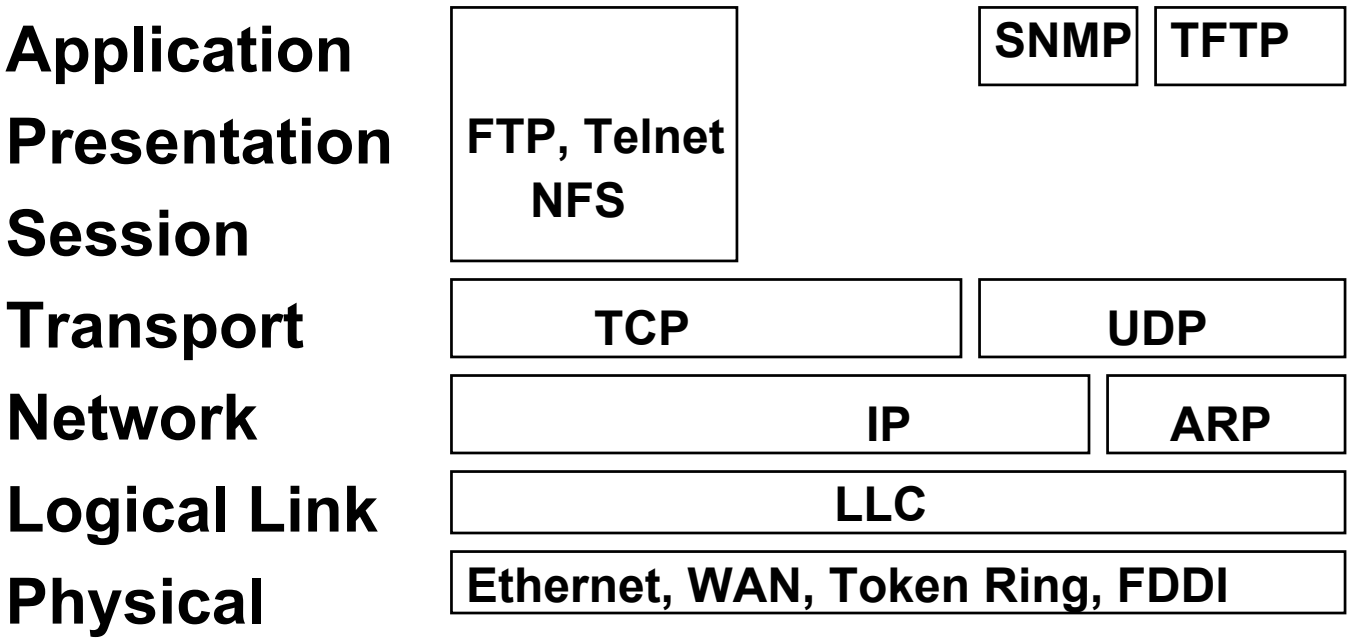
Variety of upper level protocols 5 through 7



TCP/IP 3 and 4

Variety of lower level protocols 1 and 2

# Lesson 3
# TCP/IP in the OSI Model



# Lesson 3
# TCP/IP



- Application Protocols
  - Terminal Emulation (Telnet)
  - HyperText Transfer Protocol (HTTP)
  - File Transfer Protocol (FTP)
  - Simple Mail Transfer Protocol (SMTP)
  - Simple Network Management Protocol (SNMP)
  - Domain Name Service (DNS)
- Network Protocols
  - Transmission Control Protocol (TCP)
  - Internet Protocol (IP)

# Lesson 3
# Simple Network Management Protocol (SNMP)

- SNMP is a common communication protocol for collecting management information from devices on the network.
- Almost every network device manufacturer has implemented SNMP support.
- SNMP is currently the most commonly implemented management environment protocol.

IM7 and our ProLiant agents use SNMP

# Lesson 3
# Domain Name Service

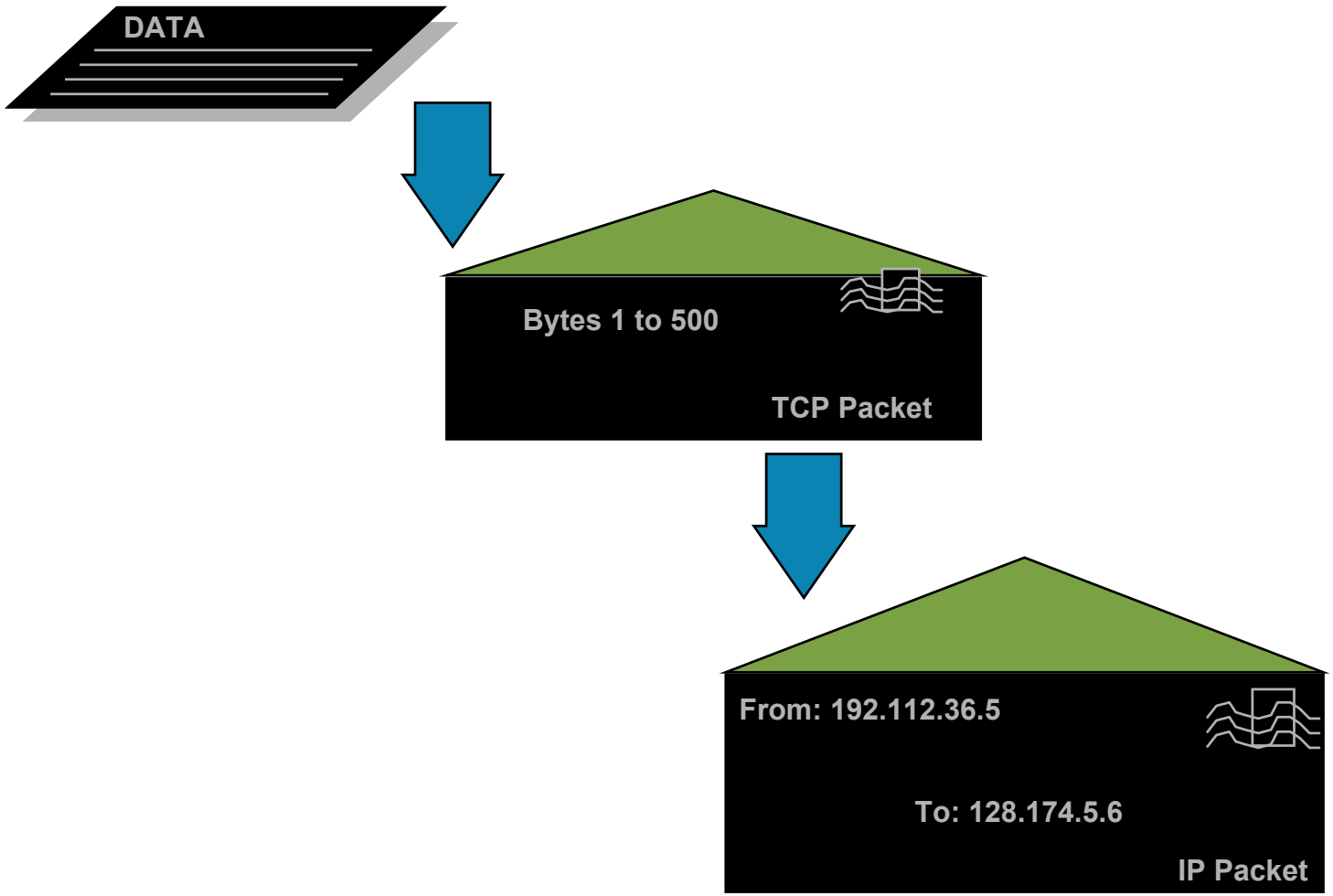
- DNS is a TCP/IP service that maps IP addresses, for example, 123.156.222.022, to an easy to remember name, such as www.hp.com.

- Internet and TCP/IP applications such as *telnet,* FTP and SMTP access DNS to locate names you've specified and resolves them to an IP address and inserts it into a message for transport.

# Lesson 3
# Transmission Control Protocol

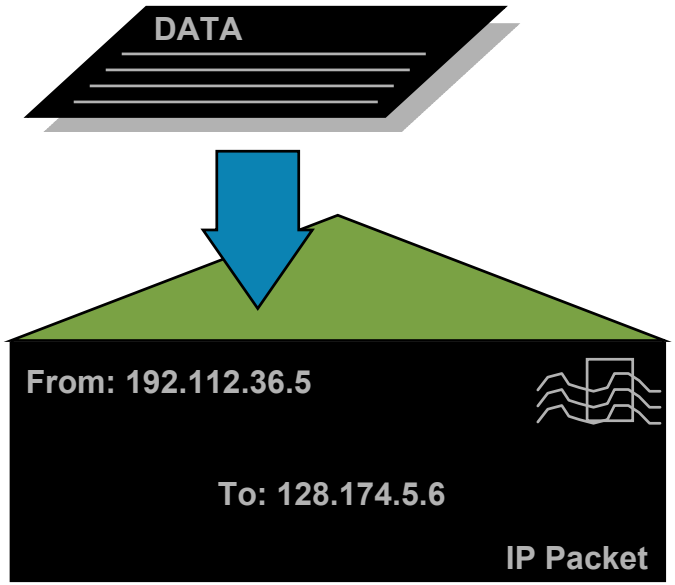
- Reliable (Connection Oriented)
- TCP takes the information you want to transmit and breaks it into pieces.
- TCP numbers each piece so receipt can be verified and the data can be put back in the proper order.
- Acknowledgments
- Timeouts
- Re-Transmissions
- Error Detection

# Lesson 3
# TCP packet encapsulation



# Lesson 3
# Internet Protocol (IP)

- IP is a connectionless service that provides basic datagram delivery services.
- IP takes care of addressing, or making sure the routers know what to do with your data when it arrives.



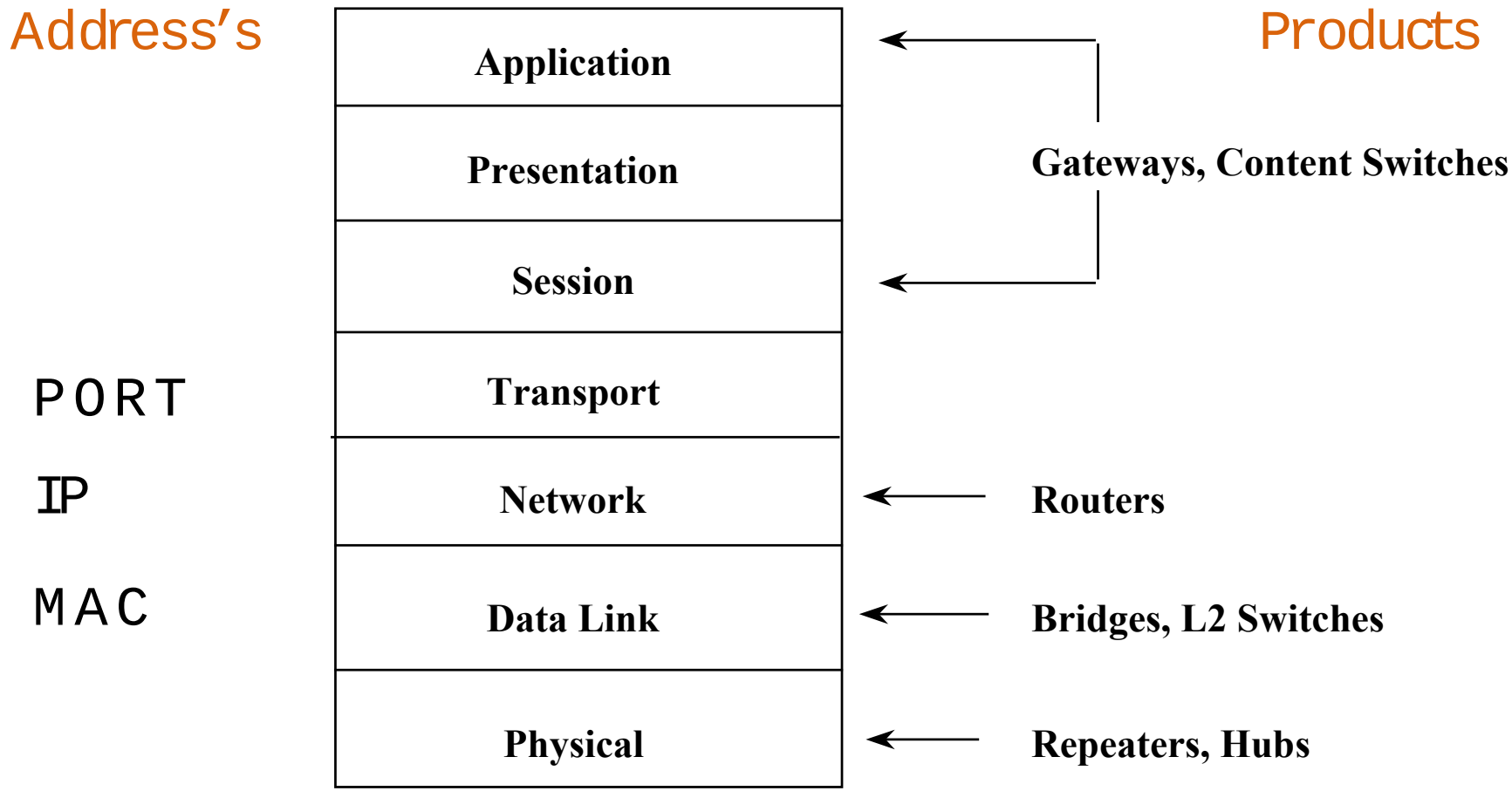

- Every end node has a unique address.
- Information sent across IP networks is broken up into bite-sized pieces, called *packets*.
  - The information within a packet is usually between 1 and about 1500 characters long.

# Lesson 3
# User Datagram Protocol



- Best effort transfer (unreliable)
- Connectionless
- One way - no acknowledgments
- Examples of Applications that use this
  - NFS
  - DNS
  - TFTP
- Applications provide
  - Timeouts
  - Acknowledgements
  - Retrys, etc.

# Lesson 4 - Addresses and VLANs



# Lesson 4
# IP Address



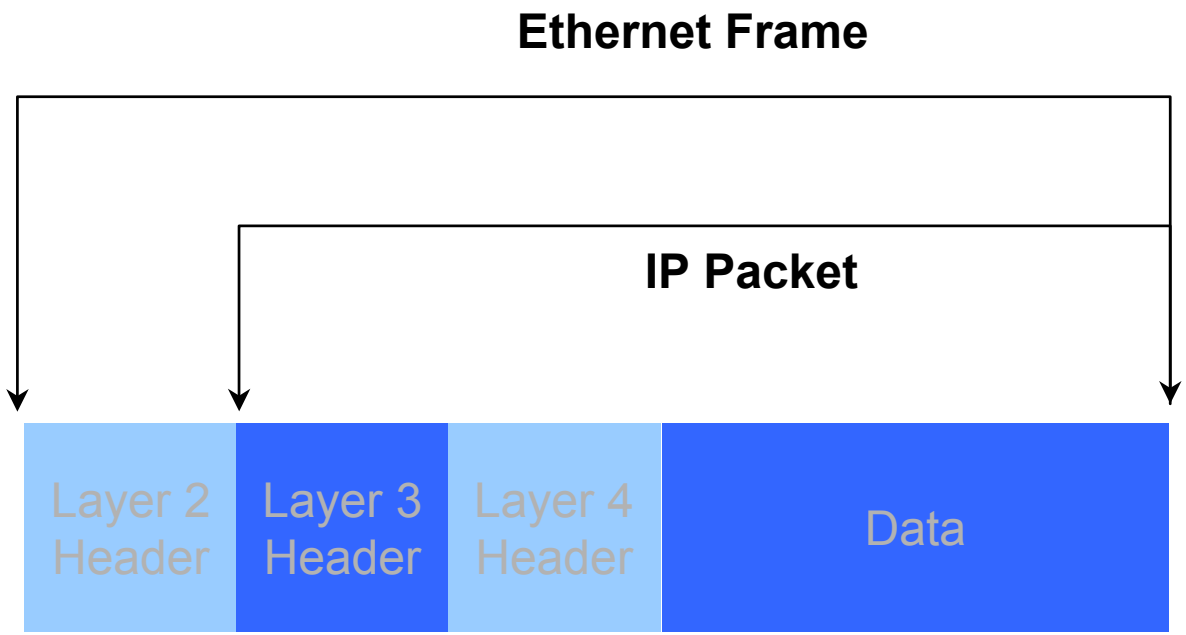
- IPV4 Internet addresses consist of four numbers each less than 256, (4 x 8 bits = 32 bit)
  - 192.112.36.5
  - 128.174.5.6
- IP Addresses
  - Class A Networks: 128.x.x.x 15M nodes
  - Class B Networks: 146.79.x.x 64K nodes
  - Class C Networks: 192.100.10.x 250 nodes
- IP addresses are running out - Extensions to the current IP address protocol will be required – IPV6 (128 bit)
  - 128 bit long. $2^{128} = 3.4 \times 10^{38}$ addresses
  - $665 \times 10^{21}$ addresses per sq. m of earth surface

# Lesson 4
# VLANs

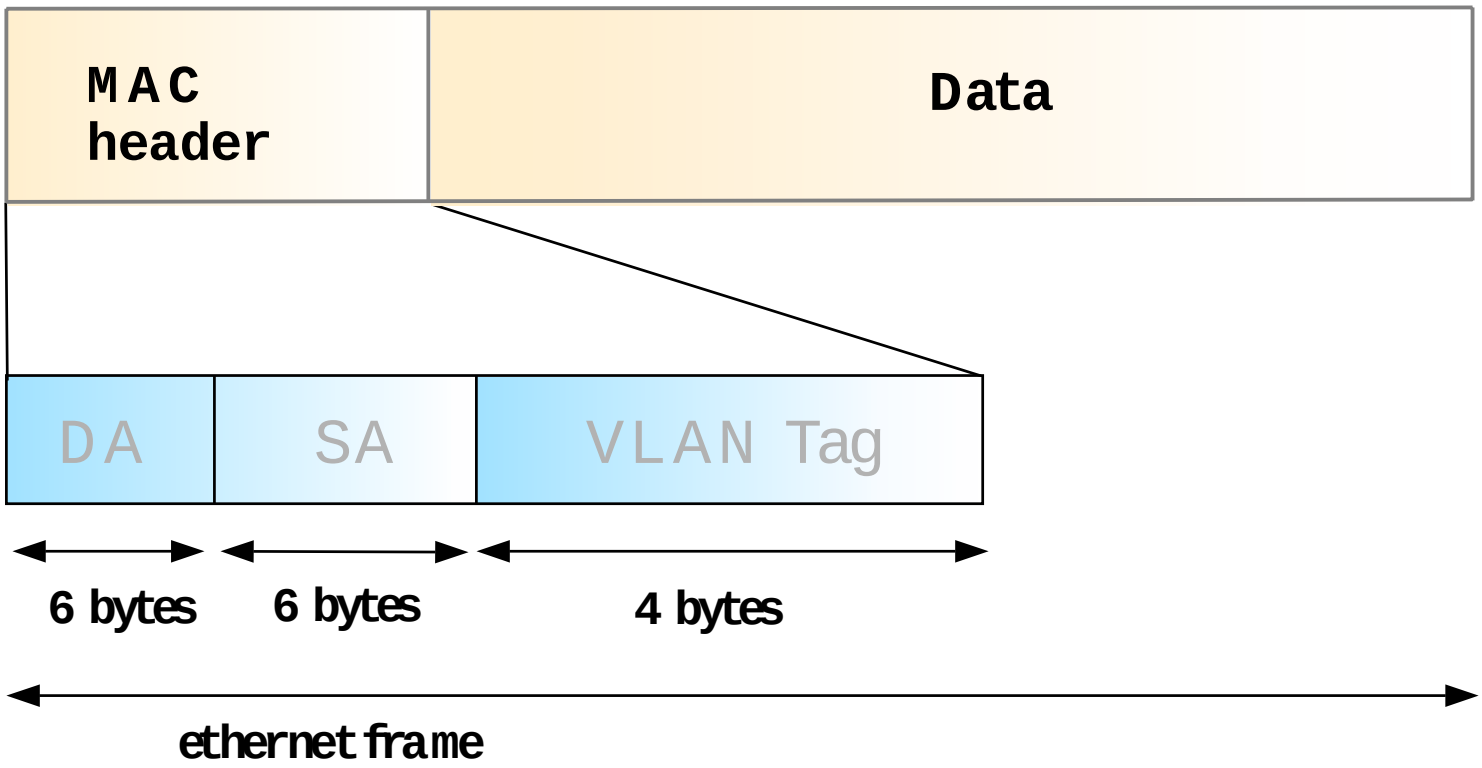
- Virtual LANs … not Physical
- Nodes communicate as if they are on the same
  - Network HUB
  - L2 Switch Segment
- Why do we have them?
  - Security Concerns
    - Need a router to go between VLANs
  - Broadcast Storms (Availability)
    - Protect against faulty or buggy communication and noise problems

Servers need to allow NIC ports to belong to multiple VLANs (Multiple Applications)

# Lesson 4
# Frames versus Packets



# Lesson 4
# The Tagged Ethernet Frame - VLANs



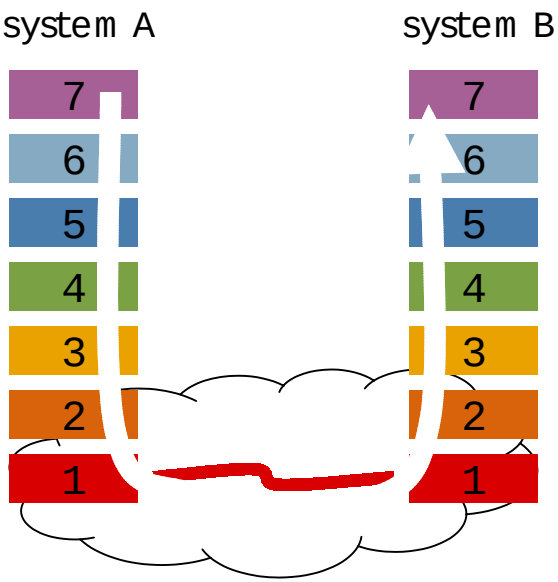
# Lesson 5
# L2 Switches



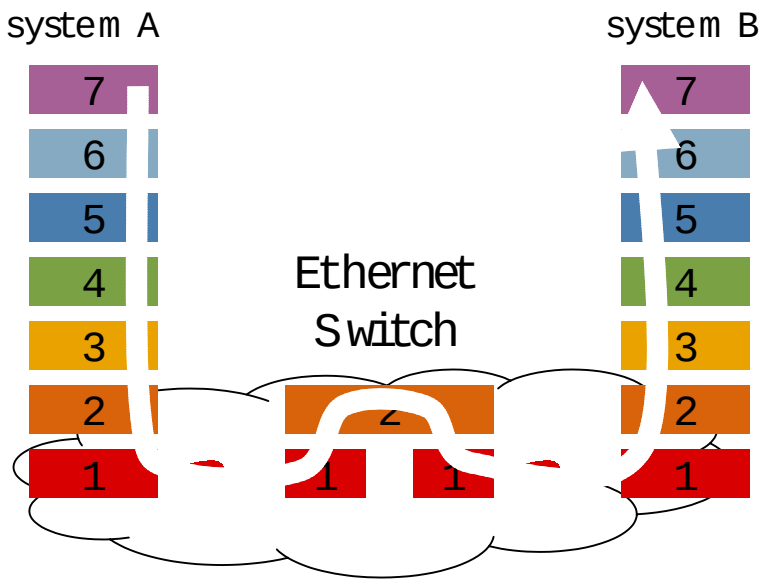
- Multi port
- Operates at Layer 2 (Link or Packet layer)
- Tend to be more expensive than simple HUBs (Bit stream)
- Tend to be less expensive than routers
- Allows for very fast switching (hardware assist)
- Learns as it goes …
- "I received a frame a while back from MAC address ABC on port 4 so if I need to forward a new one to MAC address ABC, I will transmit it out on port 4. Otherwise I will transmit it on all other ports"

MAC Addresses used to navigate through a L2 Switch

# Lesson 5 connecting end nodes within a network



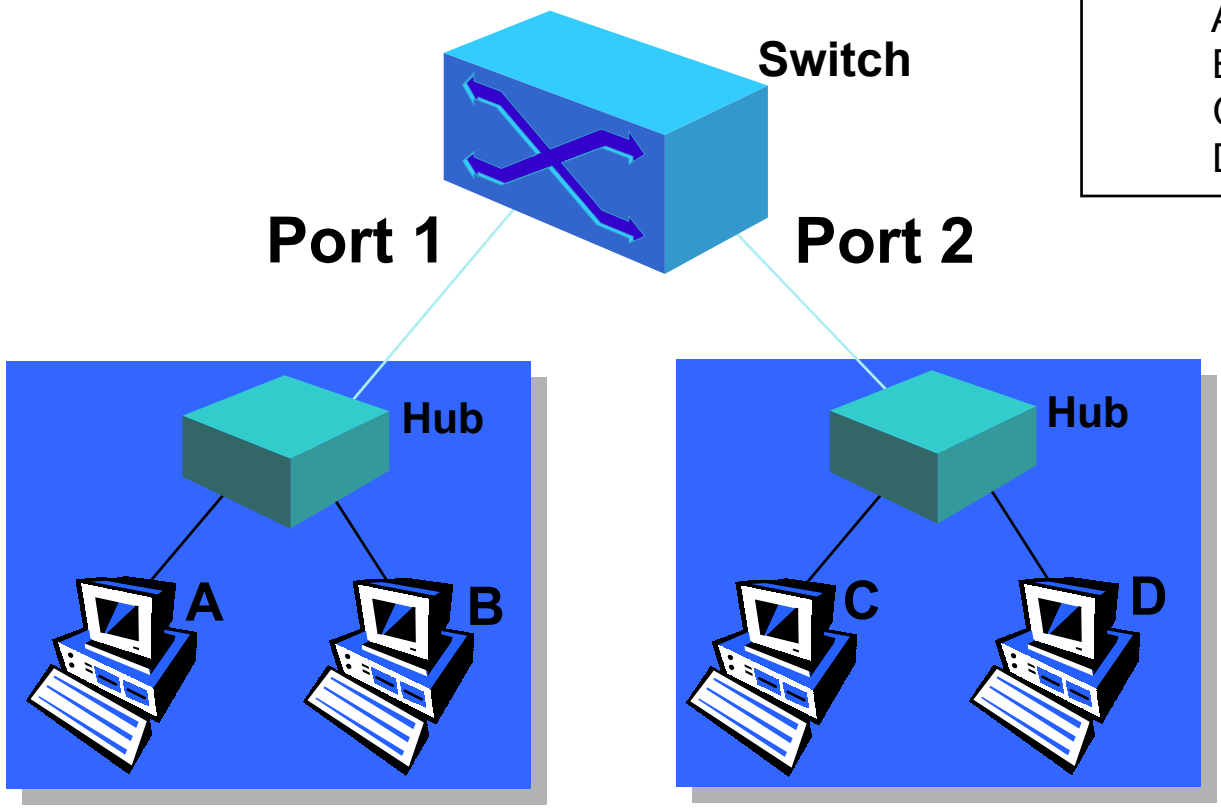

- two end nodes
- nodes connected via cable



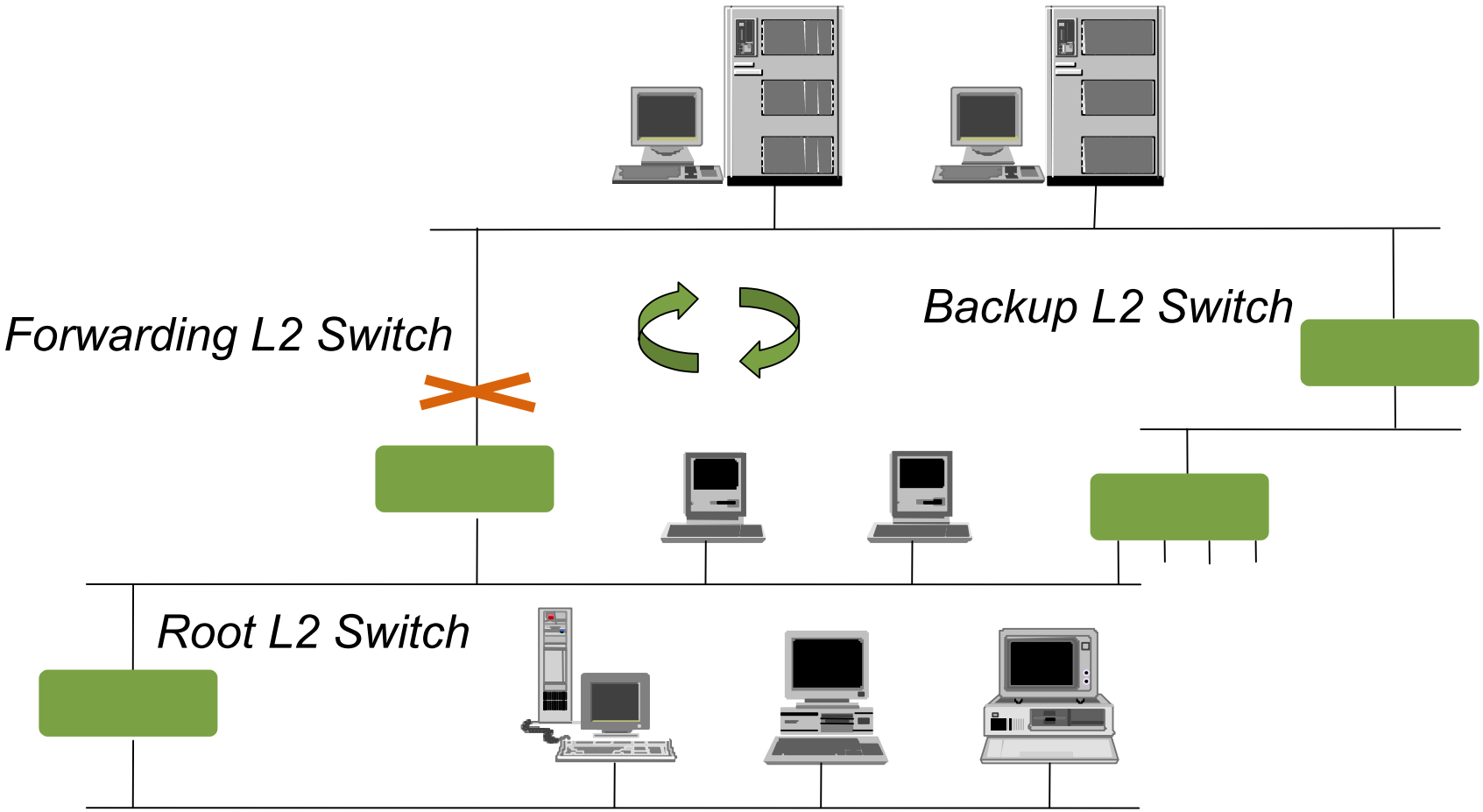

- two end nodes
- one Ethernet switch (layer 2)
- nodes connected via switch or bridge/hub

# Lesson 5
# Forwarding Process in a L2 Switch

| Forwarding Table | |
|---|---|
| MAC Address | Port |
| A | 1 |
| B | 1 |
| C | 2 |
| D | 2 |



# Lesson 5
# Spanning Tree Protocol, Loop Prevention



# Lesson 6
# Routers

- Routers are data forwarding devices but operate differently than a L2 switch
- Operate at layer 3
- Routes packets destined for a network other than the local network
- Routers tend to be larger and more expensive than L2 switches

IP Addresses used to navigate through a Router

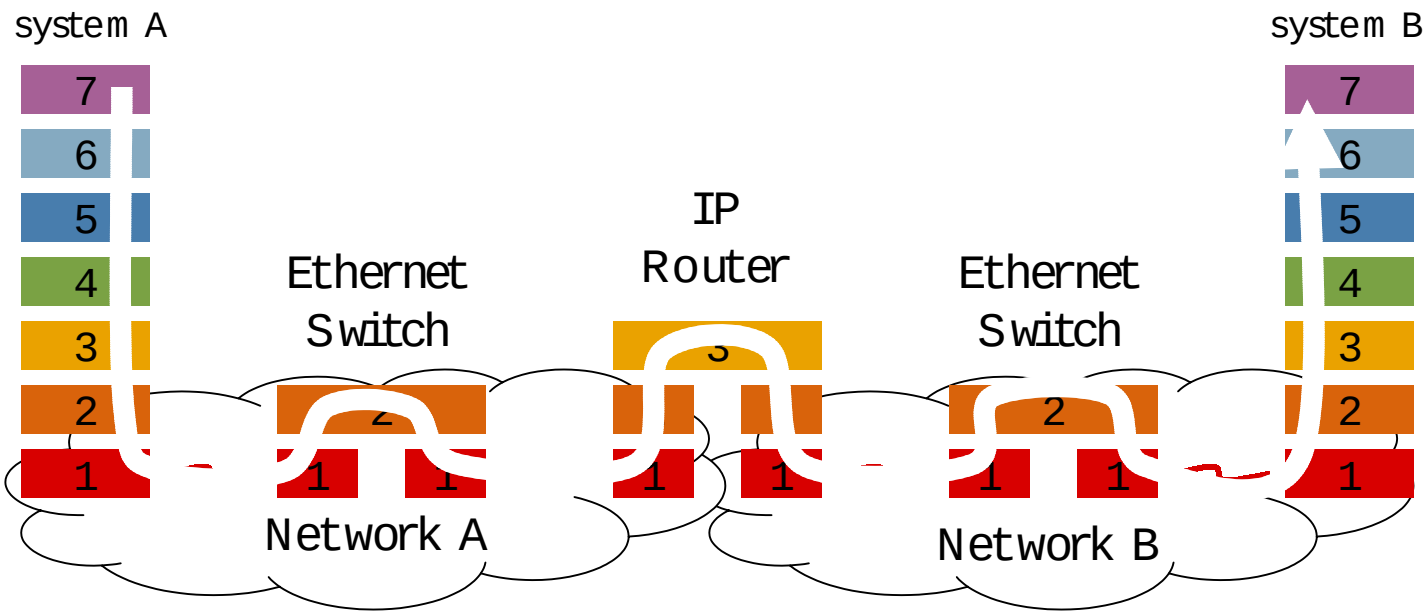
# Lesson 6: some key IP-related protocols/terms



- ARP – Address Resolution Protocol
  - helps map from IP addresses to local network (MAC) addresses
  - a node broadcasts an 'ARP request' asking for the MAC address corresponding to a specific IP address
  - the targeted node (or a router that can get to that node) responds with its MAC address
  - the results are cached and re-used

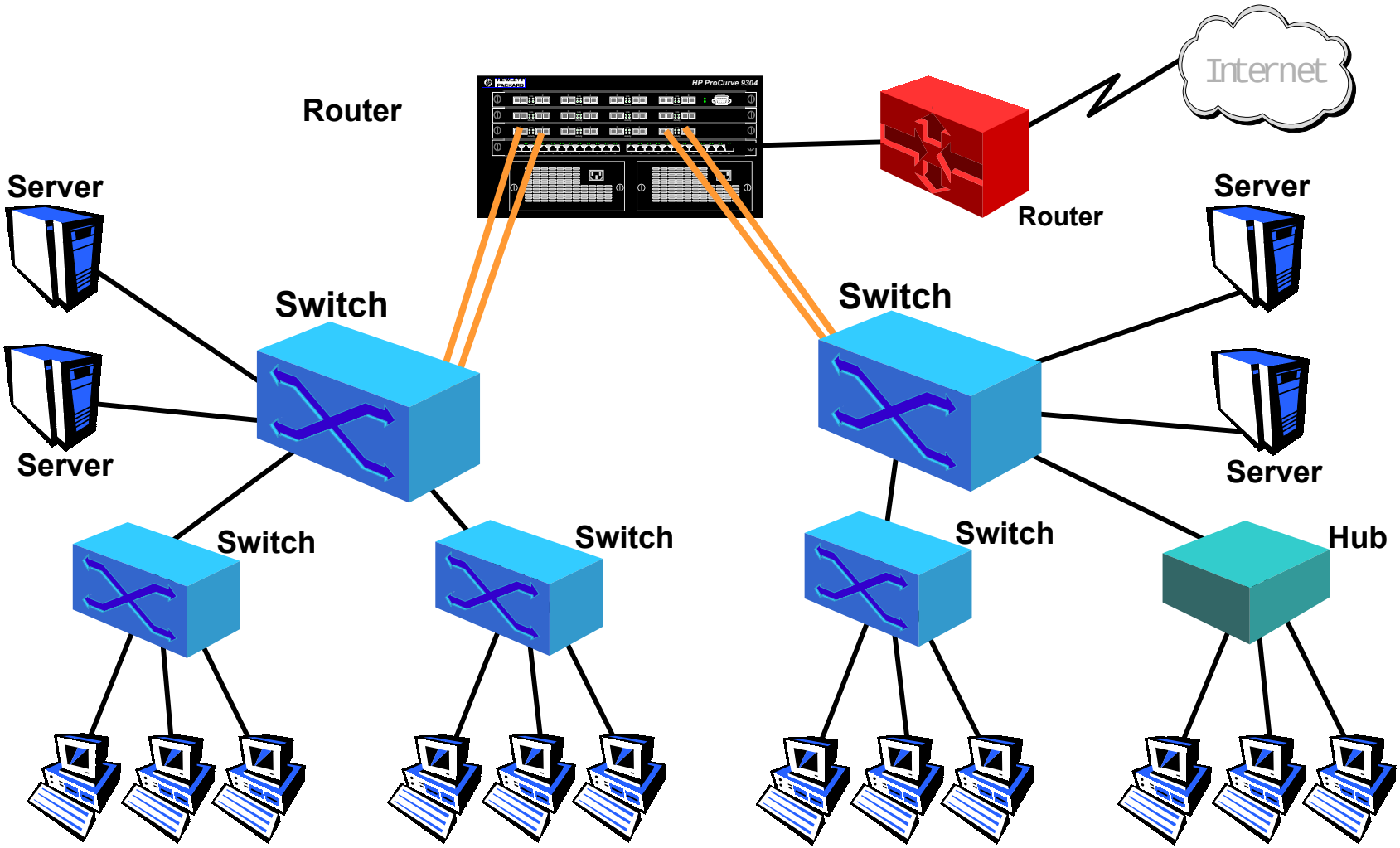
- DHCP – Dynamic Host Configuration Protocol
  - dynamic assignment of IP address to nodes
  - provided via DHCP server on local network
  - IP-to-MAC address relationship can be preserved

# Lesson 6 connecting nodes on different networks




- router (layer 3) used to connect separate networks
- switches used to connect devices within a local network

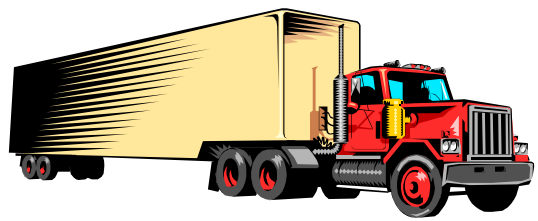
# Lesson 6
# Routing & Switch Deployment



# Lesson 6
# Routers – Hopping from one to another

- If the destination network is not directly attached to the router, the router will forward the packet to another router in the forwarding path of the destination network.
- Router-to-router communication is directly MAC addressed.
- All routers in the path will perform the same decisions as the previous router.
- The last router in the path to the destination will forward the packet directly to the destination.
- The data link MAC headers will constantly change while the packet is being forwarded

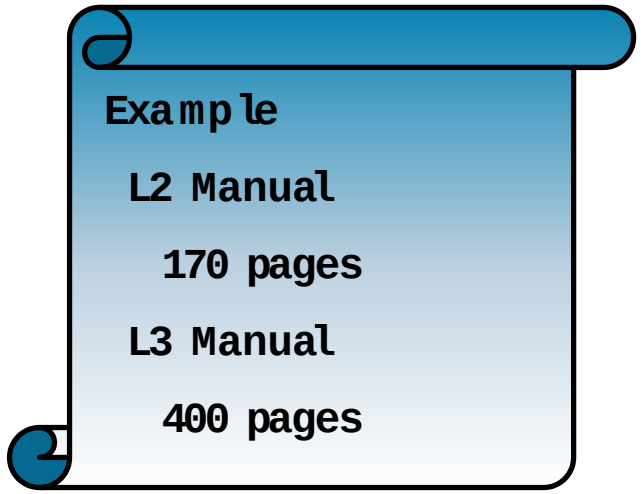

*Switch*



*Router*

# Lesson 6
# Layer 3 Switch

- Behaves like a L3 Router
  - Forwards on IP Address
  - Routing Protocols
- Fast as a L2 Switch
  - HW Assist
- Generally, Gig Speeds
- Benefits over L2
  - No Spanning Tree Start Up Delay
  - Allows VLAN to VLAN Access
  - Offloads routers of some traffic



# Lesson 6
# Switch Versus Router

| Switch | Router |
| --- | --- |
| Many Connectors | Fewer Connectors |
| Forwarding at wire speed | Less fast |
| Less Robust | More Robust, Intelligent |
| Less Software (L2 especially) | More Software |
| L2 Spanning Tree/Broadcasts | Wan Links |
| L3 has L2 plus routing protocols | Routing Protocols |

# Lesson 7
# Layer 4 - 7 switching



- A layer 4 switch distinguishes between types of data using the TCP port ID information in an IP header of a packet.

  Can provide basic load balancing.

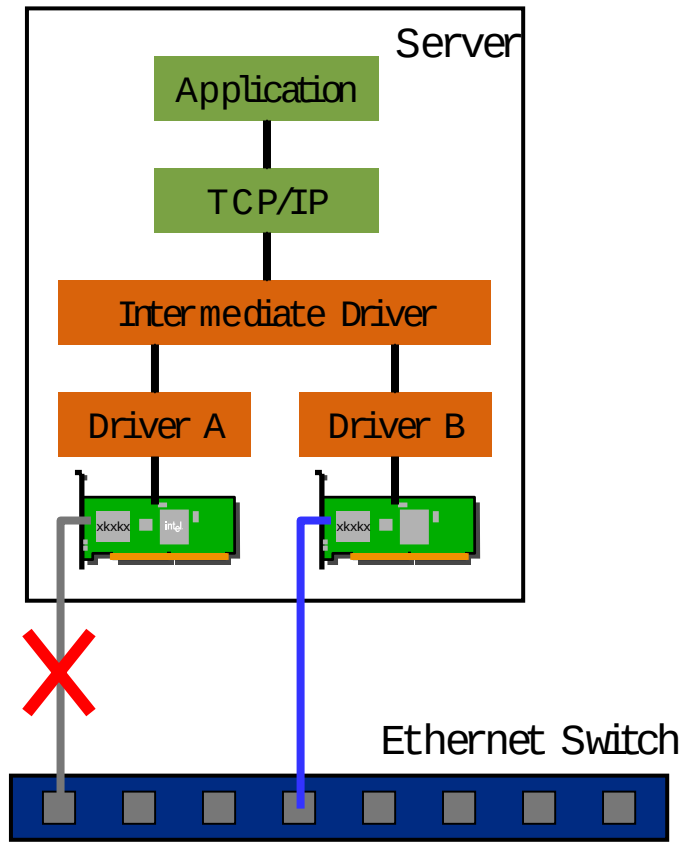
- Layer 5 to 7 switches are designed to identify and route web traffic in an intelligent way using the HTTP header, cookie, and URL.

  Provide enhanced content delivery networking such as firewall and cache load balancing, SSL switching, URL and cookie switching, global load balancing, and XML parsing.

Protect and make network applications work faster

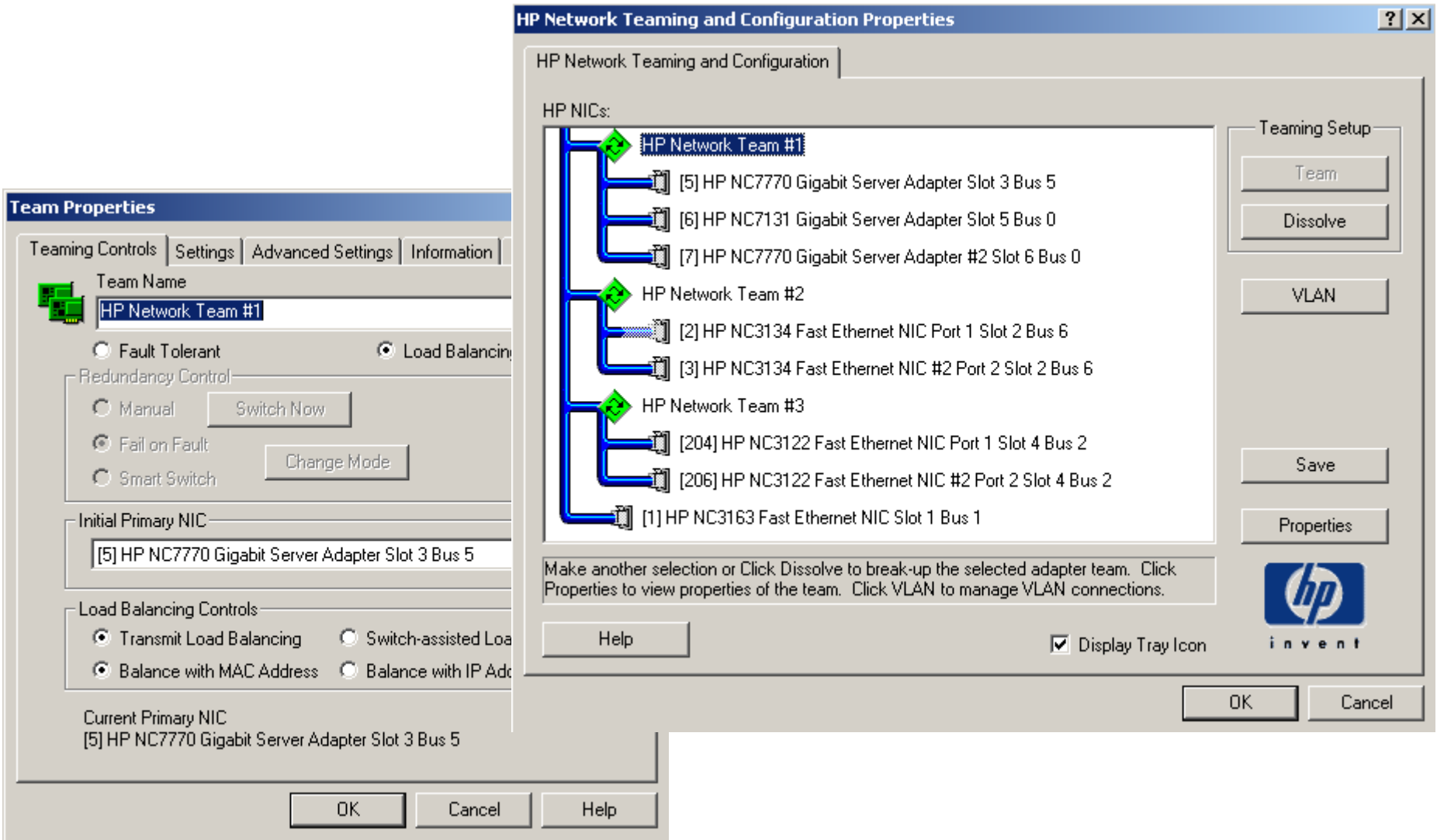
# Lesson 8
# teaming / trunking / aggregation

- two or more physical adapters are configured as one logical adapter
- provides support for fail-over
- provides increased throughput
- multiple algorithms available
  - fail-over
  - transmit load-balancing
  - IEEE 802.3ad standard
- reference:

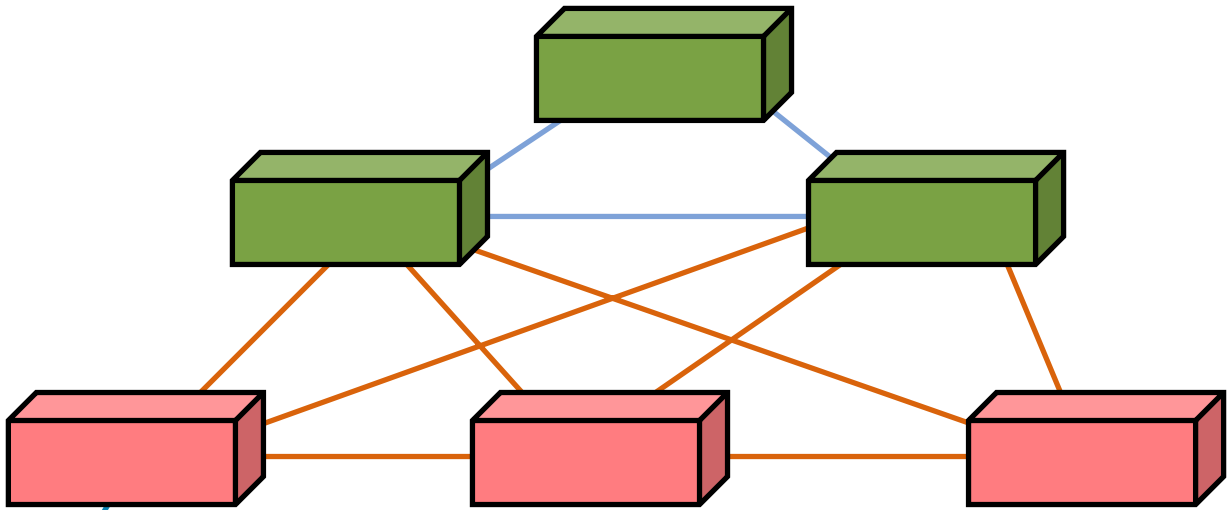



http://h18004.www1.hp.com/products/servers/networking/whitepapers.html

# Lesson 8
# teaming / trunking / aggregation
## (continued)



# Lesson 8
# No Teaming – Single Port Examples

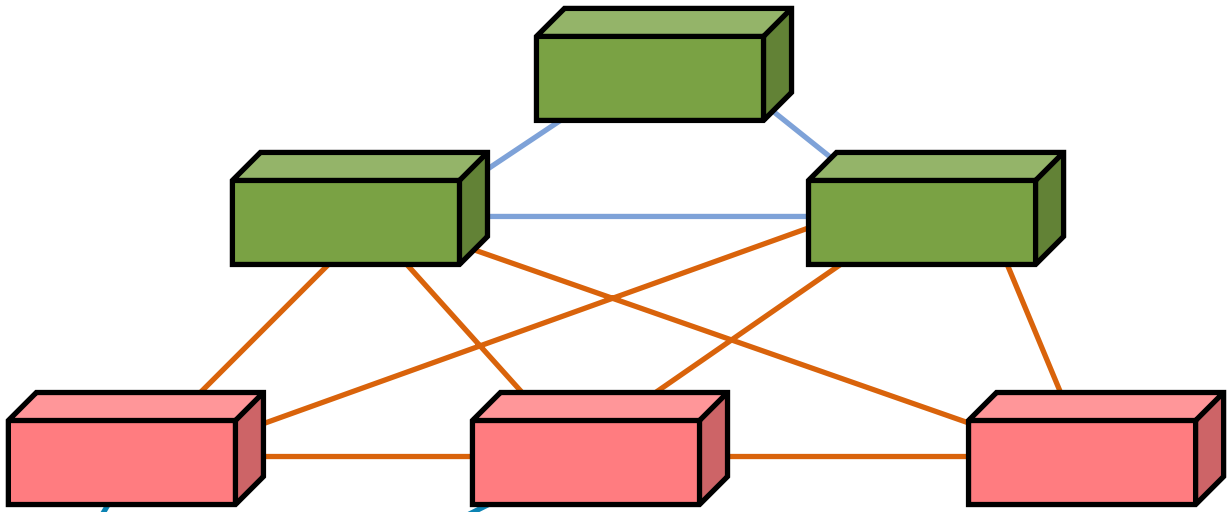



Simple Server
One Link
One MAC Address
One IP Address
One NIC port

*Or …*

Simple Server
One Link
One MAC Address
Four IP Address
One NIC port
Four VLANs

# Lesson 8
# Teaming – Dual Port Examples



Routers

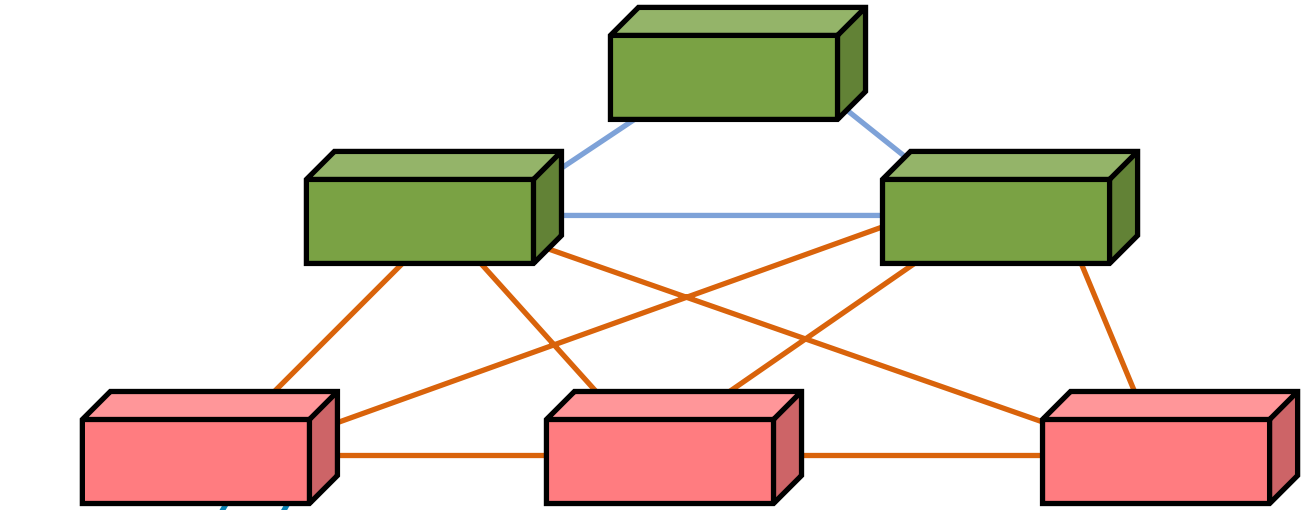
L2 Switches

Two Links
Two MAC Address
Two IP Address

*Or …*

Two Links
Two MAC Address
One IP Address
FT Team
(Standby-Failover)
Swap MAC Address

# Lesson 8
# Teaming Advanced – Dual Port Examples



Routers

L2 Switches

Two Links
Two MAC Address
One IP Address
Transmit Load Balance
One Receives

*Or …*

Two Links
Two MAC Address
One IP Address
Switch Assist Load Balance
All Xmit, Receive

# Lesson 9 – ProLiant Blade Switches

- e and p class blade switches
  - Level 2 switch
  - VLANs
  - Most popular L2 options
  - Managed
    - Can be configured local and remote
    - Can report back statistics and status
    - Integrated with ProLiant management tools (IM7)
  - Positioned as a edge of the network device

# Lesson 10: Ethernet features: Pre-boot Execution Environment (PXE)



- allows network device to be put in PC boot order
- code usually contained in option ROM
- option ROM code is loaded into host and includes
  - Trivial File Transfer Protocol (TFTP)
  - Internet Protocol
  - Universal Network Driver Interface (UNDI) driver
- uses DHCP to obtain IP address
- loads program from PXE server and runs it
- used by the HP ProLiant Essentials Remote Deployment Pack (RDP)

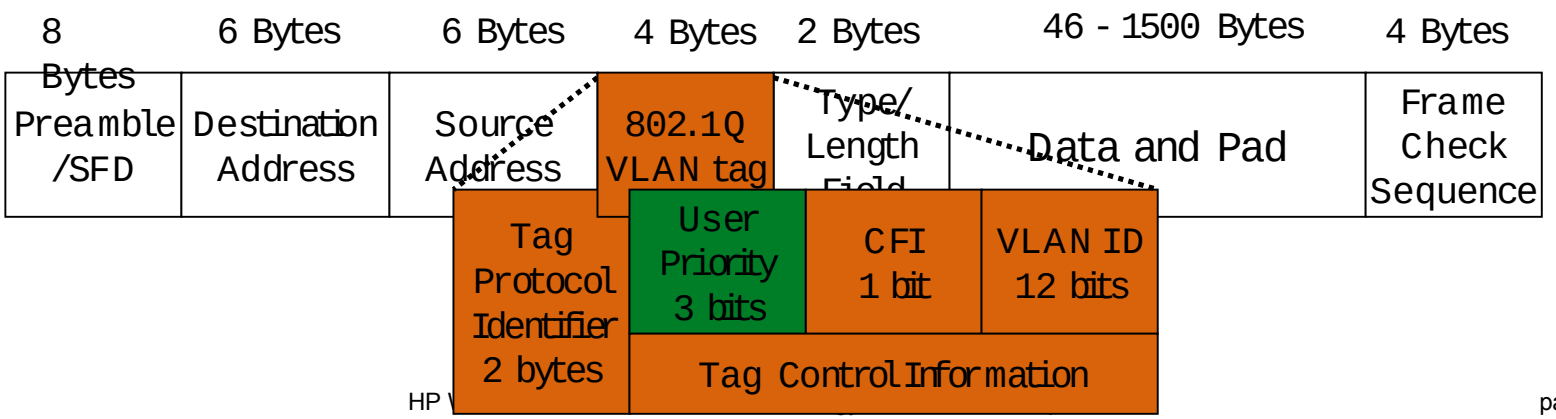
# Lesson 10: Ethernet features: Wake on LAN (WOL)

- allows for remote “wake up” of server or PC
  - Server in low-power mode, but NIC remains powered
  - NIC monitors wire for special packets
  - NIC asserts PCI PME# signal to wake-up the server
- Magic Packet™ wakeup
  - contains 16 contiguous copies of the receiving NICs Ethernet MAC address
- Pattern Match wakeup
  - OS writes wake-up pattern to NIC before sleeping host
  - flexible pattern as it uses a pattern and bit mask

Reference: “Device Class Power Management Reference Specification, v2.0; October 12, 2000
Note: Magic Packet is a trademark of Advanced Micro Devices, Inc.

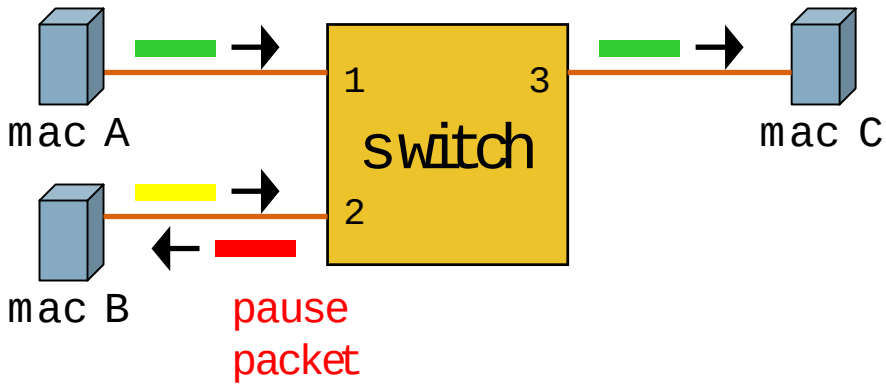
# Lesson 10: Ethernet features: Quality of Service (QoS)

- Ethernet QoS helps support layer 3 QoS
- Provides packet-by-packet priority queuing
- Support provided for 8 levels (3-bits) in VLAN tag
- Switch (802.1p) plus Layer 3 QoS makes best effort to reserve requested Bandwidth, Latency, or Packet loss.
  - QoS specified in special RSVP messages from application to all routers in path.
- No industry standard on which level to apply for given situation.



# Lesson 10: Ethernet features: flow control (802.3x)

- if a device (switch) is receiving more data than it can buffer it
  - drops packets
  - or requests flow control
- IEEE 802.3x defines flow control
  - sends ‘pause packets’ to stop flow
  - prevents dropped packets
- must be supported by both end node (s) and switch

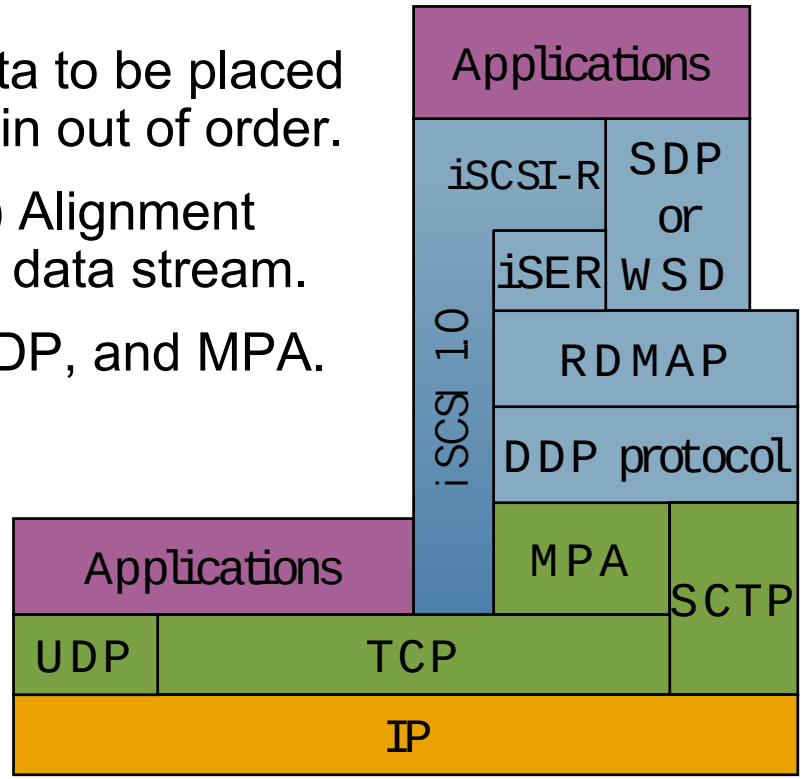


# Lesson 10: Ethernet features: VLANs and GVRP overview

- Virtual LAN
  - divides a single Ethernet into multiple virtual networks
  - IEEE 802.1Q
- common usage
  - simplify network wiring
  - reduce broadcast traffic within network segment
  - separate networks for different groups
  - separate networks for certain data types (iSCSI)
- GVRP
  - GARP VLAN Registration Protocol
  - Allows switches and devices to exchange information on VLANs in use.
- two VLAN types
  - port-based VLANs
  - tagged VLANs

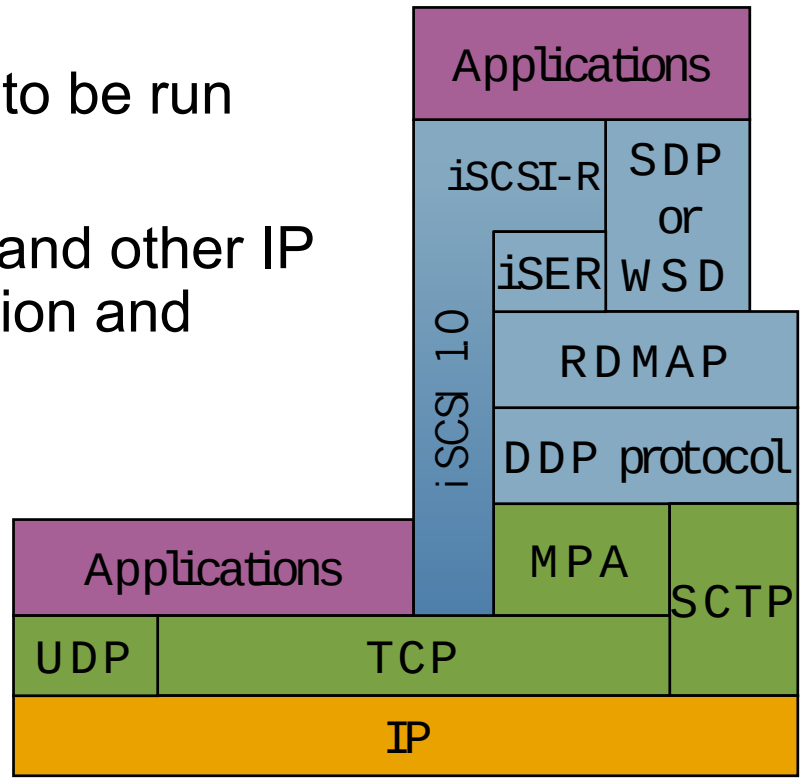
# Lesson 10: Internet Protocol (IP) some newer IP-related protocols

- RDMAP – Remote Direct Memory Access Protocol allows hosts to access memory buffers in remote hosts with minimal processing.
- DDP – Direct Data Placement allows data to be placed directly in memory, even when it comes in out of order.
- MPA – Marker PDU (Protocol Data Unit) Alignment used to identify DDP operations within a data stream.
- iWARP – common name for RDMAP, DDP, and MPA.
- SDP – Sockets Direct Protocol provides a way for existing sockets applications to benefit from RDMA.
- WSD – WinSock Direct is the Microsoft precursor to SDP.



# Lesson 10: Internet Protocol (IP) some newer IP-related protocols

- iSCSI – protocol for transmission of SCSI block storage data over TCP/IP. Includes protocol for login between initiator and target.
- iSER – protocol layer to allow iSCSI to be run over RDMAP.
- IPSec – IP security. Used by iSCSI and other IP protocols to provide data authentication and encryption for IP communications.



# Networking – Summary

Networking is central to IT. The type of products at the edge of the network may vary over time, but the core is ‘sacred ground’.

Some faults are fatal. Product failures or poor procedures can take out lots of end users, very quickly.

Open standards offer flexibility, versatility, and evolution. Innovation and optimizations can be implemented in a straight forward manner.

# For More Information

Web site:

http://www.protocols.com

http://networking.ittoolbox.com

Texts:

Network + Certification for Dummies

Networking Explained (Gallo and Hancock)

CCNP for Dummies

MCSE TCP/IP for Dummies

Microsoft:  WIN2000 TCP/IP – Technical Reference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