Ethernet Fundamentals

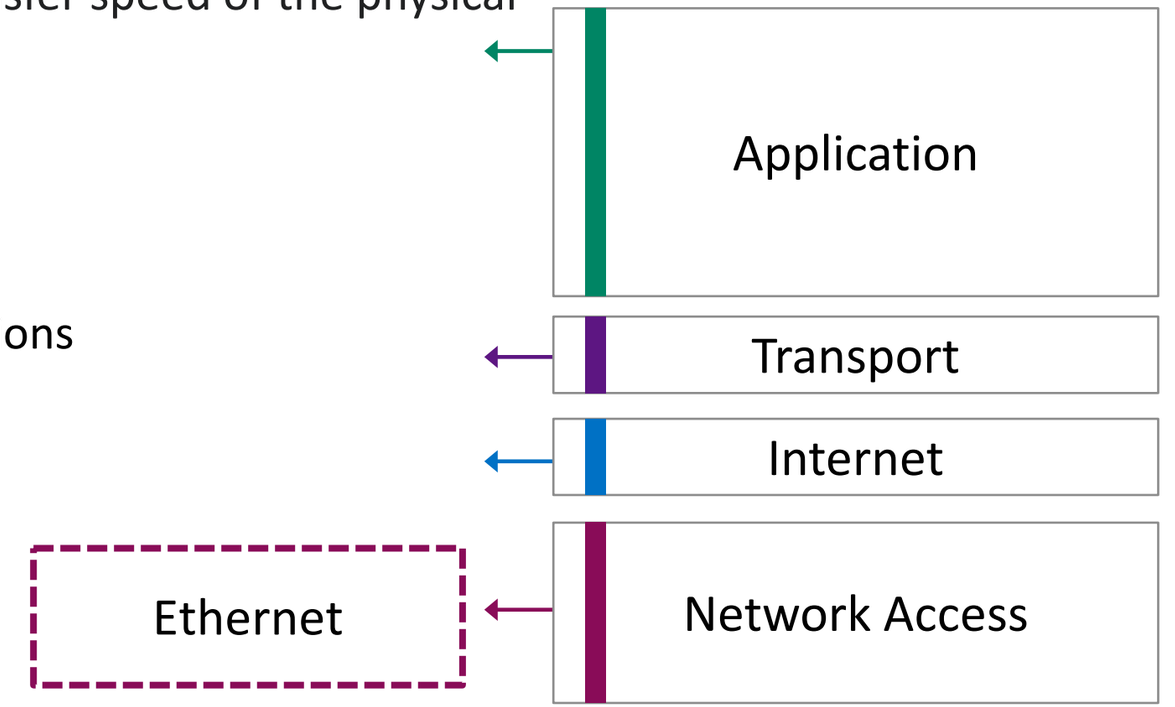
Unit 3

Unit Outline

- Ethernet Standards
- Ethernet Evolution
- MAC Addresses
- Ethernet Frame Structure and MTU
- MAC Address Tables and Frame Forwarding

Ethernet Technology

- Ethernet operates in the data link layer and the physical layer of the OSI model
  - Data link layer:
    - Defines functional and procedural means to transfer data between network nodes
    - Detect errors that can occur in the physical layer
  - Physical layer:
    - Defines electrical or optical properties and the transfer speed of the physical connection between network nodes
- Ethernet is the predominant LAN technology
  - Evolves and delivers higher levels of performance
  - Maintains backward compatibility
  - Designed to suit the needs of a broad range of applications



Ethernet Evolution

Ethernet was invented by Robert Metcalfe

1973

FAST

100Mbps Ethernet

1995

10Gbps Ethernet

1998

25G Ethernet 50G Consortium

25/50Gbps Ethernet

2015

800Gbps and 1.6Tbps

2025

1985

IEEE

10Mbps Ethernet was standardized

Gb

1Gbps Ethernet

2002

40/100Gbps Ethernet

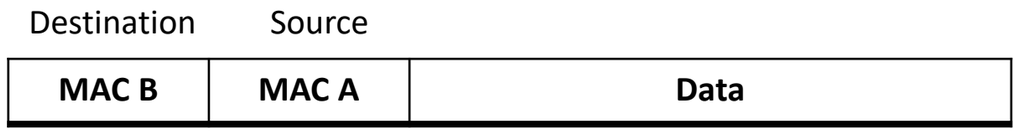
2010

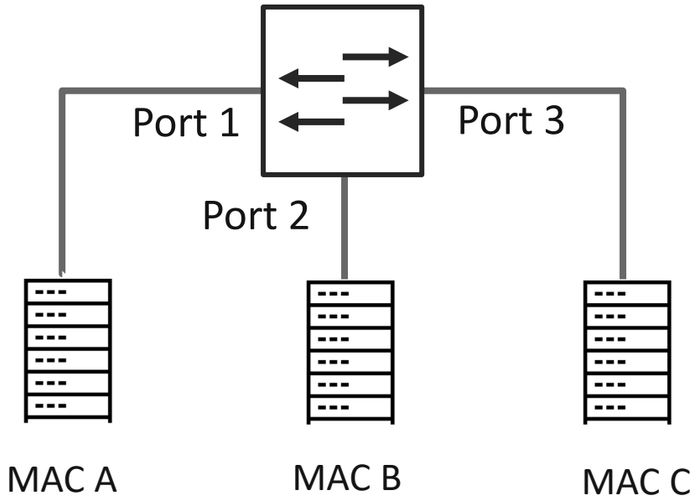
200/400Gbps Ethernet

2017

Ethernet Addressing

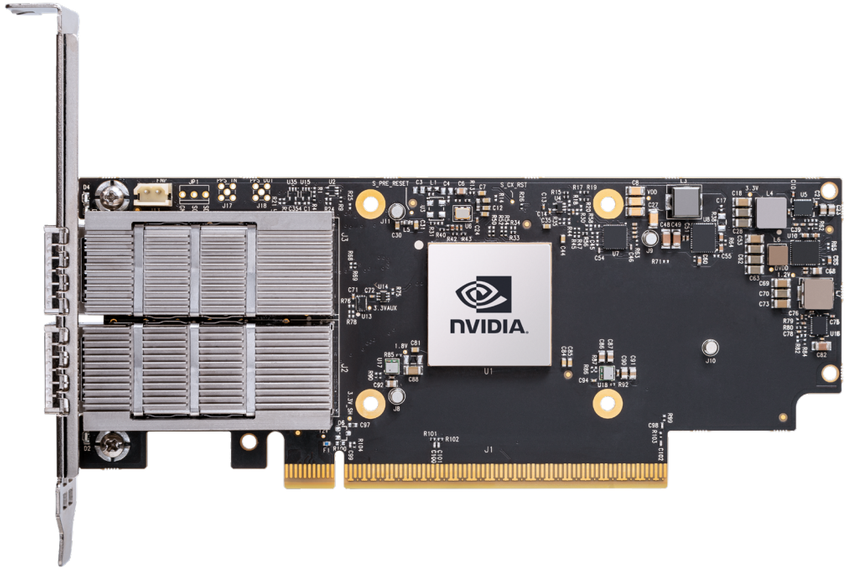
- Nodes send Ethernet frames to each other
- Ethernet nodes are identified with a unique address known as the MAC address
- The Ethernet frame header contains a source and a destination MAC address
- Forwarding decisions are based on the destination MAC address





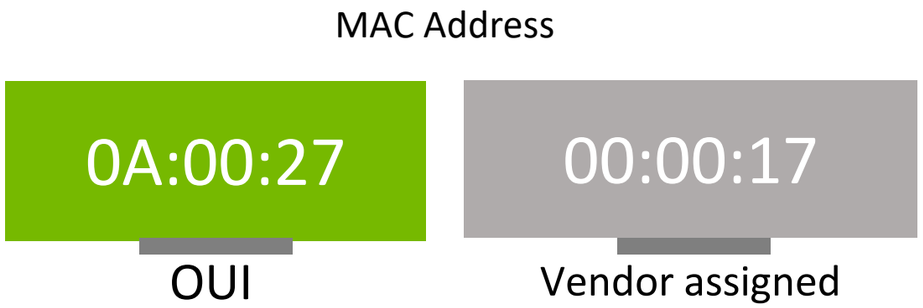
Ethernet Network Adapters

- A network interface card is a hardware component that connects a node to the network
- The NIC allows devices to communicate over a network, either by using cables or wirelessly
- The NIC is both a physical layer and data link layer device
  - Provides physical access to the physical medium
  - Provides an addressing system using MAC addresses



MAC Addresses

- A media access control address (MAC) is a unique identifier assigned to a network interface for use as a network address
- A MAC address is burned on the network adapter's hardware by the vendor
- The Ethernet standard requires that every Ethernet vendor register with IEEE, and be assigned with an OUI (Organizationally Unique Identifier)
- A MAC address is 48-bit, represented by 12 hexadecimal digits:
  - 6 left hex digits represent the OUI
  - 6 right hex digits represent the serial number assigned by the vendor



MAC Address Example

- Linux

```
root@mtlacad:~$ ifconfig

eth0      Link encap:Ethernet  HWaddr 00:10:57:C0:09:18
          inet addr:10.8.44.21  Bcast:10.8.255.255  Mask:255.255.0.0
          EtherTalk Phase 2 addr:65280/25
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:17291 errors:0 dropped:0 overruns:0 frame:0
          TX packets:706 errors:0 dropped:0 overruns:0 carrier:0
          collisions:11
```

- Windows

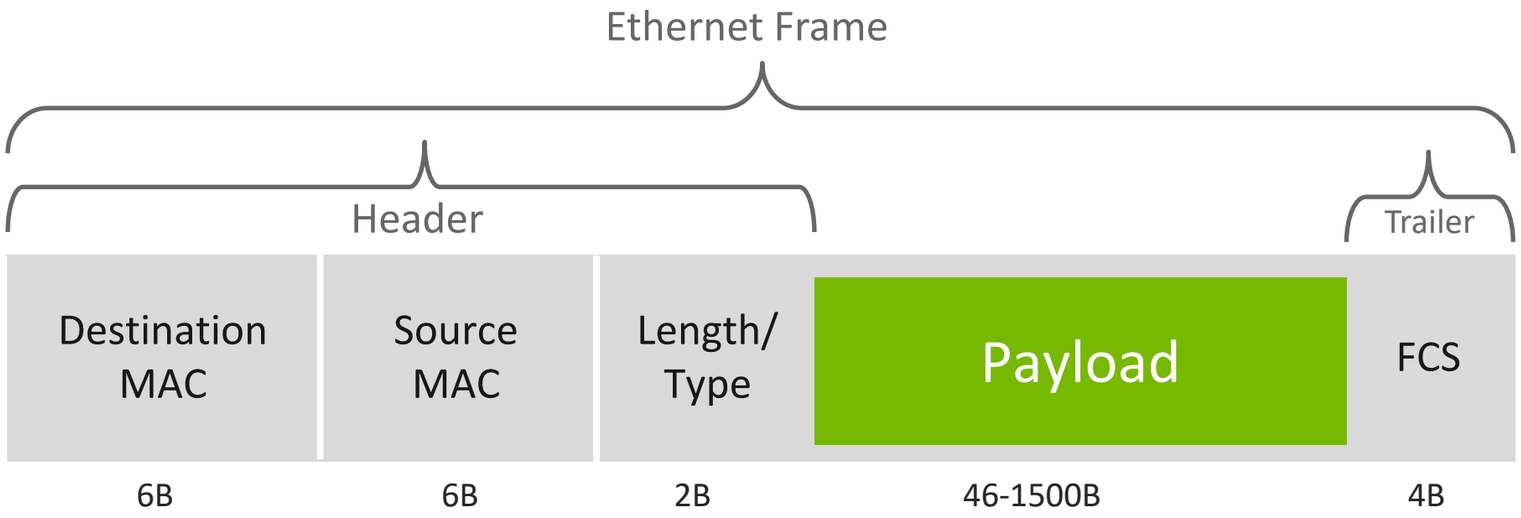
```
C:\>ipconfig /all

Ethernet adapter Local Area Connection:
   Description . . . . . . . . . . . : Intel(R) Gigabit Network Connection
   Physical Address. . . . . . . . . : 60-57-18-BD-67-A8
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IPv4 Address. . . . . . . . . . . : 10.1.2.38 (Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.0.0
```

Ethernet Frame Structure

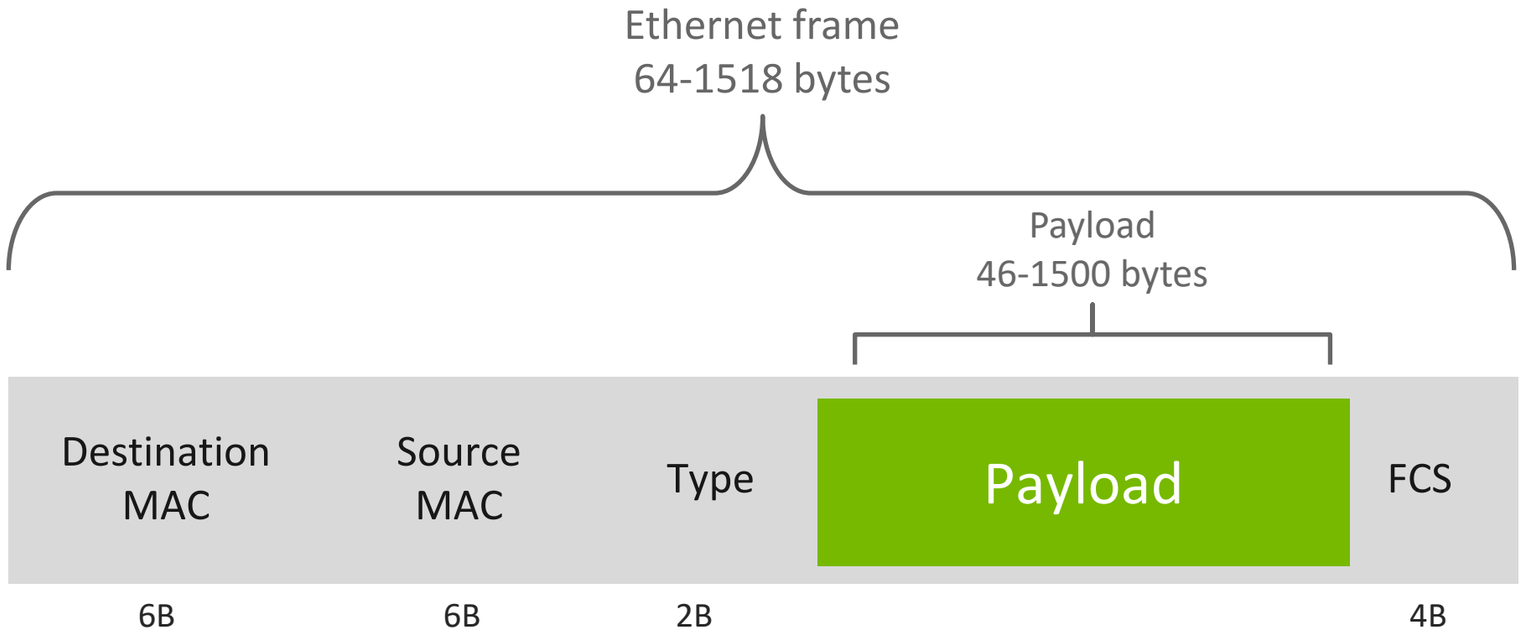
An Ethernet frame includes the following fields:

- Payload - upper layer protocol data (IPv4/6 packet, etc.)
- Destination MAC Address - specifies the node for which the frame is intended
- Source MAC Address - specifies the node sending the frame
- Length/Type - indicates the upper layer protocol (EtherType)
- FCS - used for the detection of corrupted frames



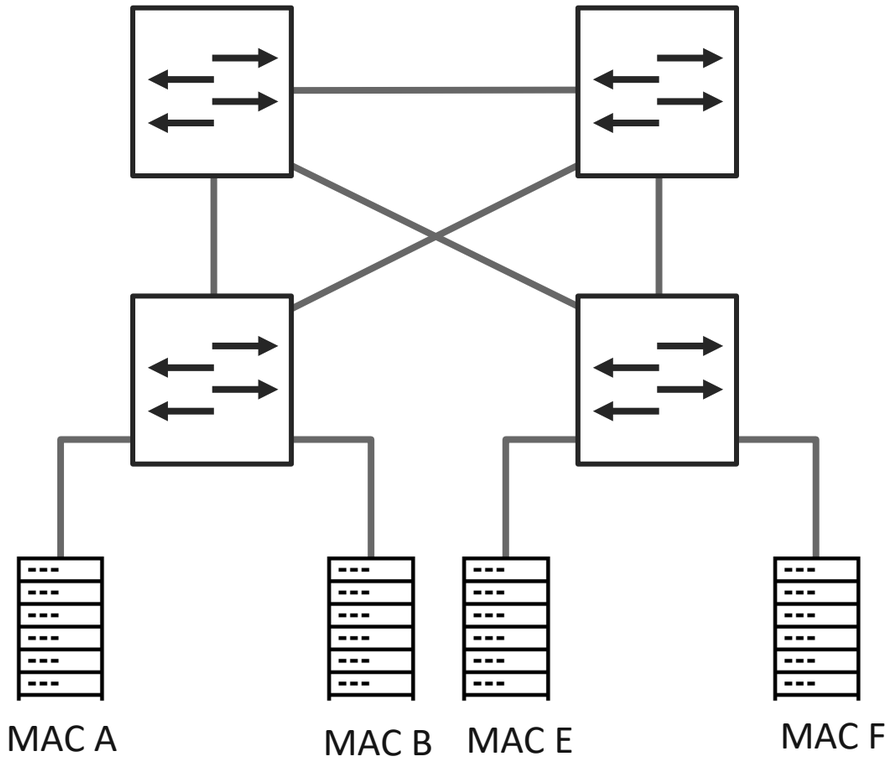
MTU and Frame Size

- Maximum Transmit Unit (MTU) defines the maximum payload size that can be carried in a single Ethernet frame
  - Frames with more than 1500 bytes payload are considered “jumbo frames”
- Ethernet frame size is 64-1518 bytes
  - Any frame less than 64 bytes in length is considered a “collision fragment” or “runt” and is automatically discarded by the receiving nodes



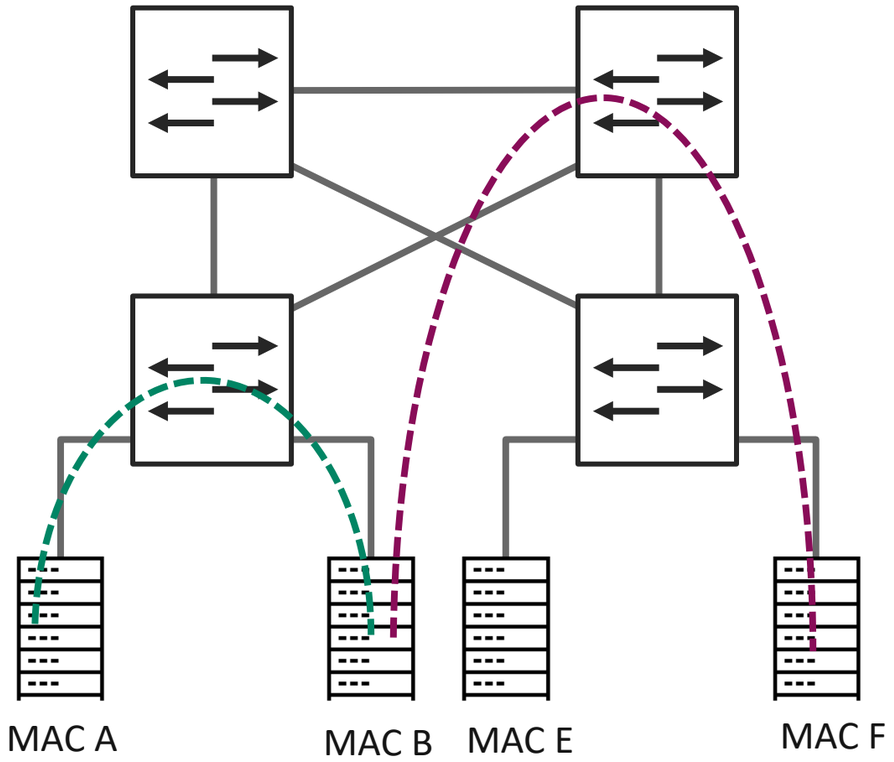
Ethernet Switches

- An Ethernet switch connects multiple Ethernet nodes
- The switch size, type, number and speed of ports depend on the switch vendor and specific model



Forwarding Decisions

- Ethernet nodes may have one or more Ethernet switches connecting between them
- How are frames forwarded from source to destination?
- The switches need to learn the whereabouts of destination nodes

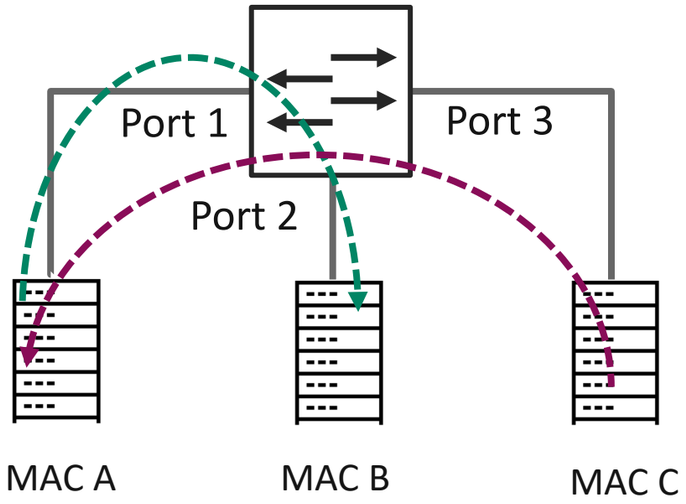


MAC Address Table

- An Ethernet switch forwards frames based on the destination MAC address
- A switch builds and maintains a forwarding database called a MAC address table
  - MAC address table contains destination MAC to exit port mappings
  - Entries are populated based on the source MAC of incoming frames
  - Entries learned dynamically have an aging time
  - Static entries can be configured

MAC Address Table:

MAC A	Port 1
MAC B	Port 2



Forwarding Unicast Frames

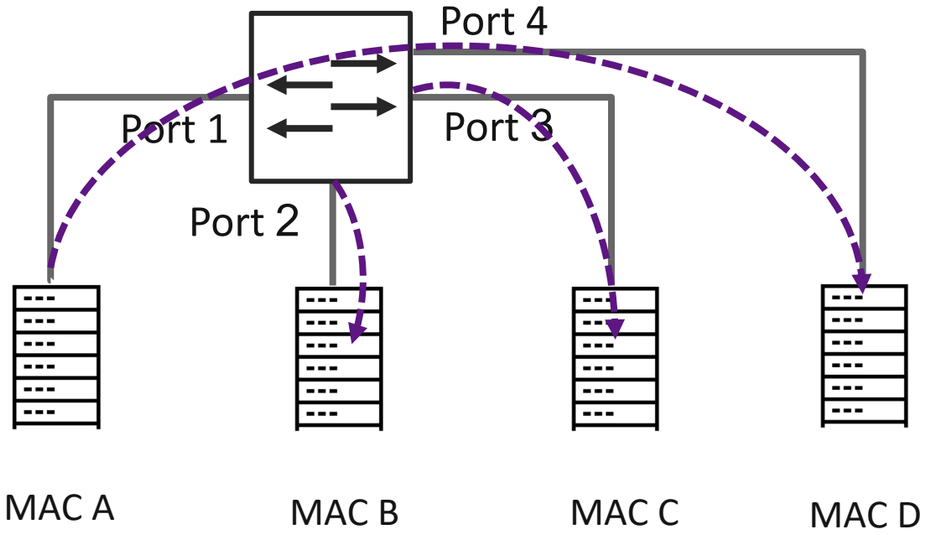
- A unicast address represents a single interface in the network
- Unknown unicast frames are flooded (sent on all ports, besides the incoming port)
- Known unicast frames are forwarded to the specified port

MAC Address Table:

MAC A	Port1
MAC B	Port 2
MAC C	Port 3

Unicast Frame

Destination	Source	
MAC D	**MAC A**	**Data**



Forwarding Broadcast Frames

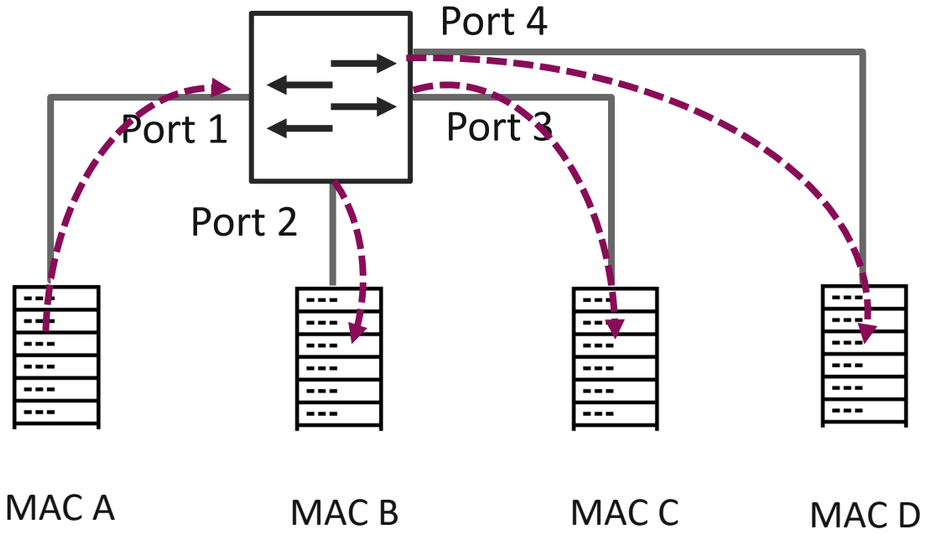
- A broadcast address represents all nodes in the network
- Broadcast frames are identified by a special MAC address
  - All bits in the destination MAC address are set to 1
  - Hexadecimal representation is FF:FF:FF:FF:FF:FF
- Broadcast frames are flooded in the network

MAC Address Table:

MAC A	Port1
MAC B	Port 2
MAC C	Port 3

Broadcast Frame

Destination	Source	
FF:…:FF	**MAC A**	**Data**



Forwarding Multicast Frames

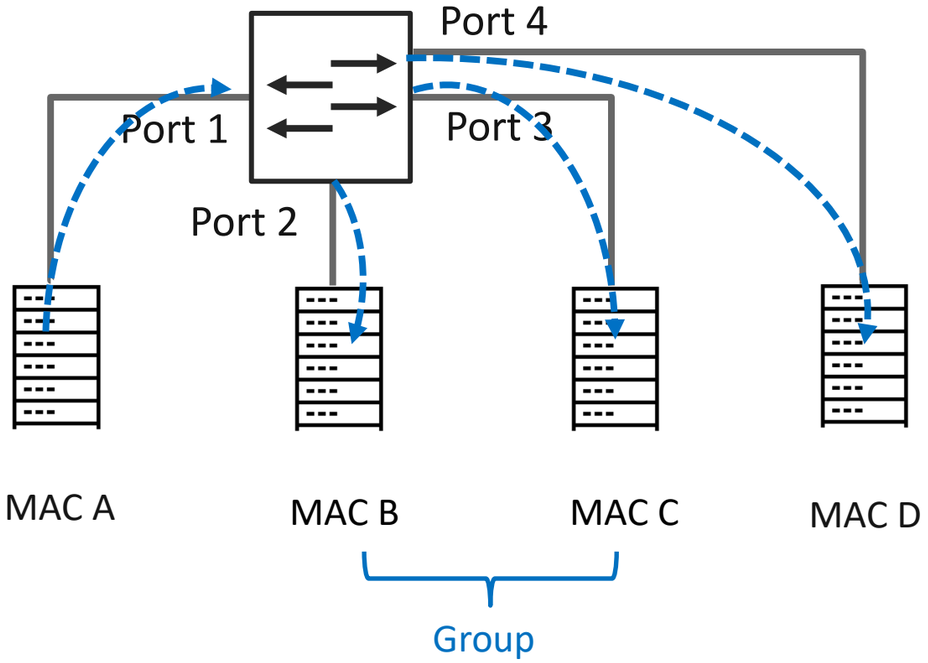
- A multicast address represents a selected group of nodes in the network
- Multicast frames are identified by special MAC addresses
  - The least-significant bit of the first octet is set to 1
  - Hexadecimal representation is *01:XX:XX:XX:XX:XX*
- Multicast frames are flooded

MAC Address Table:

MAC A	Port1
MAC B	Port 2
MAC C	Port 3

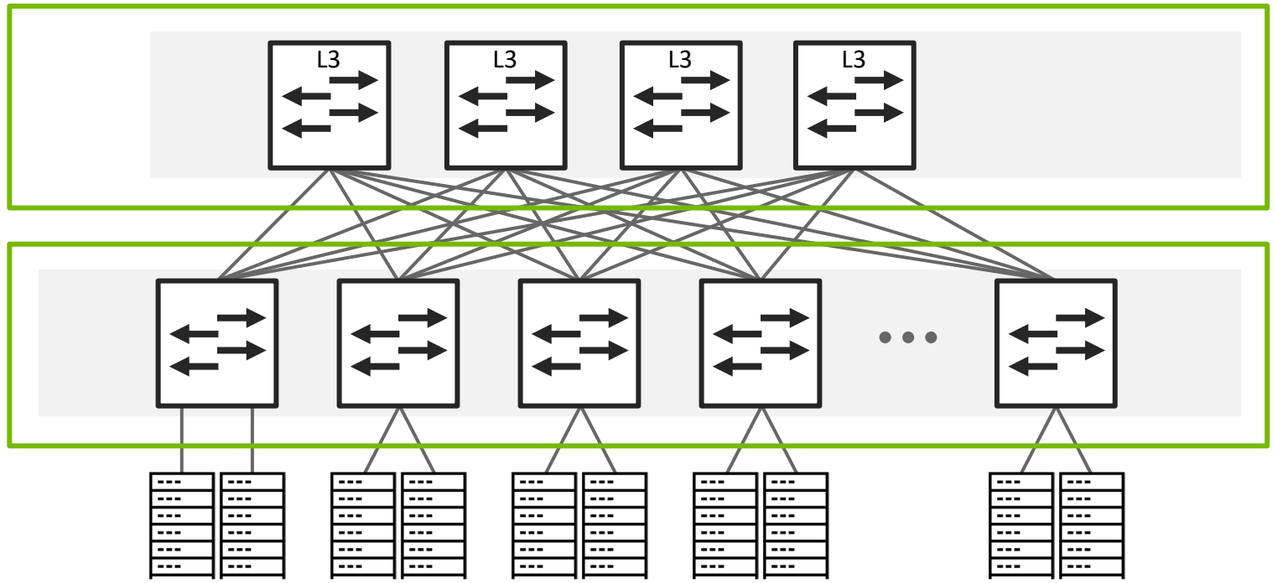
Multicast Frame

Destination	Source	
01:…:XX	**MAC A**	**Data**



Layer 3 Switches

- Traditional switches operate at layer 2, forwarding frames based on destination MAC addresses.
- Routers operates at layer 3 forwarding packets based on destination IP addresses.
- A layer 3 switch combines the functionality of a switch and of a router thus adds flexibility to the network.



Unit Summary

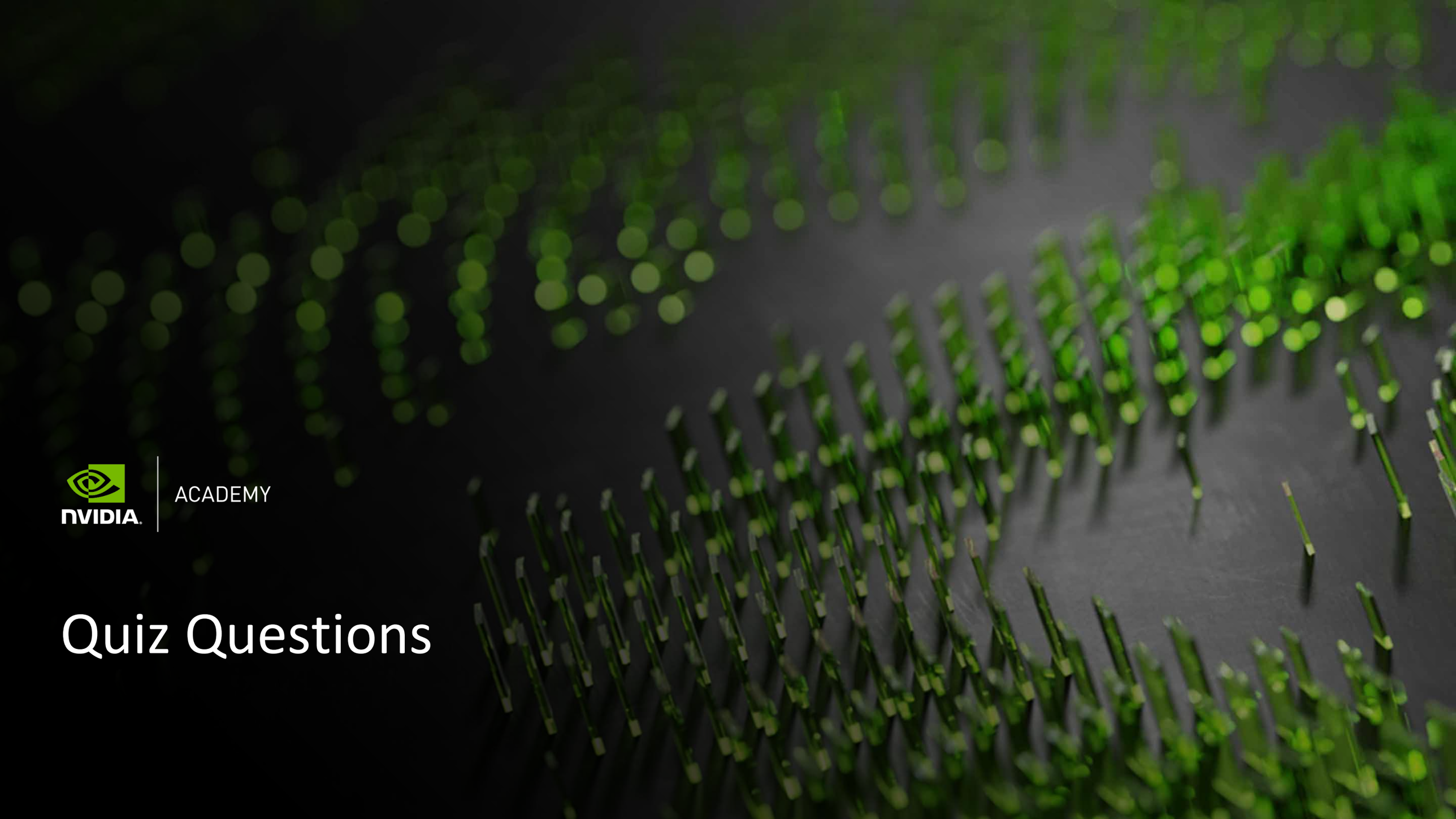
Ethernet Standards

Ethernet Evolution

MAC Addresses

Ethernet Frame Structure and MTU

MAC Address Tables and Frames Forwarding



Quiz Questions

Examine Your Knowledge 1

What is the meaning of the output MTU 1500 Bytes?

A. The maximum number of bytes that can traverse this interface per second is 1500.
B. The maximum frame size that can traverse this interface is 1500 bytes.
C. The minimum packet size that can traverse this interface is 1500 bytes.
D. The maximum packet size that can traverse this interface is 1500 bytes.

```
mlnx-leaf1a [standalone: master] # show interfaces ethernet 1/1

:Eth1/1
Admin state                          : Enabled
Operational state                    : Up
Last change in operational status: 1w 0d and 16:38:19 ago (11 oper change)
Boot delay time                      : 0 sec
Description                          : N/A
Mac address                          : 24:8A:07:CF:66:88
MTU                                  : 1500 bytes
Fec                                  : auto
Operational Fec                      : rs-fec
Flow-control                         : receive off send off
Supported speeds                     : 1G 10G 25G 40G 50G 56G 100G
Advertised speeds                    : 100G
Actual speed                         : 100G
```

Examine Your Knowledge 2

What is the purpose of a switch in the network?

A. To choose the path over which data is sent to its destination
B. To provide network attachment to the end systems and intelligent switching of the data within the local network
C. To serve as the end point in the network, sending and receiving data
D. To connect separate networks and filter the traffic over those networks so that the data is transmitted through the most efficient route

Examine Your Knowledge 3

Switch ‘leaf1’ needs to send a frame to a host with MAC address of 00b0.d056.efa4.
Based on the MAC address table shown here, what will switch ‘leaf1a’ do with the frame?

```
leaf1 # show mac-address-table
------------------------------------------------
Vlan    Mac Address          Type          Port
------------------------------------------------
1       EC:0D:9A:46:9E:7C    Dynamic       Eth1/8
1       EC:0D:9A:6F:96:F2    Dynamic       Eth1/9
Number of unicast:    2
Number of multicast:  0
```

A. Drop the frame because it does not have an entry for that MAC.
B. Flood the frame out all of its ports.
C. Send an ARP request out all of its ports.
D. Forward the data to its default gateway.

Examine Your Knowledge 4

Why will a switch never learn a broadcast address?

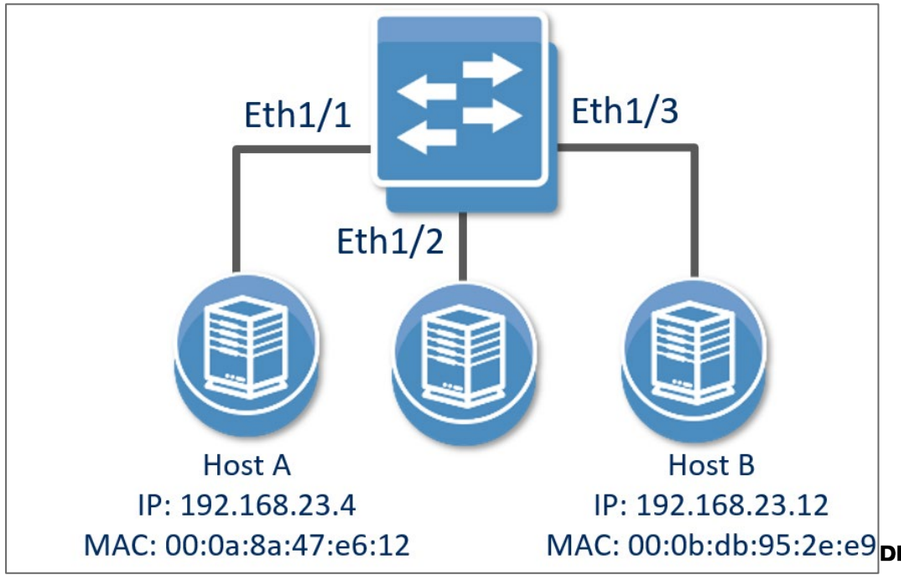
A. Broadcast frames are never sent to switches.
B. Broadcast addresses use an incorrect format for the switching table.
C. A broadcast address will never be the source address of a frame.
D. A broadcast frame is never forwarded by a switch.

Summary Exam

Examine Your Knowledge 5

Host A sends an initial frame to Host B. What is the first thing the switch will do?

A. It will add address 00:0a:8a:47:e6:12 to the ARP table
B. It will add address 00:0a:8a:47.e6:12 to the switching table
C. It will add address 00:0b:db95.2e:e9 to the ARP table
D. It will add address 00:0b:db:95:2e:e9 to the switching table



Examine Your Knowledge 6

What is true about MAC addresses? (Select two)

A. It consists of 48-bit address
B. It consists of 32-bit address
C. MAC address comes under the link layer of the OSI model
D. MAC address comes under the network layer of the OSI model