Module 2: Switching Concepts

Introduction

Welcome to Switching Concepts!

You can connect and configure switches, that's great! But even a network with the newest technology develops its own problems eventually. If you have to troubleshoot your network, you need to know how switches work. This module gives you the fundamentals of switches and switch operation. Luckily, switch operation is easy to understand!

Module Objectives

Module Title: Switching Concepts

Module Objective: Explain how Layer 2 switches forward data.

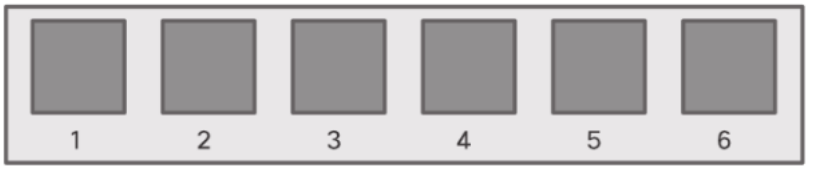
Topic Title	Topic Objective
Frame Forwarding	**Explain how frames are forwarded in a switched network.**
Switching Domains	**Compare a collision domain to a broadcast domain.**

Module 2: Switching Concepts

TOPIC 2.1: Frame Forwarding
2.1.1 Switching in Networking

The concept of switching and forwarding frames is universal in networking and telecommunications. Various types of switches are used in LANs, WANs, and in the public switched telephone network (PSTN).

The decision on how a switch forwards traffic is made based on the flow of that traffic.



Port Table

Destination Addresses	Port
EE	1
AA	2
BA	3
EA	4
AC	5
AB	6

Two terms are associated with frames entering or leaving an interface:

- **Ingress** – entering the interface
- **Egress** – exiting the interface

A switch forwards based on the ingress interface and the destination MAC address.

A switch uses its MAC address table to make forwarding decisions.

Note: A switch will never allow traffic to be forwarded out the interface it received the traffic.

2.1 Frame Forwarding
2.1.2 The Switch MAC Address Table

A switch is made up of integrated circuits and the accompanying software that controls the data paths through the switch. Switches use destination MAC addresses to direct network communications through the switch, out the appropriate port, toward the destination.

For a switch to know which port to use to transmit a frame, it must first learn which devices exist on each port. As the switch learns the relationship of ports to devices, it builds a table called a MAC address table. This table is stored in content addressable memory (CAM) which is a special type of memory used in high-speed searching applications. For this reason, the MAC address table is sometimes also called the CAM table.

LAN switches determine how to handle incoming data frames by maintaining the MAC address table. A switch populates its MAC address table by recording the source MAC address of each device connected to each of its ports. The switch references the information in the MAC address table to send frames destined for a specific device out of the port which has been assigned to that device.

2.1 Frame Forwarding
2.1.3 The Switch Learn and Forward Method

The following two-step process is performed on every Ethernet frame that enters a switch.

Step 1. Learn - Examining the Source MAC Address

Every frame that enters a switch is checked for new information to learn. It does this by examining the source MAC address of the frame and port number where the frame entered the switch:

If the source MAC address does not exist in the MAC address table, the MAC address and incoming port number are added to the table.

If the source MAC address does exist, the switch updates the refresh timer for that entry. By default, most Ethernet switches keep an entry in the table for five minutes. If the source MAC address does exist in the table but on a different port, the switch treats this as a new entry. The entry is replaced using the same MAC address, but with the more current port number.

Step 2. Forward - Examining the Destination MAC Address

If the destination MAC address is a unicast address, the switch will look for a match between the destination MAC address of the frame and an entry in its MAC address table:

If the destination MAC address is in the table, it will forward the frame out of the specified port.

If the destination MAC address is not in the table, the switch will forward the frame out all ports except the incoming port. This is called an unknown unicast. If the destination MAC address is a broadcast or a multicast, the frame is also flooded

2.1 Frame Forwarding
2.1.4 Video – MAC Address Tables on Connected Switches

This video will cover the following:

- How switches build MAC address tables
- How switches forward frames based on the content of their MAC address tables

NOTE: You have to login your NETACAD Account to View this Video.

2.1 Frame Forwarding
2.1.5 Switching Forwarding Methods

Switches make Layer 2 forwarding decisions very quickly. This is because of software on application-specific-integrated circuits (ASICs). ASICs reduce the frame-handling time within the device and allow the device to manage an increased number of frames without degrading performance.

Layer 2 switches use one of two methods to switch frames:

Store-and-forward switching - This method makes a forwarding decision on a frame after it has received the entire frame and checked the frame for errors using a mathematical error-checking mechanism known as a cyclic redundancy check (CRC). Store-and-forward switching is Cisco's primary LAN switching method.

Cut-through switching - This method begins the forwarding process after the destination MAC address of an incoming frame and the egress port have been determined.

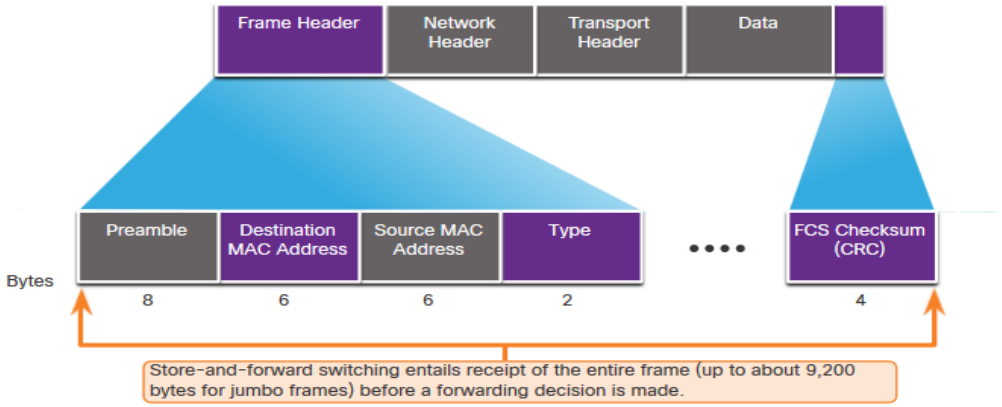
2.1Frame Forwarding
2.1.6 Store-and-Forward Switching

Store-and-forward switching, as distinguished from cut-through switching, has the following two primary characteristics:

Error checking - After receiving the entire frame on the ingress port, the switch compares the frame check sequence (FCS) value in the last field of the datagram against its own FCS calculations. The FCS is an error checking process that helps to ensure that the frame is free of physical and data-link errors. If the frame is error-free, the switch forwards the frame. Otherwise, the frame is dropped.

Automatic buffering - The ingress port buffering process used by store-and-forward switches provides the flexibility to support any mix of Ethernet speeds. For example, handling an incoming frame traveling into a 100 Mbps Ethernet port that must be sent out a 1 Gbps interface would require using the store-and-forward method. With any mismatch in speeds between the ingress and egress ports, the switch stores the entire frame in a buffer, computes the FCS check, forwards it to the egress port buffer and then sends it.

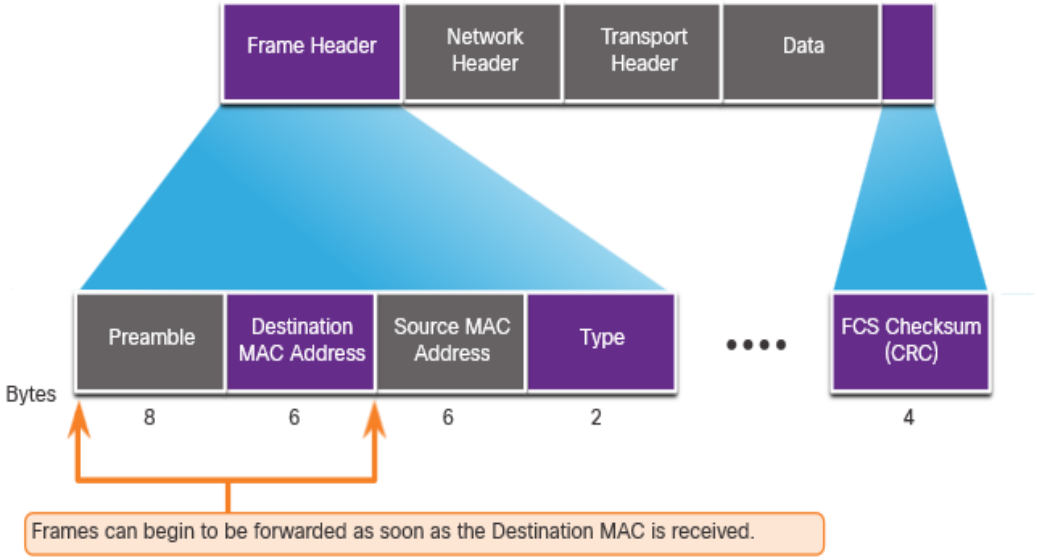
The figure illustrates how store-and-forward makes a decision based on the Ethernet frame.



2.1 Frame Forwarding
2.1.7 Cut-Through Switching

The store-and-forward switching method drops frames that do not pass the FCS check. Therefore, it does not forward invalid frames.

By contrast, the cut-through switching method may forward invalid frames because no FCS check is performed. However, cut-through switching has the ability to perform rapid frame switching. This means the switch can make a forwarding decision as soon as it has looked up the destination MAC address of the frame in its MAC address table, as shown in the figure.



The switch does not have to wait for the rest of the frame to enter the ingress port before making its forwarding decision.

Fragment free switching is a modified form of cut-through switching in which the switch only starts forwarding the frame after it has read the Type field. Fragment free switching provides better error checking than cut-through, with practically no increase in latency.

The lower latency speed of cut-through switching makes it more appropriate for extremely demanding, high-performance computing (HPC) applications that require process-to-process latencies of 10 microseconds or less.

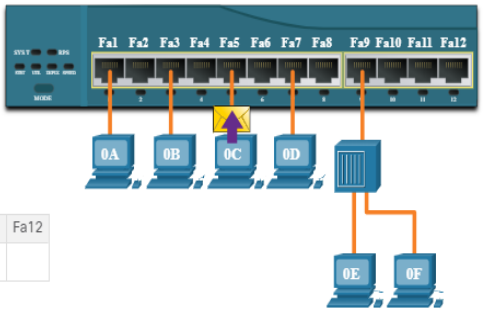
The cut-through switching method can forward frames with errors. If there is a high error rate (invalid frames) in the network, cut-through switching can have a negative impact on bandwidth, thereby clogging up bandwidth with damaged and invalid frames.

TOPIC 2.1: Frame Forwarding
Written Activity 2.1.8 – Switch It!

Use this activity to check your understanding of how a switch learns and forwards frames.

Frame

Preamble	Destination MAC	Source MAC	Type / Length	Frame	End of Frame
	0E	0C			



MAC Table

Fa1	Fa2	Fa3	Fa4	Fa5	Fa6	Fa7	Fa8	Fa9		Fa10	Fa11	Fa12
0A		0B				0D		0E				

Question 1 - Where will the switch forward the frame?

☐ Fa1 ☐ Fa2 ☐ Fa3 ☐ Fa4 ☐ Fa5 ☐ Fa6 ☐ Fa7 ☐ Fa8 ☐ Fa9 ☐ Fa10 ☐ Fa11 ☐ Fa12

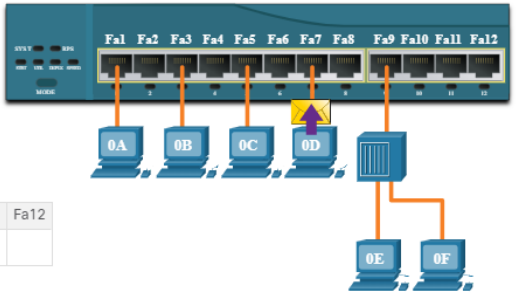
Question 2 - When the switch forwards the frame, which statement(s) are true?

- ☐ Switch adds the source MAC address which is currently not in the MAC address table.
- ☐ Frame is a broadcast frame and will be forwarded to all ports.
- ☐ Frame is a unicast frame and will be sent to specific port only.
- ☐ Frame is a unicast frame and will be flooded to all ports.
- ☐ Frame is a unicast frame but it will be dropped at the switch.

Use this activity to check your understanding of how a switch learns and forwards frames.

Frame

Preamble	Destination MAC	Source MAC	Type / Length	Frame	End of Frame
	0E	0D			



MAC Table

Fa1	Fa2	Fa3	Fa4	Fa5	Fa6	Fa7	Fa8	Fa9		Fa10	Fa11	Fa12
0A		0B		0C		0D		0E	0F			

Question 1 - Where will the switch forward the frame?

☐ Fa1 ☐ Fa2 ☐ Fa3 ☐ Fa4 ☐ Fa5 ☐ Fa6 ☐ Fa7 ☐ Fa8 ☐ Fa9 ☐ Fa10 ☐ Fa11 ☐ Fa12

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- ☐ Frame is a unicast frame and will be flooded to all ports.
- ☐ Frame is a unicast frame but it will be dropped at the switch.

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TOPIC 2.2: Switching Domains
2.2.1 Collision Domains

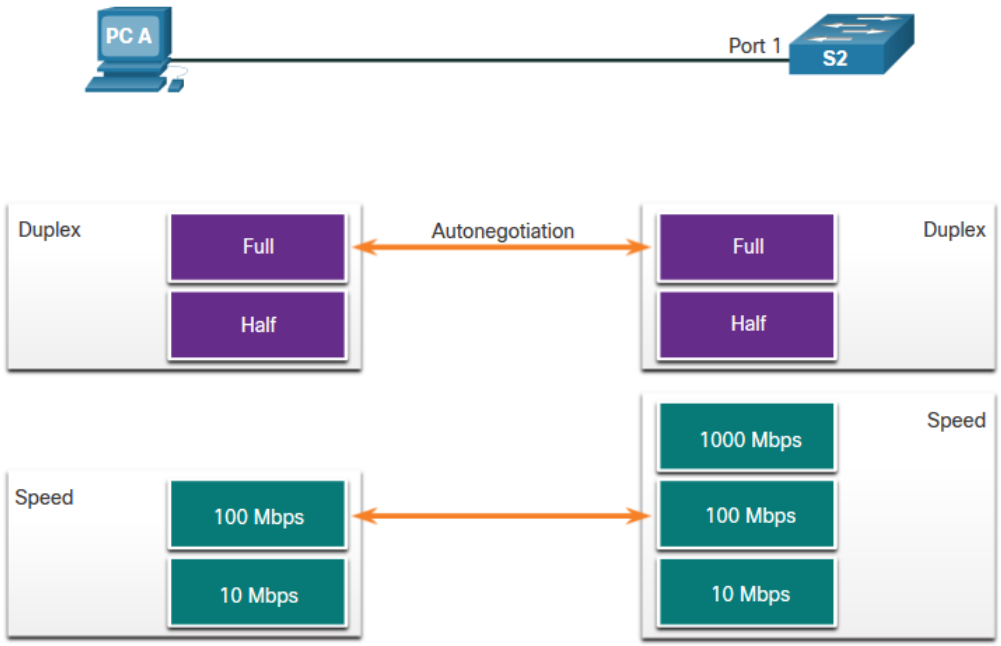
This topic discusses how switches work with each other and with other devices to eliminate collisions and reduce network congestion. The terms collisions and congestion are used here in the same way that you use them in street traffic.

In legacy hub-based Ethernet segments, network devices competed for the shared medium. The network segments that share the same bandwidth between devices are known as collision domains. When two or more devices within the same collision domain try to communicate at the same time, a collision will occur.

If an Ethernet switch port is operating in half-duplex, each segment is in its own collision domain. There are no collision domains when switch ports are operating in full-duplex. However, there could be a collision domain if a switch port is operating in half-duplex.

By default, Ethernet switch ports will autonegotiate full-duplex when the adjacent device can also operate in full-duplex. If the switch port is connected to a device operating in half-duplex, such as a legacy hub, then the switch port will operate in half-duplex. In the case of half-duplex, the switch port will be part of a collision domain.

As shown in the figure, full-duplex is chosen if both devices have the capability along with their highest common bandwidth.

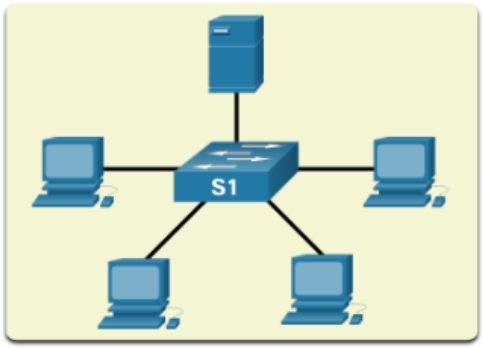


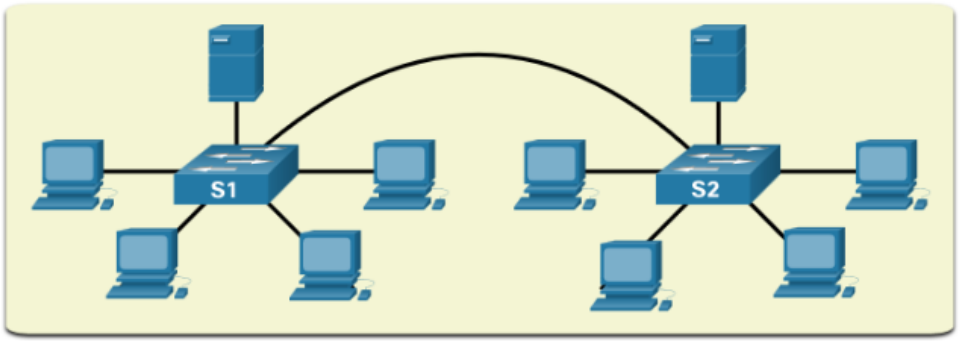
2.2 Switching Domains
2.2.2 Broadcast Domains

A collection of interconnected switches forms a single broadcast domain. Only a network layer device, such as a router, can divide a Layer 2 broadcast domain. Routers are used to segment broadcast domains, but will also segment a collision domain.

When a device sends a Layer 2 broadcast, the destination MAC address in the frame is set to all binary ones.

The Layer 2 broadcast domain is referred to as the MAC broadcast domain. The MAC broadcast domain consists of all devices on the LAN that receive broadcast frames from a host.





When a switch receives a broadcast frame, it forwards the frame out each of its ports, except the ingress port where the broadcast frame was received. Each device connected to the switch receives a copy of the broadcast frame and processes it.

Broadcasts are sometimes necessary for initially locating other devices and network services, but they also reduce network efficiency. Network bandwidth is used to propagate the broadcast traffic. Too many broadcasts and a heavy traffic load on a network can result in congestion, which slows down network performance.

When two switches are connected together, the broadcast domain is increased, as seen in the second half of the animation. In this case, a broadcast frame is forwarded to all connected ports on switch S1. Switch S1 is connected to switch S2. The frame is then also propagated to all devices connected to switch S2.

2.2 Switching Domains
2.2.3 Alleviated Network Congestion

LAN switches have special characteristics that help them alleviate network congestion. By default, interconnected switch ports attempt to establish a link in full-duplex, therefore eliminating collision domains. Each full-duplex port of the switch provides the full bandwidth to the device or devices that are connected to that port. Full-duplex connections have dramatically increased LAN network performance, and are required for 1 Gbps Ethernet speeds and higher.

Switches interconnect LAN segments, use a MAC address table to determine egress ports, and can lessen or eliminate collisions entirely. Characteristics of switches that alleviate network congestion include the following:

Protocol	Function
Fast Port Speeds	Depending on the model, switches may have up to 100Gbps port speeds.
Fast Internal Switching	This uses fast internal bus or shared memory to improve performance.
Large Frame Buffers	This allows for temporary storage while processing large quantities of frames.
High Port Density	This provides many ports for devices to be connected to LAN with less cost. This also provides for more local traffic with less congestion.

TOPIC 2.2: Switching Domains
QUIZ 2.2.4 – Check your Understanding

1. Which port speed will be autonegotiated between a host with a 1 Gbps NIC connecting to a Cisco Catalyst 2960 switch with a 100 Mbps port?

- ◯ 10 Mbps
- ◯ 100 Mbps
- ◯ 1 Gbps
- ◯ 10 Gbps

2. Which device separates broadcast domains?

- ◯ access point
- ◯ hub
- ◯ router
- ◯ switch

3. Which two special characteristics do LAN switches use to alleviate network congestion? (Choose two.)

- ☐ fast port speeds
- ☐ fast internal switching
- ☐ low port densities
- ☐ small frame buffers

MODULE 2: SWITCHING CONCEPTS
2.3 What Did I Learn in This Module?

Frame Forwarding

- The decision on how a switch forwards traffic is based on the flow of that traffic.
- The term ingress describes the port where a frame enters a device.
- The term egress describes the port that frames will use when leaving the device.
- An Ethernet frame will never be forwarded out the port where it entered.
- For a switch to know which port to use to transmit a frame, it must first learn which devices exist on each port.
- As the switch learns the relationship of ports to devices, it builds a table called a MAC address table.
- Every frame that enters a switch is checked for new information to learn by examining the source MAC address of the frame and port number where the frame entered the switch.
- If the destination MAC address is a unicast address, the switch will look for a match between the destination MAC address of the frame and an entry in its MAC address table.
- Switch forwarding methods include store-and-forward and cut-through.
- Store-and-forward uses error-checking and automatic buffering.
- Cut-through does not error check.
- Instead it performs rapid frame switching.
- This means the switch can make a forwarding decision as soon as it has looked up the destination MAC address of the frame in its MAC address table.

Switching Domains

- If an Ethernet switch port is operating in half-duplex, each segment is in its own collision domain.
- There are no collision domains when switch ports are operating in full-duplex.
- By default, Ethernet switch ports will autonegotiate full-duplex when the adjacent device can also operate in full-duplex.
- A collection of interconnected switches forms a single broadcast domain.
- Only a network layer device, such as a router, can divide a Layer 2 broadcast domain.
- The Layer 2 broadcast domain is referred to as the MAC broadcast domain.
- The MAC broadcast domain consists of all devices on the LAN that receive broadcast frames from a host.
- When a switch receives a broadcast frame, it forwards the frame out each of its ports, except the ingress port where the broadcast frame was received.
- Each device connected to the switch receives a copy of the broadcast frame and processes it.
- Switches can: interconnect LAN segments, use a MAC address table to determine egress ports, and can lessen or eliminate collisions entirely.
- Characteristics of switches that alleviate network congestion are fast port speeds, fast internal switching, large frame buffers, and high port density.

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MODULE 2: SWITCHING CONCEPTS
MODULE QUIZ

1. Which statement is true about broadcast and collision domains?

- ◯ Adding a router to a network will increase the size of the collision domain.
- ◯ The size of the collision domain can be reduced by adding hubs to a network.
- ◯ The more interfaces a router has the larger the resulting broadcast domain.
- ◯ Adding a switch to a network will increase the size of the broadcast domain.

2. What is one function of a Layer 2 switch?

- ◯ forwards data based on logical addressing
- ◯ duplicates the electrical signal of each frame to every port
- ◯ learns the port assigned to a host by examining the destination MAC address
- ◯ determines which interface is used to forward a frame based on the destination MAC address

3. What is the significant difference between a hub and a Layer 2 LAN switch?

- ◯ A hub divides collision domains, and a switch divides broadcast domains.
- ◯ A switch creates many smaller collision domains, and a hub increases the size of a single collision domain.
- ◯ Each port of a hub is a collision domain, and each port of a switch is a broadcast domain.
- ◯ A hub forwards frames, and a switch forwards only packets.

4. What will a Cisco LAN switch do if it receives an incoming frame and the destination MAC address is not listed in the MAC address table?

- ◯ Drop the frame.
- ◯ Send the frame to the default gateway address.
- ◯ Use ARP to resolve the port that is related to the frame.
- ◯ Forward the frame out all ports except the port where the frame is received.

5. Which switch characteristic helps alleviate network congestion when a 10 Gbps port is forwarding data to a 1 Gbps port?

- ◯ fast internal switching
- ◯ high port density
- ◯ fast port speed
- ◯ frame buffering

6. Which switching method makes use of the FCS value?

- ◯ broadcast
- ◯ cut-through
- ◯ large frame buffer
- ◯ store-and-forward

7. What does the term "port density" represent for an Ethernet switch?

- ◯ the memory space that is allocated to each switch port
- ◯ the number of available ports
- ◯ the numbers of hosts that are connected to each switch port
- ◯ the speed of each port

8. Which information does a switch use to keep the MAC address table information current?

- ◯ the destination MAC address and the incoming port
- ◯ the destination MAC address and the outgoing port
- ◯ the source and destination MAC addresses and the incoming port
- ◯ the source and destination MAC addresses and the outgoing port
- ◯ the source MAC address and the incoming port
- ◯ the source MAC address and the outgoing port

MODULE 2: SWITCHING CONCEPTS
MODULE QUIZ

9. Which two statements are true about half-duplex and full-duplex communications? (Choose two.)

- [ ] Full duplex offers 100 percent potential use of the bandwidth.
- [ ] Half duplex has only one channel.
- [ ] All modern NICs support both half-duplex and full-duplex communication.
- [ ] Full duplex allows both ends to transmit and receive simultaneously.
- [ ] Full duplex increases the effective bandwidth.

10. Which type of address does a switch use to build the MAC address table?

- ◯ destination IP address
- ◯ source IP address
- ◯ destination MAC address
- ◯ source MAC address

11. Which option correctly describes a switching method?

- ◯ cut-through: makes a forwarding decision after receiving the entire frame
- ◯ store-and-forward: forwards the frame immediately after examining its destination MAC address
- ◯ cut-through: provides the flexibility to support any mix of Ethernet speeds
- ◯ store-and-forward: ensures that the frame is free of physical and data-link errors

12. Which network device can serve as a boundary to divide a Layer 2 broadcast domain?

- ◯ router
- ◯ Ethernet bridge
- ◯ Ethernet hub
- ◯ access point

13. What is the purpose of frame buffers on a switch?

- ◯ They provide a basic security scan on received frames.
- ◯ They provide temporary storage of the frame checksum.
- ◯ They execute checksum values before transmission.
- ◯ They hold traffic, thus alleviating network congestion.

14. Which network device can be used to eliminate collisions on an Ethernet network?

- ◯ firewall
- ◯ hub
- ◯ router
- ◯ switch

Reference:

CCNAv7 Switching, Routing and Wireless Essentials

https://www.netacad.com

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