LAN Switching: Basic Switch Concepts

1

Network Switches

- A **Network Switch** is a component of computer **network** that connects two **network** segments and/or two **network** devices (**switches** or routers) together.
- Generally **Switches** can also be referred to as **network** bridges with multiple ports (i.e. multiport bridges)
- Switches help to process and route packets at data link layer of the OSI reference model

2

Ethernet and LAN Switching

- LAN operation requires a network **access method** as the basis for its operation
- **Ethernet** is the most common network access method in use today for local area networks
- Ethernet multi-access broadcast technology i.e. it is a shared technology where all users on a given LAN segment compete for the **same available bandwidth**
- It uses **CSMA/CD**
- Collisions impact on network performance
- **Layer 2** devices can improve performance

3

Ethernet and LAN Switching

- With network growth bandwidth needs increased
  - Internet/intranet/email
  - Multimedia
  - Increasing use of enterprise servers
- Ethernet has developed to meet this challenge
  - 10Mbps, 100Mbps, 1000Mbps, 10Gbit
  - Coaxial, Twisted Pair, Fibre Optic, Wireless
  - Repeaters, hubs, bridges, switches, routers
- **NB:** You must understand the features of all this technology to gain best performance in your network design!

4

Types of Ethernet Transmission

Half-duplex

- Host checks medium for signal – if clear host transmits
- Only 1 host can transmit at a time
- Collisions – jam signal generated, back-off algorithm before retransmission
- 50-60% bandwidth available

Full duplex

- Host can transmit immediately
- 2 hosts can transmit simultaneously
- No collisions
- 100% bandwidth available
- Requires dedicated connection to a switch port

5

Types of Ethernet Transmission

- Benefits of using full-duplex:
  - i. Time is not wasted retransmitting frames because collisions do not occur
  - ii. The full bandwidth is available in both directions because the send and receive functions are separate
  - iii. Stations do not have to wait until other stations complete their transmissions because only one transmitter is used for each twisted pair

6

Limitations of Ethernet

1. Collisions which affect network performance
2. Distance – the coverage is within a short range (with older technology)
3. Broadcast storms
4. Security concerns

7

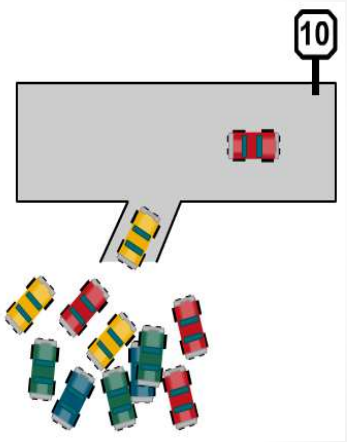
LAN Segmentation

- You can improve the performance of your Ethernet network by reducing the number of stations per collision domain
- Typically, network administrators implement bridges, switches, or routers to segment the network and divide the collision domains

8

Segmenting with Hubs

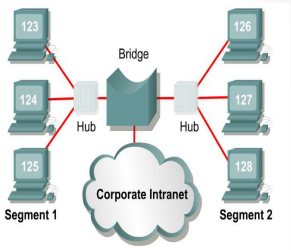
- Layer 1 devices
- Regenerate, retime, amplify signals
- 1 **collision/bandwidth domain**
- Broadcasts propagated out of every port
- Only 1 device can transmit at a time
- Only 50-60% bandwidth available



9

Segmenting with Bridges

- Bridges are layer 2 devices
- They split a network into more collision/bandwidth domains
- Are capable of collecting and selectively passing data frames between two network segments
- They do this by learning the MAC address of all devices on each connected segment and use the information to build a bridge table
- They then forward or block traffic based on the bridge table
- This results in smaller collision domains and greater network efficiency



NB:

- Bridges do **NOT** restrict **broadcast traffic**
- They add 10-30% latency

10

Segmenting with Bridges (contd)

Points to remember about bridges:

1. Bridges reduce collisions on the LAN and filter traffic based on MAC addresses
2. A bridge does not reduce **broadcast** or **multicast** traffic
3. A bridge can extend the useful distance of the Ethernet LAN
4. The bandwidth for the new individual segments is increased
5. Bridges can be used to limit traffic for security purposes

11

Segmenting with Routers

- Routers operate at layer 3 of the OSI reference model
- Used to "route" traffic between two or more Layer 3 networks
- Routing decisions are made based on groups of network addresses, or classes, as opposed to individual Layer 2 MAC addresses
- They use **routing tables** to record the Layer 3 addresses of the networks that are directly connected to the local interfaces and network paths learned from neighboring routers
- They **do not** propagate broadcast traffic; thus, they reduce network traffic even more than bridges do

12

Segmenting with Routers (continued)

When you segment a LAN with routers, they will:

1. Decrease collisions by filtering traffic
2. Reduce broadcast and multicast traffic by blocking or selectively filtering packets
3. Support multiple paths and routes between them
4. Provide increased bandwidth for the newly created segments
5. Increase security by preventing packets between hosts on one side of the router from propagating to the other side of the router

13

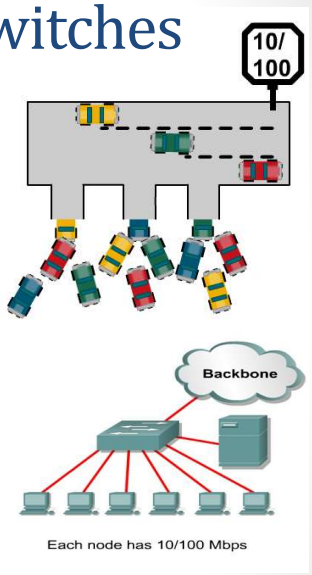
Segmenting with Routers (continued)

6. Increase the effective distance of the network by creating new collision domains
7. Provide layer 3 routing, packet fragmentation and reassembly, and traffic flow control
8. Provide communications between different technologies, such as Ethernet and Token Ring or Ethernet and Frame Relay
9. Have a higher latency than bridges, because routers have more to process; faster processors in the router can reduce some of this latency

14

Segmenting with Switches

- Layer 2 devices
- Learn MAC addresses of devices attached to each port and build a switching table
- They use this switching table to selectively forward traffic
- They create a virtual circuit between two connected devices, establishing a dedicated communication path between two devices
- They **microsegment** the network by connecting each port to an individual workstation
- Each switch port therefore has dedicated bandwidth (100% bandwidth is available)
- A switch is also able to facilitate multiple, simultaneous virtual circuit connections



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15

15

Switch Operation

- When a switch starts up it sends a broadcast out of all ports to learn host MAC addresses
- When a frame is received for **an unknown destinatio**n a broadcast is sent to discover its location
- Addresses are added to a switching table mapping them to the port on which they were learned
- When a frame is received for **a known destination** it is switched to the appropriate port

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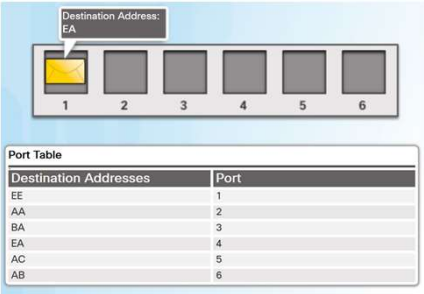
16

16

Switch Operation



- A LAN switch makes decisions based on two criteria:
  i. **Ingress port** - where a frame enters the device
  ii. **Destination address**

- A LAN switch maintains a table that it uses to determine how to forward traffic
- In the diagram, If a message enters switch port 1 with a destination address of EA, then the switch forwards the traffic out port 4
- Layer 2 Ethernet switches forward frames based on the destination MAC address.

17

Switch CAM Table

- Switches contain RAM – known as CAM "Content Addressable Memory" which stores the MAC address table
- CAM is also used as frame buffer to queue frames in asymmetric switching – switch ports operating at different speeds e.g. 10 and 100 Mbps
- The table matches switch port with MAC address of attached device
- It is built by inspecting source MAC address of incoming frames, just like the bridge

18

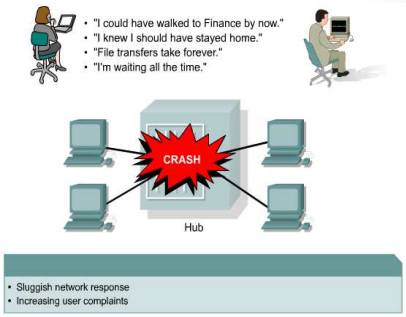
Switch CAM Table

- Destination MAC address is checked against table, frame sent through correct port
- If the destination MAC address and port mapping is not in table, the frame flooded
  - NB: Broadcasts are flooded

19

Switches and Collision Domains

- The network area where frames originate and collide is called the **collision domain or**
- A network segment where devices must compete to communicate



- All **shared media environments** are collision domains

20

Switches and Collision Domains

- Examples of Collision Domain Environments
  1. All ports of a hub belong to the same collision domain
  2. Every port of a switch is a collision domain on its own (*if configured to operate in full-duplex mode)*
  3. Every port of a router is a collision domain on its own
- NB:
  - Switches break the segment into smaller collision domains, easing device competition

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21

21

Switches and Collision Domains

- Collisions reduce throughput
- The more devices the more collisions
- Using a hub there may be 60% of bandwidth available
- Using a switch (+ full duplex transmission) dedicated link each way there's 100% bandwidth in each direction
  - **NB:** The full duplex link above is regarded as an individual collision domain if you are asked to count them.

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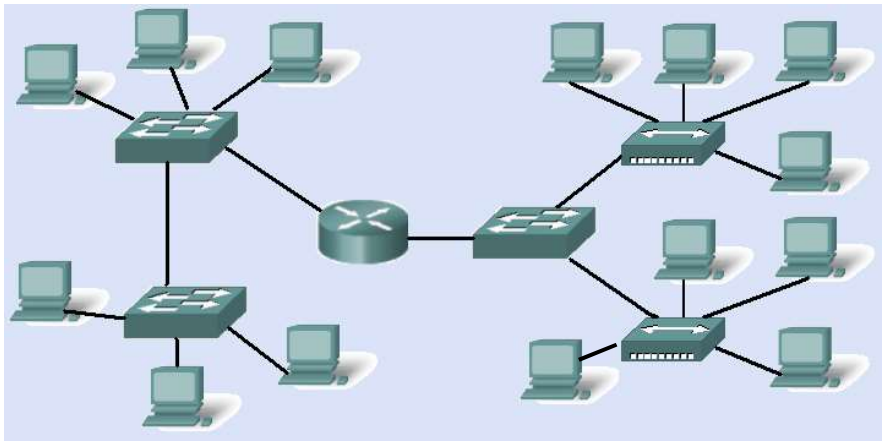
22

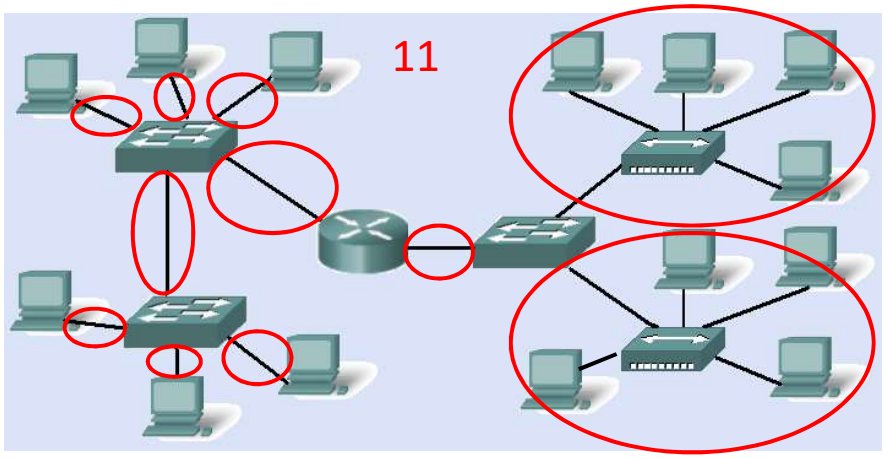
22

How many collision domains?



23

How many collision domains?



24

Switches and Broadcast Domains

- Broadcasting is when one transmitter tries to reach all the receivers in the network i.e. the sending station sends out one message, and all nodes on that segment receive the message
- A **broadcast domain** is the extend of the network where a broadcast frame can be 'heard' or propagated
- Layer 2 switches flood broadcasts frames to all ports; therefore, switches do not break broadcast domains
- All ports of a switch, with its default configuration, belong to the same broadcast domain
- Devices linked by switches are in the same broadcast domain (if there are no VLANs configured)

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25

25

Switches and Broadcast Domains

- If two or more switches are connected, broadcasts are forwarded to all ports of all switches, except for the port that originally received the broadcast
- Destination MAC address for broadcast is all 1s, that is FF:FF:FF:FF:FF:FF
- A layer 3 device (e.g. a router) splits up broadcast domains, does not forward broadcasts

NB:

- Layer 2 switches configured with VLANs break broadcast domains into smaller ones
- Too many broadcasts can cause **network congestion**

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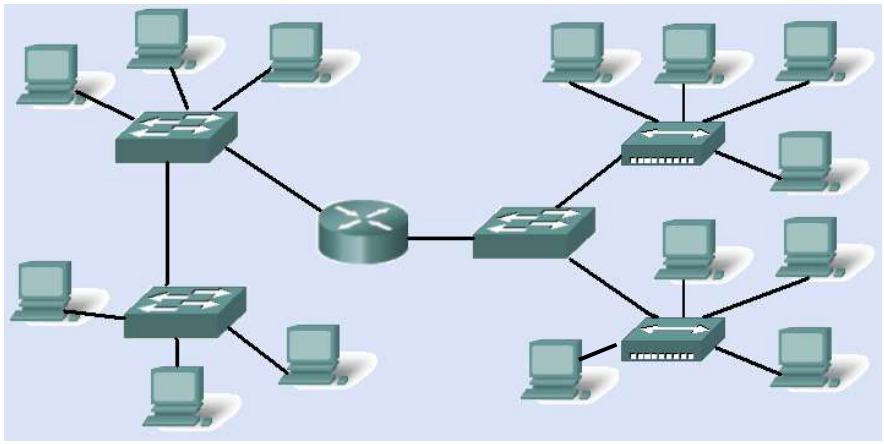
26

26

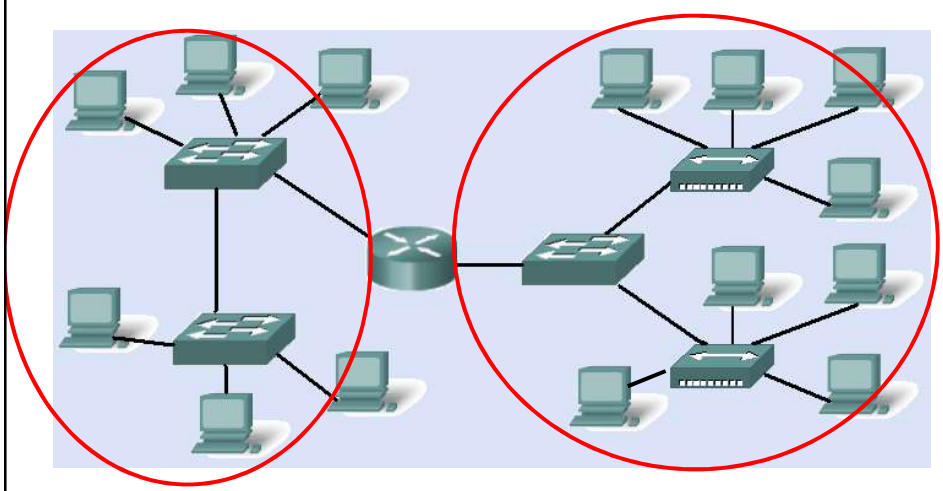
How many broadcast domains?



No VLANs

27

How many broadcast domains?



28

Alleviating Network Congestion

Switches help alleviating network congestion by:

- Facilitating the segmentation of a LAN into separate collision domains
- Providing full-duplex communication between devices
- Taking advantage of their high-port density
- Buffering large frames
- Employing high-speed ports
- Taking advantage of their fast internal switching process
- Having a low, per-port cost

29

Switch Forwarding Methods

- All switches base frame-forwarding decisions on a frame's destination MAC address
- There are two main frame forwarding methods used in switches
  1. Store and forward
  2. Cut through
- Cut through switching has two variants:
  1. Fast Forward and
  2. Fragment Free

30

Store and Forward

- Store and forward switches:
  - Read whole frame into buffer
  - Discard any frames that are too short/long
  - Perform cyclic redundancy check (CRC) and discard any frames with errors
  - Find correct port and forward frame
  - Allows entry and exit at different bandwidths
- **Benefit:** These switch forwarding method will not forward frames with errors
- **Drawback:** The store-and-forward method has the highest latency

31

Store-and-Forward Forwarding (continued)

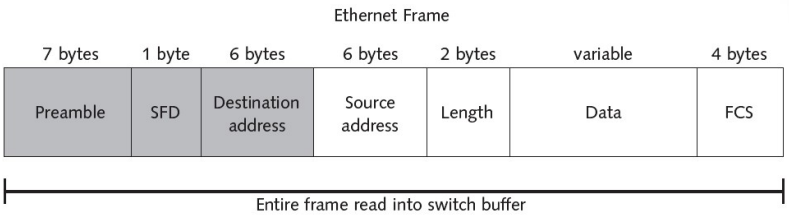


Figure 12-6 Entire packet read into buffer by a store-and-forward switch

32

Cut Through - Fast forward

- Switches that use the cut through-fast forwarding method:
  - Read start of frame as it comes in, as far as end of destination MAC address (first 6 bytes after start delimiter)
  - Look up port and start forwarding while remainder of frame is still coming in
  - Require entry and exit to be of the same bandwidth
- **Benefit:** They have the lowest latency
- **Drawback**: potential for errors. They Perform no checks or discarding of bad frames

33

Cut-Through Forwarding (contd)

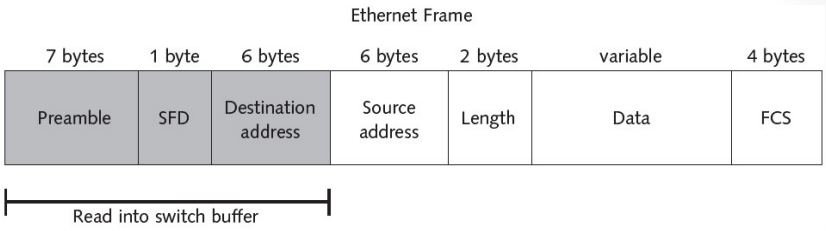


Figure 12-5 Portion of packet read into buffer by a cut-through switch

34

Cut Through – Fragment Free

- Switches that use the cut through-fragment free forwarding method:
  - Read start of frame as it comes in, as far as the first 64 bytes
  - Look up port and start forwarding while remainder of frame (if any) is still coming in
  - Discards collision fragments (too short) but other bad frames are forwarded
  - Require that the entry and exit be of the same bandwidth

35

Cut Through – Fragment Free

- Cut-through fragment free switches provide a compromise between low latency and error checks

36

Fragment-Free Forwarding (cont)

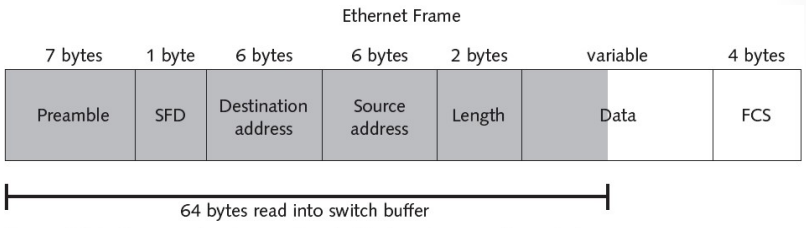


Figure 12-7 Amount of packet read into buffer by a fragment-free switch

37

Fragment-Free Forwarding (cont)

The adaptive cut-through switch

- This switch will act as a normal cut-through switch providing low latency, however, if a certain level of errors is detected, the switch will change forwarding techniques and act more as a store-and-forward switch

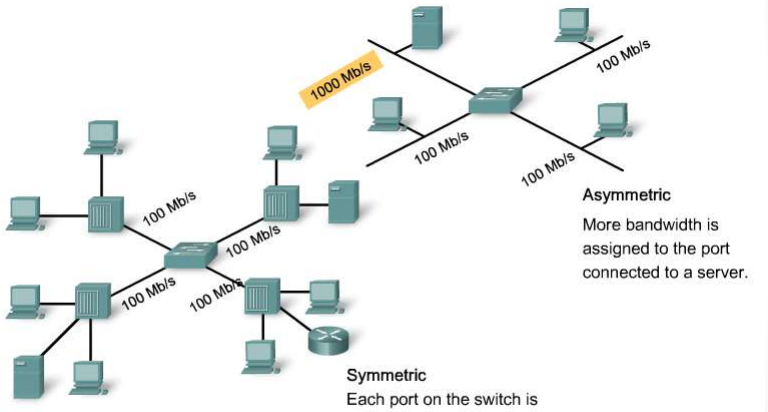
38

Symmetric and Asymmetric Switching

- In symmetric switching all ports operate at same bandwidth
- In asymmetric switching different bandwidths are used, e.g. server or uplink has greater bandwidth
- Asymmetric switching requires store and forward operation with buffering
- Most switches now are asymmetric to allow flexibility

39

Symmetric and Asymmetric Switching



40

Memory Buffering

- Is the use of memory to store the
- Switches analyse some or all of a packet before it forwards it to the destination host based on the forwarding method
- Switches store the packet for the brief time in a memory buffer
- Buffering may also be used when the destination port is busy due to congestion and the switch stores the frame until it can be transmitted
- Memory buffering is built into the hardware of the switch and, other than increasing the amount of memory available, is not configurable

41

Memory Buffering

- There are two methods of memory buffering:
  1. Port-based memory buffering
  2. Shared memory buffering

42

Port Based Buffering

- Each incoming port has its own queue
- Frames stay in buffer until outgoing port is free
- Frames destined for busy outgoing port can hold up all the others even if their outgoing ports are free
- Each incoming port has a fixed and limited amount of memory

43

Shared Memory Buffering

- In shared memory buffering
  - All incoming frames go in a common buffer
  - The switch maps frame to destination port and forwards it when port is free
  - Frames do not hold each other up
- Shared memory buffering makes flexible use of memory by allowing larger frames
- Shared memory buffering is important for asymmetric switching where some ports work faster than others

44

Layer 2 and Layer 3 Switching

Traditional Ethernet switches work at layer 2.

They use MAC addresses to make forwarding decisions.

They do not look at layer 3 information.

45

Layer 2 and Layer 3 Switching

Layer 3 switches can carry out the same functions as layer 2 switches.

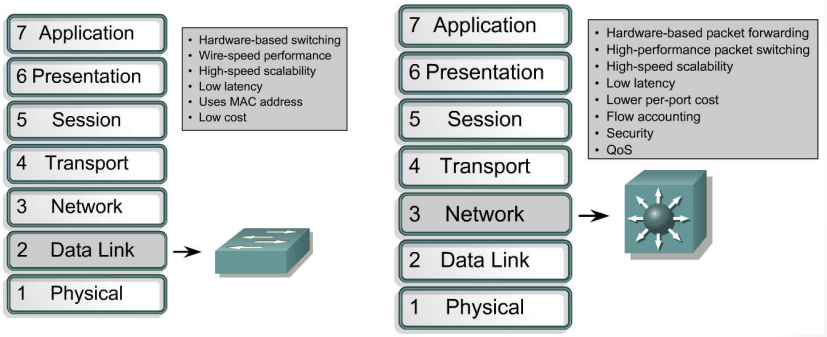
They can also use layer 3 IP addresses to route between networks.

The can control the spread of broadcasts.

46

Layer 2 and Layer 3 Switching

- Layer 2 Switching
- Layer 3 Switching



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47

47