Topologies

Physical and Logical Topologies

In any network in the previous topic, the data link layer prepares network data for the physical network. A most known the logical topology of a network in order to be able to determine what is needed to transfer frames from one device to another. This chart explains the ways in which the data link layer works with different logical topologies.

The topology of a network is the arrangement, or the relationship, of the network devices and the interconnections between them.

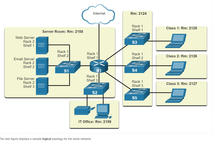
There are two types of topologies seen when describing LAN and WAN networks:

- **Physical topology** - identifies how end devices and network devices are interconnected by devices (i.e. routers, switches, and wireless access points) and the various media types that are required to connect devices and hosts such as twisted copper pairs and fiber-optic cable and location on the equipment rack. Physical topologies are usually represented in a two-dimensional diagram.
- **Logical topology** - identifies how the media or network transfers frames from one node to the next. This topology identifies virtual connections using device interfaces and Layer 2 addressing schemes.

The data link layer "sees" the logical topology of a network when controlling data access to the media. It is the logical topology that influences the type of network framing and media access control used.

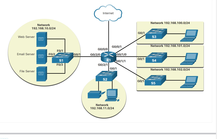
The figure displays a sample **physical** topology for a small service network.

Physical Topology



The next figure displays a sample **logical** topology for the same network.

Logical Topology



WAN Topologies

The figure illustrates how WANs are commonly interconnected using three common physical WAN topologies.

Click each button for more information.

Point-to-Point | Hub and Spoke | Mesh

This is the simplest and most common WAN topology. It consists of a permanent link between two endpoints.

A hybrid is a variation or combination of any topologies. For example, a partial mesh is a hybrid topology in which some, but not all, end devices are interconnected.

Point-to-Point WAN Topology

Physical point-to-point topologies directly connect two nodes, as shown in the figure. In this arrangement, two nodes do not have to share the media with other hosts. Additionally, when using a serial communications protocol such as Point-to-Point Protocol (PPP), a node does not make its media access determination about whether an frame sent across the point-to-point link will reach a destination. The node can send a frame across the link when it is ready because it knows that its frame will not be seen or delayed by other hosts. The node places the frame on the media at one end and those frames are taken from the media by the node at the other end of the point-to-point circuit.

Point-to-point topologies are limited to two nodes.

Note: A point-to-point connection over Ethernet requires the device to determine if the incoming frame is destined for this node.

A source and destination node may be indirectly connected to each other over several point-to-point links. In this case, the intermediary devices, frequently, the use of a store-and-forward delivery method. The frame is received and stored until the link is available to forward the frame. In this figure, using intermediary physical connections may not change the logical topology. The logical point-to-point connection is the same.

LAN Topologies

In multaccess LANs, end devices in a network are interconnected using one or extended star topologies, as shown in the figure. In the topo of topology, end devices are connected to a central intermediary device, in this case, an Ethernet switch. An **extended star** extends the topology by interconnecting multiple Ethernet switches. Wireless LANs typically use the star topology, in which wireless hosts are connected to an access point, and may be distributed. Bus topologies interconnected end devices using Ethernet hubs.

All three there may be only two devices connected on the Ethernet LAN, for example in two-interconnected routers. This would be an example of Ethernet used on a point-to-point topology.

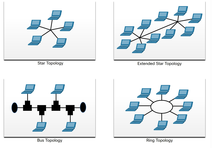
Legacy LAN Topologies

Early Ethernet and legacy Token Ring LAN technologies included two other types of topologies:

- **Bus** - All end systems are chained to each other and terminated in some form or another end. Infrastructure devices such as switches are not required to interconnect hosts. Ethernet LANs operated logically as a bus topology, regardless of the physical topology, because of the use of Ethernet hubs.
- **Ring** - Each end system connected to three respective neighbor topology Ring. The ring does not need to be terminated, unlike in the bus topology. Legacy Fiber Distributed Data Interface (FDDI) and Token Ring networks used ring topologies.

The figures illustrate how end devices are interconnected on LANs. It is common for a straight line to remaining graphics to represent an Ethernet LAN including a simple one and an extended star.

Physical Topologies



Half and Full Duplex Communication

Understanding duplex communication is important when discussing LAN topologies because it refers to the direction of data transmission between two devices. There are two common modes of duplex:

Half duplex communication

Both devices can transmit and receive on the media but cannot do so simultaneously. WLANs and legacy bus topologies with Ethernet hubs use the half duplex mode. Half duplex allows only one device to send or receive at a time on the shared medium. Click play in the figure to see the animation showing half duplex communication.

Full duplex communication

Both devices can simultaneously transmit and receive on the shared media. The data link layer assumes that the media is available for transmission for both nodes of a point-to-point circuit. Full duplex mode is the default duplex mode by default, but they can operate in half duplex if overcoming a device such as an Ethernet hub. Click play in the figure to see the animation showing full duplex communication.

In summary, half duplex communications restrict the exchange of data to one direction at a time. Full duplex allows the sending and receiving of data to happen simultaneously.

It is important that two interconnected interfaces, such as a host NIC and an interface on an Ethernet switch, operate using the same duplex mode. Otherwise, there will be a duplex mismatch creating inefficiency and delays on the link.

Access Control Methods

Ethernet LANs and WLANs are examples of multaccess networks. A multaccess network is a network that can have two or more end devices attempting to access the shared environment.

Some multaccess networks require rules to govern how devices share the physical media. There are two basic access control methods for shared media:

- Controlled based access
- Contention based access

Contention-based access

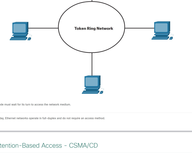
In contention-based multaccess networks, all nodes are operating in half duplex, competing for the use of the medium. However, only one device can send at a time. Therefore, there is a process in place that uses device transmits at the same time. Examples of contention-based access methods include the following:

- Carrier sense multiple access with collision detection (CSMA/CD) used on legacy bus topology Ethernet LANs
- Carrier sense multiple access with collision avoidance (CSMA/CA) used on Wireless LANs

Controlled access

In a controlled-based multaccess network, each node has its own time to use the medium. These deterministic types of legacy networks are inefficient because a device must wait its turn to access the medium. Examples of multaccess networks that use controlled access include the following:

- Legacy Token Ring
- Legacy ARCNET



Each node must wait for its turn to access the network medium.

Note: Today, Ethernet networks operate in full duplex and do not require an access method.

Contention-Based Access - CSMA/CD

Examples of contention-based access networks include the following:

- Legacy bus topology Ethernet LANs
- Legacy hub-topology Ethernet LANs (using CSMA/CD)
- Legacy Ethernet LAN using a hub (using CSMA/CD)

These networks operate in half duplex mode, meaning only one device can send or receive at a time. This requires a process to govern when a device can send and when hopefully when multiple devices send at the same time.

Ethernet LANs using hubs are now legacy networks. In the legacy Ethernet LANs, both devices will detect the collision on the network. This is the collision detection (CD) portion of CSMA/CD. The NIC computes stop transmitting until data received, or by recognizing that the signal amplitude is higher than normal on the media. The data sent by both devices will be corrupted and will need to be resent.

Click each button for an image and description of the CSMA/CD process in legacy Ethernet LANs that use a hub.

Step 1 | Step 2 | Step 3 | Step 4

PC1 has an Ethernet frame to send to PC3. The PC1 NIC needs to determine if any device is transmitting on the medium. If it does not detect a carrier signal (in other words, it is not receiving transmissions from another device), it will assume the network is available to send.

The PC1 NIC sends the Ethernet frame when the medium is available, as shown in the figure.

Contention-Based Access - CSMA/CA

Another form of CSMA used by IEEE 802.11 WLANs is carrier sense multiple access/collision avoidance (CSMA/CA).

CSMA/CA uses a method similar to CSMA/CD to detect if the media is clear. CSMA/CA uses additional techniques, to wireless environments it may not be possible for a device to detect a collision. CSMA/CA does not detect collisions but attempts to avoid them by adding before transmitting. Each device that transmits includes the length of time it will need to transmit in the header of the frame. All devices on the network receive this information and know how long the medium will be in use.

In the figure, S has a frame to deliver to D. Before S sends the frame, it sends a broadcast message to all devices that it will need to use the medium for a specific amount of time. Now all devices know that the medium will be unavailable for a specific amount of time and it cannot send.

After a wireless device sends an 802.11 frame, the receiver returns an acknowledgment so that the sender knows the frame arrived.

Whether it is an Ethernet LAN using hubs, or a WLAN, contention-based systems do not scale well under heavy media use.

Note: Ethernet LANs using switches do not use a contention-based system because the switch and the hosts NIC operate in full duplex mode.

Check Your Understanding - Topologies

Check your understanding of topologies by choosing the BEST answer to the following questions.

1. Which topology displays interlocking device legs IP addresses?
   - serial topology
   - IP address topology
   - logical topology
   - physical topology
2. What kind of network would use point to point, hub and spoke, or mesh topologies?
   - WAN
   - LAN
   - WLAN
   - WAN
3. Which LAN topology is a hybrid topology?
   - Bus
   - extended star
   - ring
   - star
4. Which duplex communication method is used in WLANs?
   - half duplex
   - full duplex
   - simplex
5. Which media access control method is used in legacy Ethernet LANs?
   - carrier sense multiple access/collision avoidance
   - carrier sense multiple access/collision avoidance
   - carrier sense multiple access/collision detection
   - carrier sense multiple access/collision detection

Check | Show Me | Reset