[For MCA/BCA Vocational]

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Network Topologies

Introduction

You should now be familiar with foundational network communication concepts. You have seen the technology required to create computer networks and discussed the reasons that network communication is an effective solution to a variety of problems. You have also seen and discussed the role of network servers and workstations, and the different classifications of networks. In this section, you learn about network topologies. To understand the idea of network topology, you were first introduced to general network concepts like communication models, network types, and network operating systems. In this section, you learn in greater detail networking concepts you need for understanding

- How a network is laid out
- How data transmission is controlled on a network
- The role of media access schemes
- The topology of the two most common networks:
- Token ring
- Ethernet

What is a Topology?

A network topology is a pictorial representation of the layout of a network. Have you ever sketched a map for someone to tell them how to get somewhere, or created a floor plan of a house so you could get a better idea of how space is used? These types of drawings are topologies. In simple terms, a topology is a pictorial representation of the layout of something.

Types of Network Topologies

Network topologies have two aspects:

- A physical topology
- A logical topology

Physical Topology

Let's use the street layout idea to begin to explain physical topology. If you had to plan the layout of the streets for a growing town, what kinds of things would you consider? Among other things, you would make sure that all areas of town, both residential and business, are connected by the streets. You want to make sure that everyone has access to every part of town. Computer networks must also be connected so that every computer has access to the entire network.

Logical Topology

When you plan the way traffic flows along the streets you laid out, what kinds of things do you consider? You would certainly consider which streets would carry the most traffic. From there you would consider which intersections need stop signs and which need traffic lights. Perhaps some of your streets need to be one-way, some need to carry 2 lanes of traffic, and others 4 or more. You also have to consider which side of the road cars will travel on. These are all considerations belonging to logical topology. As shown in the following figure, the physical topology accommodates the various options for the logical topology.

Physical Network Topologies

A physical network topology defines how network devices are connected. To understand how a network is laid out, you need to understand the following:

- Hardware specific to physical topologies
- Physical bus topologies
- Physical star topologies
- Physical ring topologies

Hardware Specific to Topologies

Cables, servers, and workstations are part of a physical network topology. You also need to know about two other components used in a network: hubs and repeaters.

Hubs

Hubs provide a common physical connection point for network devices. A hub is a single device that can be used for connecting many workstations to the network, as illustrated in the following figure.

Repeaters

Repeaters increase the distance over which a network signal can travel. As a signal travels though a cable it loses its strength due to resistance in the cable. This is overcome with the help of a repeater. When a repeater receives a weakening signal, it retransmits that signal at its original strength so the signal can arrive at its destination intact and undistorted. Most hubs have repeating capabilities built in.

Bus Topology

A physical bus network topology is a simple topology that uses one long cable, called a backbone. Short cables, called drop cables, can be attached to the backbone using T-connectors. The term bus, as it is used in electronics, has to do with transporting (bussing) signals from one point to another. You can remember the concept of a bus topology, because that’s really all it does. The backbone is terminated at both ends to remove the signal from the wire after it has passed all devices. One end must also be grounded. Most bus topologies allow electromagnetic signals to travel in both directions.

Points to Consider: Bus Topology

Installation. A bus topology is relatively easy to install. You string the backbone cable from site to site. Because the shortest route is typically chosen between each device, buses require less cable than other topologies. However, the electrical and physical properties of cable impose constraints on bus networks. Every physical bus topology must limit the number of connections and the distance between them to maintain a readable signal.

Reconfiguration. Because most bus topologies are laid out to minimize the required amount of cable and to maintain the required distance between taps, reconfiguration tends to be moderately difficult. When the acceptable number of connections is reached, the backbone must be moved, modified, or replaced.

Ring Topology

The ring topology is a circle-like topology (or closed loop of point-to-point links). Each device connects to the ring or through a device, like a hub, and a cable. The feature that makes it a ring topology is that the layout is essentially a closed loop, rather than being ring-shaped.

Points to Consider: Ring Topology

Installation. Ring topologies are moderately simple to install. Because the ring requires a closed loop, more cabling is required than with bus networks. As with bus topologies, you must not exceed the maximum acceptable distance between repeating devices.

Reconfiguration. Ring networks become harder to reconfigure as the scale of relocations increases. Ring segments must be divided (or replaced with two new segments) each time a segment is changed. Rings are limited by a maximum ring length and number of devices.

Star Topology

Star topologies use a central device with drop cables extending in all directions. Each device is connected through a point-to-point link to the hub. In star topologies, electric or electromagnetic signals travel from the networked device up its cable to the hub. From there the signal is sent to other networked devices.

Points to Consider: Star Topologies

Installation. Star topologies are moderately difficult to install. The design of the network is simple, but you must install a separate media segment for every arm of the star. Cabled star topologies require more cabling than most other topologies.

Reconfiguration. Star topologies are relatively easy to reconfigure. Moves, adds, and changes do not involve more than the connection between the changed networked device and a hub port.

Logical Network Topologies

After planning the physical layout of a network, you must consider the logical use of that layout. There are two commonly used logical topologies:

- Bus
- Ring

Recall the different ways that traffic can flow on a system of streets as an example of a logical topology. The logical topology of a network is, in essence, a strategy for directing signal flow. Another way of looking at it is that logical topology is the set of traffic rules that keeps electronic signals traveling on the network cabling in an orderly fashion. This traffic metaphor is a very valid way of looking at logical topology. As you will see, the terms network traffic and collisions are commonly used in networking terminology. Logical topologies are a necessary aspect of networking because electrical signals must be kept separate and distinct from each other, to keep them from colliding and distorting each other. The devices that send the signals also must be kept in order. Devices must be told to take turns, or to watch for an opening in network traffic before sending out their messages.

Logical Bus Topology

In a logical bus topology, devices generate signals and send them throughout the network, regardless of the location of the intended receiver, as illustrated in the following figure. A logical bus topology can only be used with the physical bus and the physical star topologies. The message sent to all devices in a logical bus topology contains information that says which device is to receive the message. The device that is supposed to receive the message receives it. Other devices ignore it. A logical bus topology is necessary because network devices are not aware of other devices' physical locations. You cannot give a device "directions" for sending messages directly to other devices. For example, a device cannot know that another device is located "three nodes south, on the left." So, a device must send the message to all directions. Then each device determines if the message was meant for that device.

Logical Ring Topology

In a logical ring topology, the signal is generated and travels along a specified path in a single direction:

The logical ring topology can be used with the physical ring and physical star topologies. The difference between the logical ring and the logical bus is that signals sent in a logical bus go in all directions. Signals sent in a logical ring can only go in one direction. A physical star topology can handle a logical ring topology because signals come in to the hub and are sent back out again to network devices in a predetermined order:

Media Access Schemes

A media access scheme is a set of rules that directs the signals sent over network transmission media.There are three types of media access schemes:

- Contention
- Token passing
- Polling

As you know from traffic rules that regulate vehicle traffic, controlling the direction of traffic flow is not enough to keep the streets safe. For example, at busy intersections traffic lights and stop signs keep vehicles from being in the same place at the same time. Being in the same place at the same time causes vehicles to collide. In the same way, being on network transmission media at the same time causes electronic network signals to collide. Therefore, a media access scheme (a set of rules for network traffic control) needs to be in place to control when network devices are allowed to transmit data signals. If network devices operate without a media access scheme, devices transmit whenever they are ready. Sometimes they transmit at the same time. Signals combine and become damaged to the point that the signal data is lost. This is called a collision, and it destroys effective network communications. You cannot operate a network unless you can control or eliminate the effects of collisions.

Contention-Based Schemes

Contention-based access schemes allow network devices to transmit data whenever they want, regardless of other devices on the network. This scheme is simple and provides equal access rights to all stations. Unfortunately, the “transmit whenever ready” strategy has one important shortcoming: Stations sometimes transmit at the same time. When this happens, the result is a co- mingling of signals and information is lost. Contention-based access schemes call for stations to listen to the channel before transmitting. If the listening station detects a signal, it refrains from transmitting and tries again later. These are called CSMA (Carrier Sense, Multiple Access) schemes. They reduce collisions, but collisions still occur if two stations sense the cable, detect nothing, and subsequently transmit data at the same time. Therefore, this type of scheme must also be able to detect a collision. If a collision is detected, the signal is sent again. You will see these referred to as CSMA/CD protocols (meaning CSMA with collision detection). Contention-based schemes handle average network traffic conditions very well but lose performance when network traffic gets heavy and more collisions occur.

Token-Passing Schemes

In token-passing schemes, an electronic signal (the token) is passed from one device to another. A token is a special message that temporarily gives media access control to the device holding the token. Passing the token around distributes access control among the network’s devices. Each device knows which device it receives the token from and which device it should pass the token to. Each device periodically gets control of the token, transmits its data, and then retransmits the token for the next device to use. Protocols limit how long each device can control the token. Token-passing schemes work with physical ring and physical star topologies. Token-passing schemes do not allow contention. One token exists on the media as devices take turns using the media. Under average traffic conditions, token- passing is slower than contention-based access schemes, but under heavy traffic conditions it performs better.

Polling Schemes

Polling is an access scheme that designates one device (called a controller, primary, or master) as a media access administrator. This device queries all other devices (referred to as secondaries) in a predetermined order to determine whether they have information to transmit. The following figure shows the relationship of primary and secondary devices. This access scheme is analogous to a classroom in which the teacher goes from student to student in a predetermined order. The teacher asks each student to speak for a preset amount of time and then moves on to the next student. The teacher is the primary and the students are the secondaries in this example.

Token Ring Networks

Token ring networks combine physical star and logical ring topologies with the token-passing media access scheme. This is a popular network configuration. When a station wants to transmit on the ring, it waits for a free token to pass. When it does, this source station takes the free token and adds data to it. The station then sends the token out on the ring. As the now busy token is passed to each active station around the ring, each station checks to see which station the token is intended for. If a station is not the recipient of the token, it re-sends the token along the ring. If a station is the recipient, it copies the data that the source station added to the token. Then it adds data to the token to indicate that it has recognized the address and copied the data. It then sends the altered token out to the ring. The token continues around the ring until it reaches the source station. When the source sees that the data has been received and copied, it generates a new free token, which it passes to the next active station on the ring. One token is allowed to be on a ring at a time.

Ethernet Networks

Ethernet is a popular network topology standard that uses logical bus topology and can be laid out in either a physical bus or physical star topology. Ethernet uses a contention-based access scheme. Ethernet moves messages around the network in packets of information that include the source station address, the destination station address, the type of data that must be moved, and the data itself. To send packets, a device on the network must first listen to see if any other device is using the cable. When the cable appears to be clear of traffic, the device sends its packets. If two devices are trying to transmit over the cable at the same time, the packets might physically collide with each other on the wire. The result can be damaged and unreliable packets. Ethernet expects some of these collisions and is prepared to handle them. When a collision occurs, a signal is sent to ensure that the collision has been recognized around the network. The devices competing for the cable’s bandwidth retransmit, but they delay their retransmission by a random amount of time to ensure that collisions are eliminated. When devices become aware of a packet on the wire, they check to make sure the packet is not a fragment of a packet that has been damaged by a collision. If it is a whole packet, the devices check the address. A packet addressed to a device is checked for integrity by that device before it is processed.

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