Chapter 3

Local Area Networks: Topologies and Architectures

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LAN Topologies

- A LAN's **topology** is its basic layout
- Each LAN has a *physical topology*
  - Defines configuration of cables, computers, printers, and other devices on the network
- Each LAN also has a *logical topology*
  - Defines the conceptual layout of the network, or the way data travels through it

LAN Topologies

- **Bus Topology**
  - Comprised of a shared network medium, to which network devices are attached
  - Every device on the network receives every transmission

LAN Topologies

- **Star Topology**
  - Features a centralized device that provides connectivity to all other network hosts
  - All data transmissions on the network flow through the centralized device

LAN Topologies

- **Example:** Ethernet network wired with Thicknet
  - All devices on the network are attached to the same network medium (the Thicknet cabling)
  - All data transmissions flow through the Thicknet cabling, and therefore are received by every host on the network

LAN Topologies

- **Example:** Ethernet network wired with Thicknet
  - **Physical Bus Topology**
  - **Logical Bus Topology**

LAN Topologies

- **Example:** Ethernet network wired with UTP and a **hub**
  - All devices on the network are attached to the hub (a centralized device)
  - All data transmissions received by the hub are **broadcast** to every host on the network

LAN Topologies

- **Example:** Ethernet network wired with Thicknet
  - **Physical Star Topology**
  - **Logical Bus Topology**

LAN Topologies

- **Example:** Ethernet network wired with UTP and a **switch**
  - All devices on the network are attached to the switch (a centralized device)
  - All data transmissions received by the switch are **filtered**, and sent only to the intended recipient

LAN Topologies

- **Example:** Ethernet network wired with Thicknet
  - **Physical Star Topology**
  - **Logical Star Topology**
- There are inherent advantages and disadvantages to using star topology

LAN Topologies

- **Ring Topology**
  - All network hosts are connected in a closed loop
  - All data transmissions on the network flow from device to device unidirectionally

LAN Topologies

- **Ring Topology**
  - A network with a *logical ring topology* may have:
    - A *physical ring topology*, where each host is physically connected to the previous one and to the next one
    - A *physical ring topology*, where each host is connected to a centralized device that routes data around the ring

LAN Topologies

- **Wireless Network Topologies**
  - All devices use the same radio frequencies (**logical bus**)
  - All devices must connect to the WAP (**physical star**)

LAN Architectures

- A LAN's **architecture** defines the way data access network media, and the structure of the frames placed on the network media
- Each architecture has an **access method**

LAN Architectures: **Ethernet**

- Most popular architecture in modern LANs
  - Reliable
  - Easy to implement
  - Cost-effective
  - Widespread industry and technical acceptance

LAN Architectures: **Ethernet**

- Invented by Bob Metcalfe, who was working at Xerox PARC and finishing his Ph.D. at Harvard
- Inspired by the Alohanet RF network at the University of Hawaii
- Hosts couldn't tell if another host was trying to transmit, so they just transmitted; this resulted in **collisions**

LAN Architectures: **Ethernet**

- Ethernet standards are in the IEEE 802.3 family
- Access method: **CSMA/CD**
  - **Carrier Sense:** Ethernet host "listens" to the network media, and only attempts to transmit data when no other hosts are transmitting

LAN Architectures: **Ethernet**

- Access method: **CSMA/CD**
  - **Multiple Access:** Two or more hosts might try to access the network media at the same time
  - **Collision Detection:** If two hosts try to transmit at the same time, the transmissions will collide, and therefore the senders must be notified of the need to re-send

LAN Architectures: **Ethernet**

- Maximum segment size: 100 meters
  - Longest allowable length of Cat 5 cabling
  - Hosts must receive collision notification in a timely fashion

LAN Architectures: **Ethernet**

- Maximum network span: 205 meters
  - Physical distance between farthest-removed network hosts
  - This distance can be extended by creating multiple segments, using bridges and/or switches (discussed next chapter)

LAN Architectures: **Token Ring**

- Standards in the IEEE 802.5 family
- Once a viable alternative to Ethernet
- Provided 16 Mbps at the height of its popularity, at a time when Ethernet could only provide 10 Mbps
- Promised a *deterministic* (predictable) wait for network access

LAN Architectures: **Token Ring**

- No data collisions
- Eventually eclipsed by Fast Ethernet (100 Mbps) in the mid 1990s, and then again by Switched Ethernet

LAN Architectures: **Token Ring**

- Access Method: **Token Passing**
  - There exists a special frame of data called the **free token**, which travels around the ring from device to device
  - When the free token reaches a device that wants to transmit data, it modifies the token and places data on the ring

LAN Architectures: **Token Ring**

- Access Method: **Token Passing**
  - The recipient acknowledges receipt of the data by reverting the token to its original state
  - Collisions, therefore, do not occur

LAN Architectures: **Token Ring**

- Early implementations used a centralized device called a **multi-station access unit (MSAU)** through which all data passed
- Token Ring networks had a self-recovery process called **beaconing**, which let other hosts know if there was a failure on the ring

LAN Architectures: **Wireless**

- There are two kinds of wireless networks
  - WLAN: Wireless Local Area Network
  - WPAN: Wireless Personal Area Network

LAN Architectures: **WiFi** (IEEE 802.11)

- IEEE WLAN SWG first started working on WLANs in 1990
- They originally targeted the 2.4 GHz frequency spectrum, which was unlicensed at the time
- First standard was released in 1997: 1 or 2 Mbps @ 2.4 GHz

LAN Architectures: **WiFi** (IEEE 802.11)

- IEEE 802.11a (1999): 54 Mbps @ 5 GHz
- IEEE 802.11b was also published in 1999: 5.5 Mbps or 11 Mbps in the 2.4 GHz range
- IEEE 802.11g (2003): 54 Mbps @ 2.4 GHz
- IEEE 802.11n (pending): 248 Mbps @ 5 GHz

LAN Architectures: **WiFi** (IEEE 802.11)

- Access Method: **Distributed Coordination Function**
  - Any device that wants to transmit must first listen to the wireless channel to see if it's free
  - Channel must be free for a certain amount of time before the device transmits

LAN Architectures: **WiFi** (IEEE 802.11)

- Access Method: **Distributed Coordination Function**
  - The waiting helps avoid collisions; this **collision avoidance** reduces the need for full-duplex communication channels, since no data collision notification is necessary
  - Therefore, more data channels are available

LAN Architectures: **Bluetooth**

- IEEE 802.15 family of standards
- Originally conceived by Ericsson in 1994 as short-range wireless transmission service for mobile phones and accessories (**WPAN**)
- Bluetooth SIG formed in 1998 by IBM, Intel, Nokia, Toshiba, and Ericsson

LAN Architectures: **Bluetooth**

- First Bluetooth headset sold in 2000
- Access Method: Creation of a **Piconet**
  - First device becomes the Master
  - Devices added to the Piconet after the Master become Slaves

LAN Architectures: **Bluetooth**

- Access Method: Creation of a **Piconet**
  - Master device controls all communication, so there are no collisions
  - One device can join two Piconets, forming a Scatternet

LAN Architectures: **Wireless**

- **Security**
  - Because data transmissions are broadcast over radio frequencies, eavesdroppers can intercept entire transmissions
  - This creates a need for **encryption**
  - **Firewalls** are also used to protect networks

LAN Architectures: **Wireless**

- **Encryption Protocols**
  - Wired Equivalency Protection (**WEP**) provides basic encryption protection
  - WiFi Protected Access (**WPA**) defines enhanced security protocols
  - Robust Security Network (**RSN**) uses advanced authentication techniques and Advanced Encryption Standard (**AES**) to guarantee legitimacy of WLAN users

LAN Architectures: **FDDI**

- FDDI stands for **Fiber-Distributed Data Interface**
- Older technology that is still used in many places
- Once a common way to connect remote LANs
- Standards from ANSI X3T9 committee, with names like X3.139-1987 and X3.148-1988

LAN Architectures: **FDDI**

- Access Method: **Timed-Token Token Passing**
  - Host that wants to transmit waits for token
  - When token arrives, host has length of **token holding time** (usually around 5 msec) to transmit data

LAN Architectures: **FDDI**

- Access Method: **Timed-Token Token Passing**
  - Host ***must*** re-transmit token when token holding time runs out
  - This guarantees that every device gets a chance to transmit, even on a busy network

LAN Architectures: **FDDI**

- Uses a **dual-counter-rotating ring topology**
  - Some hosts are **dual-access stations**
- Total fiber length must be less than 200 meters

LAN Architectures: **ATM**

- ATM stands for **Asynchronous Transfer Mode**
- Provides high speed and low *latency* on networks that require reliable and timely data delivery
- ATM is generally reserved for network **backbones**, WANs, and carrier services

LAN Architectures: **ATM**

- Access Method: **None**
  - ATM sets up a *switched* point-to-point connection between two communicating devices before any data are transferred
  - ATM is *connection-oriented*, and requires no shared access to the network medium
  - ATM uses *virtual-circuit* identifiers rather than MAC addresses

LAN Architectures: **ATM**

- Access Method: **None**
  - Hosts must be connected to an ATM *switch* (as discussed in Chapter 4)
  - ATM uses **Quality of Service (QoS)** to establish transmission priorities