

Introduction to WANs

WAN Technology Concepts

Purpose of WANs

- A WAN operates beyond the geographic scope of a LAN
- WANs are used to interconnect the enterprise LAN to remote LANs in branch sites and telecommuter sites
- A WAN is owned by a service provider whereas a LAN is typically owned by an organization
- An organization must pay a fee to use the WAN service provider's network services to connect remote sites
- Service providers provide links to interconnect remote sites for the purpose of transporting data, voice, and video

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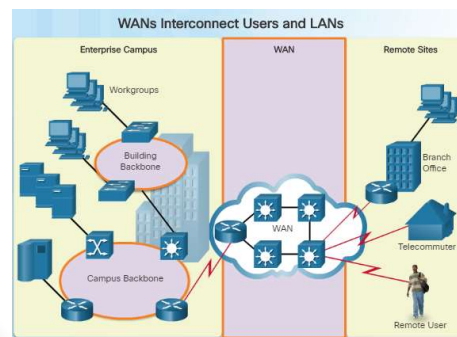
What is a Wide Area Network?

- A WAN is a data communications network that operates beyond the geographic scope of a LAN
- Typically, a **WAN** consists of two or more local-area **networks** (LANs)
- WANs
 - Connect devices that are separated by a broader geographical area than a LAN
 - Use public networks or carriers such as phone companies, cable companies, network providers
 - Use serial connections of various types to provide bandwidth over a larger geographic distance

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Purpose of WANs



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What is a Wide Area Network?

- Unlike a MAN, a WAN is not restricted to a geographical location, although it might be confined within the bounds of a state or country
- A WAN connects several LANs, and may be limited to an enterprise (a corporation or an organization) or accessible to the public
- The Internet is an example of a worldwide public WAN

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Purpose of WANs

- Without WANs, LANs would be a series of isolated networks
- As organizations expand, businesses require the ability to communicate between geographically separated sites. For example:
 - Regional or branch offices of an organization need to be able to communicate and share data with the central site
 - Organizations need to share information with other customer organizations
 - Employees who travel on company business frequently need to access the corporate network
- In addition, consumers now commonly communicate over the Internet with banks, stores, and other providers of goods and services

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WAN Topologies

- A network topology is a description of the network layout or arrangement.
- Applying the concept of topologies to WANs involves two different but interrelated perspectives
 - Physical Topology** - describes the physical arrangement of network devices that allow for data to move from a source to a destination network
 - Logical topology**- describes how data moves over the WAN.
- Interconnecting multiple sites across WANs can involve a variety of service provider technologies and WAN topologies

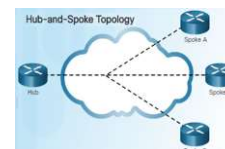
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WAN Topologies

2. Hub-and-Spoke/Point-multipoint

- Applicable when a private network connection between multiple sites is required
- A single interface to the hub can be shared by all spoke circuits
- Spoke sites can be interconnected through the hub site using virtual circuits and routed sub-interfaces at the hub
- A hub-and-spoke topology is also an example of a **single-homed topology**



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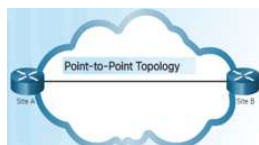
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WAN Topologies

- There are four Common WAN logical topologies

1. Point-to-Point topology

- Employs a point-to-point circuit between two endpoints
- Typically involves a dedicated leased-line connection such as a T1/E1 line
- A point-to-point connection is transparent to the customer network, as if there was a direct physical link between two endpoints
- Packets sent from one site are delivered to the other site and vice versa



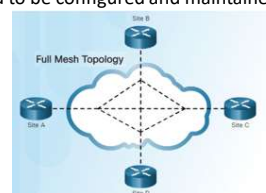
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WAN Topologies

3. Full Mesh

- A disadvantage of the hub-and-spoke topology is that all communication has to go through the hub
- With a full mesh topology using virtual circuits, any site can communicate directly with any other site.
- A disadvantage is the large number of virtual circuits that need to be configured and maintained.



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WAN Topologies

Disadvantage of point-to-point topology

- If a private network connection between multiple sites is required, a point-to-point topology with multiple point-to-point circuits could be used but would be too expensive
 - ✓ Each point-to-point circuit requires its own dedicated hardware interface that will require multiple routers with multiple WAN interface cards
- Since this interface can be expensive, a less expensive option is a **point-to-multipoint topology**, also known as a **hub-and-spoke topology**

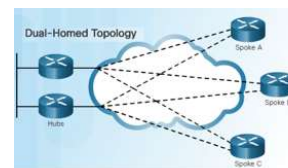
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WAN Topologies

4. Dual-homed Topology

- Provides redundancy and load balancing however they are more expensive to implement than single-homed topologies
- Requires additional networking hardware including routers and switches
- More difficult to implement since they require complex configurations



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WANs and the OSI Model

- WAN operations focus primarily on the **physical** and **data link layers** of the OSI Model
- However, this does not mean that the other five layers of the OSI model are not found in a WAN
 - It simply means that the characteristics that separate a **WAN** from a **LAN** are typically found at the **physical layer** and the **data link layers**
- WAN access standards typically describe both physical layer delivery methods and data link layer requirements
- Layer 1 protocols describe how to provide electrical, mechanical, operational, and functional connections to the services of a communications service provider
- Layer 2 protocols define how data is encapsulated and the mechanisms for transferring the resulting frames
 - i.e. physical addressing, flow control, and encapsulation etc.

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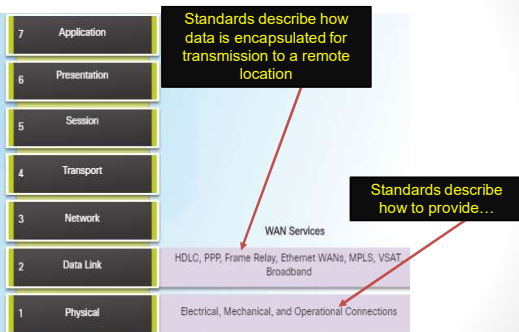
Common WAN Terminology

1. Customer Premises Equipment (CPE)
 - Consists of the devices and inside wiring located on the enterprise edge connecting to a carrier link
 - The subscriber (that is, customer) either owns the CPE or leases the CPE from the service provider
 - A subscriber, in this context, is a company that arranges for WAN services from a service provider
2. Data communications equipment (DCE)
 - Consists of devices that put data on the local loop
 - Primarily provides an interface to connect subscribers to a communication link on the WAN cloud
 - Also called **data circuit-terminating equipment** by the Telecommunications Industry Association (ITU)
 - DTE is an Electronic Industries Alliance (EIA) term

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WANs and the OSI Model



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Common WAN Terminology

3. Data Terminal Equipment (DTE)
 - The customer devices that pass the data from a customer network or host computer for transmission over the WAN
 - The DTE connects to the local loop through the DCE
4. Demarcation Point (demarc)
 - A point established in a building or complex to separate customer equipment from service provider equipment
 - Physically, the demarcation point is the cabling junction box, located on the customer premises, that connects the CPE wiring to the local loop
 - It is usually placed for easy access by a technician
 - Demarc is the place where the responsibility for the connection changes from the user to the service provider

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Common WAN Terminology

- A primary difference between a WAN and a LAN is that a company or organization must subscribe to an outside WAN service provider to use WAN carrier network services
- A WAN uses data links provided by carrier services to access the Internet and connect the locations of an organization to each other, to locations of other organizations, to external services, and to remote users
- The WAN access **physical layer** describes the physical connection between the **company network** and the **service provider network**

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Common WAN Terminology

4. Demarcation Point (demarc)
 - When problems arise, it is necessary to determine whether the user or the service provider is responsible for troubleshooting or repair
5. Local Loop
 - The actual copper or fiber cable that connects the CPE to the CO of the service provider
 - The local loop is also sometimes called the last-mile
6. Central Office (CO)
 - The CO is the local service provider facility or building that connects the CPE to the provider network

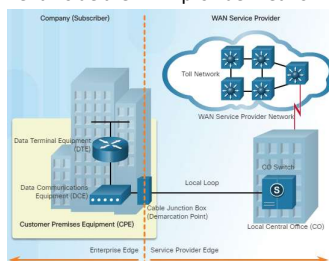
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Common WAN Terminology

7. Toll Network

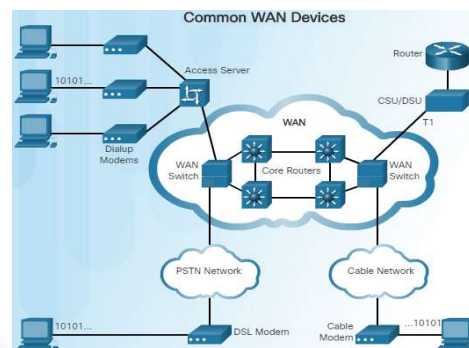
- Consists of the long-haul, all-digital, fiber-optic communications lines, switches, routers, and other equipment inside the WAN provider network



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Common WAN Devices



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Common WAN Devices

- Many types of devices are specific to WAN environment
 - Their choice or use depends on the WAN access technology chosen
- Dialup modem
 - Legacy WAN technology that converts (modulates) the digital signals produced by a computer into voice frequencies which are transmitted over the analog lines of the public telephone network to another modem for demodulation.
 - Broadband modem
 - A type of digital modem used with high-speed DSL or cable Internet service.
 - Both operate in a similar manner to the voiceband modem, but use higher broadband frequencies and transmission speeds

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WAN Operation

- WAN Switching be categorized as:
 - Circuit Switching or
 - Packet Switching

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Common WAN Devices

- Access server
 - Legacy technology where the server controls and coordinates dialup modem, dial-in and dial-out user communications.
- CSU/DSU
 - Digital-leased lines require a CSU and a DSU
 - The CSU provides termination for the digital signal and ensures connection integrity through error correction and line monitoring
 - The DSU converts line frames into frames that the LAN can interpret and vice versa
- Router
 - Provides internetworking and WAN access interface ports that are used to connect to the service provider.
- Core router/Multilayer switch
 - A router or multilayer switch that resides within the middle or backbone of the WAN

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WAN Operation Circuit Switching

- A circuit-switched network is one that establishes a dedicated circuit (or channel) between nodes and terminals before the users may communicate.
- Circuit switching dynamically establishes a dedicated virtual connection for voice or data between a sender and a receiver
- Communication can't start until the connection is established through the service provider network
- Dialing a number to make a call is an example of circuit switching technology
- The two most common types of circuit-switched WAN technologies are the public switched telephone network (PSTN) and the Integrated Services Digital Network (ISDN)

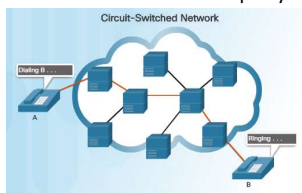
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WAN Operation Circuit Switching

Example

- The telephone system is called a circuit-switched network
- The dialed number is used to set switches in the exchanges along the route of the call so that there is a continuous circuit from the caller to the called party



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WAN Operation Packet Switching

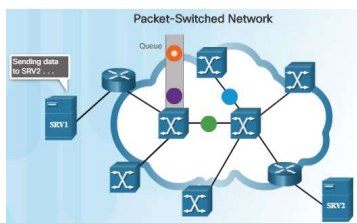
- Since the internal links between the switches are shared between many users, the **costs** of packet switching are **lower** than those of **circuit switching**
- Delays (latency) and variability of delay (jitter) are greater in packet-switched than in circuit-switched networks
 - Reason:** links are shared, and packets must be entirely received at one switch before moving to the next.
- Despite the latency and jitter inherent in shared networks, modern technology allows satisfactory transport of voice and even video communications on packet switched networks

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WAN Operation Packet Switching

- Unlike circuit switching, packet switching splits traffic data into packets that are routed over a shared network
- A circuit does not need to be established and many pairs of nodes can communicate over the same channel



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WAN Operation Packet Switching and virtual Circuits

- A virtual circuit (VC)- is a logical circuit created within a shared network between two network devices.
- Two types of virtual circuits:
 - Permanent Virtual Circuit (PVC)
 - Permanently established virtual circuit that consists of one mode: **data transfer**
 - Used in situations in which **data transfer** between devices is **constant**
 - Decreases the bandwidth use associated with establishing and terminating VCs, but they increase costs because of constant virtual circuit availability
 - Generally configured by the service provider when an order is placed for service

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WAN Operation Packet Switching

- There are two approaches to packet-switched network link determination:
 - Connectionless systems**
 - Full addressing information must be carried in each packet
 - Each switch must evaluate the address to determine where to send the packet
 - The Internet is an example of a connectionless system.
 - Connection-oriented systems**
 - The network predetermines the route for a packet, and each packet only has to carry an identifier
 - The switch determines the onward route by looking up the identifier in tables held in memory
 - The set of entries in the tables identifies a particular route or circuit through the system
 - An example of a connection-oriented system is Frame Relay (DLCIs are the identifiers)

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WAN Operation Packet Switching and virtual Circuits

- Switched Virtual Circuit (SVC)
 - Virtual circuits that are dynamically established on demand and terminated when transmission is complete
 - Communication over an SVC consists of three phases: **circuit establishment**, **data transfer**, and **circuit termination**
 - Used in situations in which **data transmission** between devices is **intermittent**
 - Greatly save on costs since the circuit is terminated once transfer has occurred

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