

THOMSON
COURSE TECHNOLOGY

Network+ Guide to Networks, Fourth Edition

Chapter 7 WANs, Internet Access, and Remote Connectivity

Objectives

- Identify a variety of uses for WANs
- Explain different WAN topologies, including their advantages and disadvantages
- Describe different WAN transmission and connection methods, including PSTN, ISDN, T-carriers, DSL, broadband cable, SONET, and wireless Internet access technologies
- Compare the characteristics of WAN technologies, including throughput, security, and reliability
- Describe the software and hardware requirements for remotely connecting to a network

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WAN Essentials

- Internet is largest WAN in existence
 - Most WANs arise from need to connect buildings
- WANs and LANs similar in fundamental ways
 - Differ at Layers 1 and 2 of OSI Model
- WANs typically send data over publicly available communications networks
 - Network service providers (NSPs)
 - Dedicated lines
- WAN link: connection between WAN sites (points)

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WAN Essentials (continued)

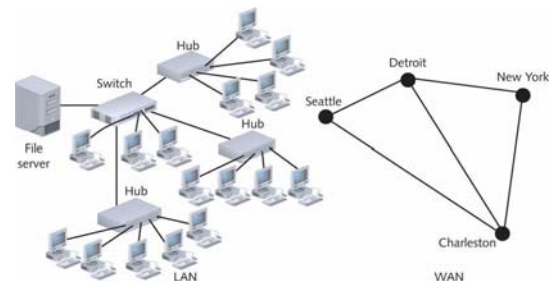


Figure 7-1: Differences in LAN and WAN connectivity

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WAN Topologies

- WAN topologies resemble LAN topologies
 - Details differ because of:
 - Distance they must cover
 - Larger number of users
 - Heavy traffic
- WAN topologies connect sites via dedicated and, usually, high-speed links
 - Requires special equipment
 - Links not capable of carrying nonroutable protocols

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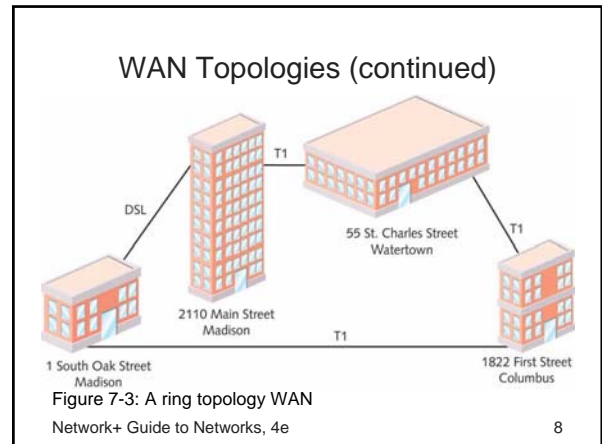
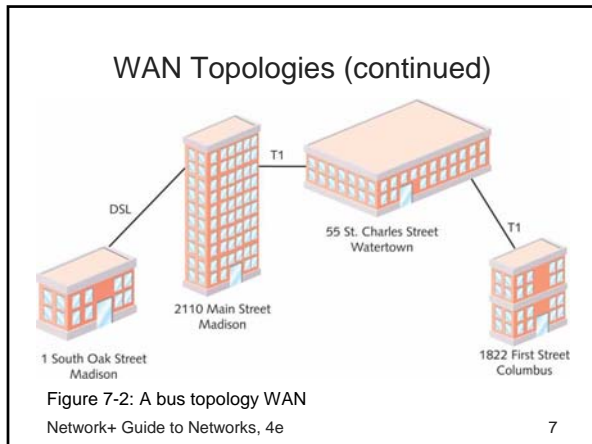
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WAN Topologies (continued)

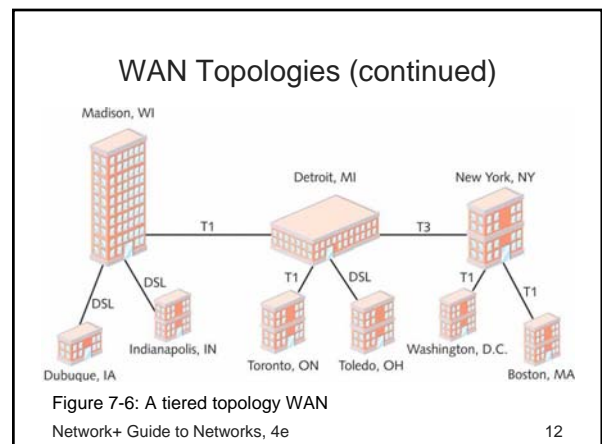
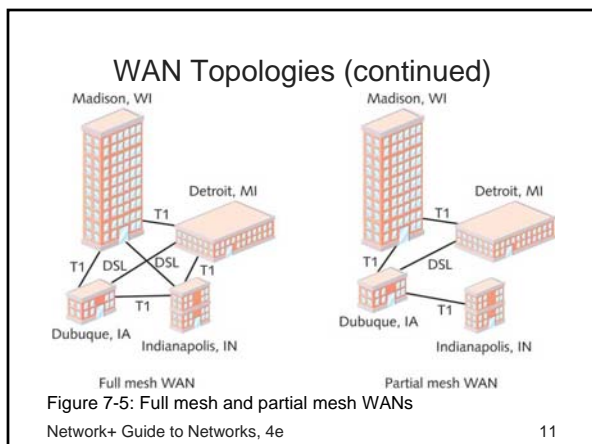
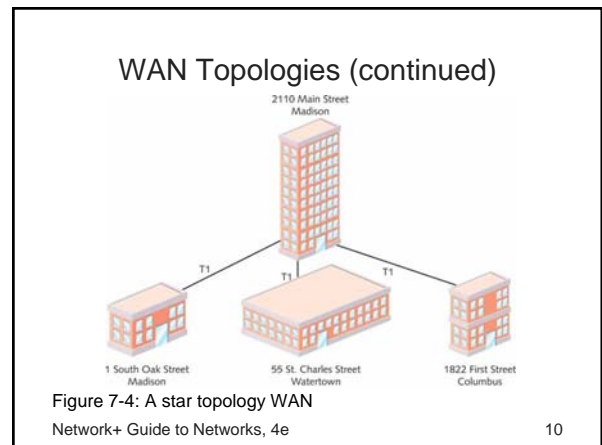
- Bus
 - Similar to bus LAN topology
 - Often best option for organizations with few sites and capability to use dedicated circuits
 - Dedicated circuits make it possible to transmit data regularly and reliably
- Ring
 - Similar to ring LAN topology
 - Usually use two parallel paths for data
 - Cannot be taken down by loss of one site
 - Only practical for connecting few locations

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- ### WAN Topologies (continued)
- Star
 - Separate routes for data between any two sites
 - Failure at central connection can bring down WAN
 - Mesh
 - Every site interconnected
 - Fault-tolerant
 - Full mesh WAN and partial mesh WAN
 - Tiered
 - Sites connected in star or ring formations interconnected at different levels
 - Highly flexible and practical
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PSTN

- Public Switched Telephone Network (PSTN) comprises entire telephone system
 - Traffic carried by fiber-optic and copper twisted-pair cable, microwave, and satellite connection
- Dial-up usually means connection using PSTN line
- Advantages: Ubiquity, ease of use, low cost
- Disadvantages: Low throughput, quality, marginal security

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PSTN (continued)

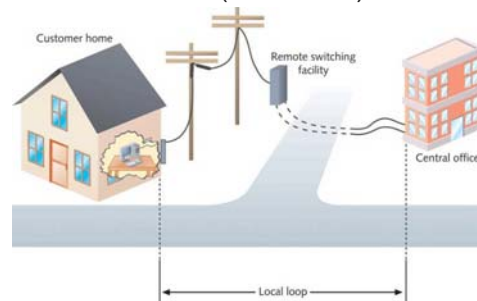


Figure 7-7: Local loop portion of the PSTN

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PSTN (continued)

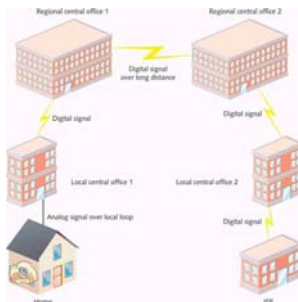


Figure 7-8: A long-distance dial-up connection

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X.25 and Frame Relay

- X.25: analog, packet-switched technology designed for long-distance data transmission
 - Specifies Physical, Data Link, Network layer protocols
 - Excellent flow control
 - Ensures data reliability over long distances
 - Comparatively slow
- Frame Relay: updated, digital version of X.25
 - Does not guarantee reliable delivery of data
 - Leaves error correction for higher-layer protocols

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X.25 and Frame Relay (continued)

- Switched virtual circuits (SVCs): connections established when parties need to transmit, then terminated after transmission complete
- Permanent virtual circuits (PVCs): connections established before data needs to be transmitted and maintained after transmission complete
 - Not dedicated, individual links
- Committed information rate (CIR): minimum bandwidth guaranteed by service provider
- With Frame Relay, pay only for bandwidth required
 - Throughput sensitive to network traffic

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X.25 and Frame Relay (continued)

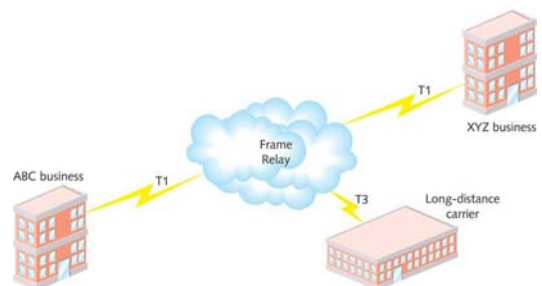


Figure 7-9: A WAN using frame relay

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ISDN

- International standard for transmitting digital data over PSTN
 - Specifies protocols at Physical, Data Link, Transport layers
 - Handle signaling, framing, connection setup and termination, routing, flow control, error detection and correction
 - Dial-up or dedicated connections
 - Carries voice calls and data simultaneously on one line
- B channel and D channel

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ISDN (continued)

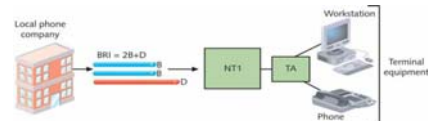


Figure 7-10: A Basic Rate Interface (BRI) link

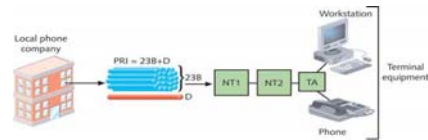


Figure 7-11: A Primary Rate Interface (PRI) link

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T-Carriers

- Standards specify method of signaling
 - Belong to Physical layer
 - Use time division multiplexing (TDM) over two wire pairs
 - Divide single channel into multiple channels

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Types of T-Carriers

Signal Level	Carrier	Number of T1s	Number of Channels	Throughput (Mbps)
DS0	—	1/24	1	.064
DS1	T1	1	24	1.544
DS1C	T1C	2	24	3.152
DS2	T2	4	96	6.312
DS3	T3	28	672	44.736
DS4	T4	168	4032	274.176

Table 7-1: Carrier specifications

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T-Carrier Connectivity

- Lines require connectivity hardware at customer site and local telecommunications provider's switching facility
- Wiring:
 - UTP, STP, coaxial cable, microwave, or fiber-optic
 - STP preferable to UTP (repeaters generally required)
 - For multiple T1s, coaxial, microwave, or fiber-optic required
 - For T3s, microwave or fiber-optic necessary

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T-Carrier Connectivity (continued)

- Channel Service Unit/Data Service Unit (CSU/DSU):
 - Connection point for T1 line at customer's site
 - CSU provides termination for digital signal
 - Ensures connection integrity through error correction and line monitoring
 - DSU converts T-carrier frames into frames LAN can interpret and vice versa
 - Connects T-carrier lines with terminating equipment
- Terminal equipment: Switches, routers, or bridges (may be integrated with CSU/DSU)

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T-Carrier Connectivity (continued)

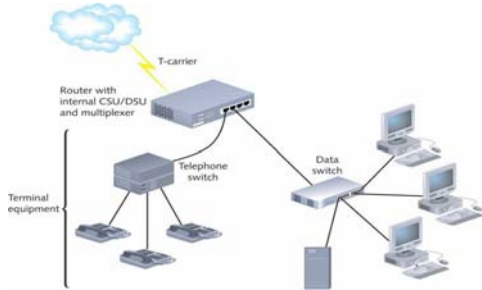


Figure 7-13: A T-carrier connection to a LAN through a router
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DSL

- Operates over PSTN
 - Best suited to local loop
 - Advanced data modulation techniques allow extraordinary throughput over telephone lines
 - Physical layer functions

Types of DSL

DSL Type	Maximum Upstream Throughput (Mbps)	Maximum Downstream Throughput (Mbps)	Distance Limitation (Feet)
ADSL "full rate"	1	8	18,000
G.Lite (a type of ADSL)	0.512	1.544	25,000
HDSL or HDSL-2	1.544 or 2.048	1.544 or 2.048	18,000 or 12,000
SDSL	1.544	1.544	12,000
SHDSL	2.36 or 4.7	2.36 or 4.7	26,000 or 18,000
VDSL	1.6, 3.2, or 6.4	12.9, 25.9, or 51.8	1000-4500

Table 7-2: Comparison of DSL types

DSL Connectivity

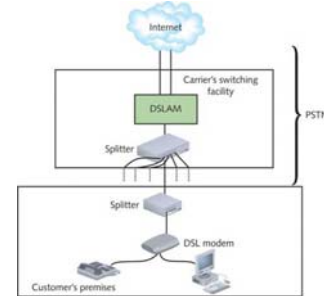


Figure 7-15: A DSL connection
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Broadband Cable

- Based on coaxial cable wiring used for TV signals
 - Asymmetrical
 - Requires cable modem
- Hybrid fiber-coax (HFC): expensive fiber-optic link that can support high frequencies

Broadband Cable (continued)

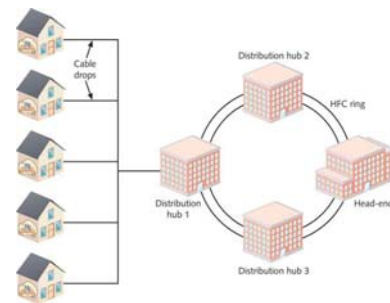
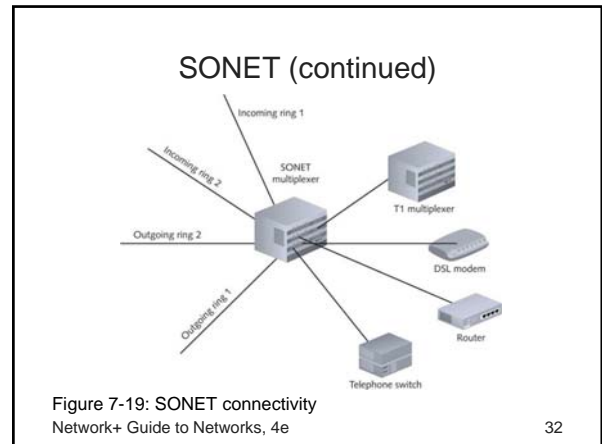
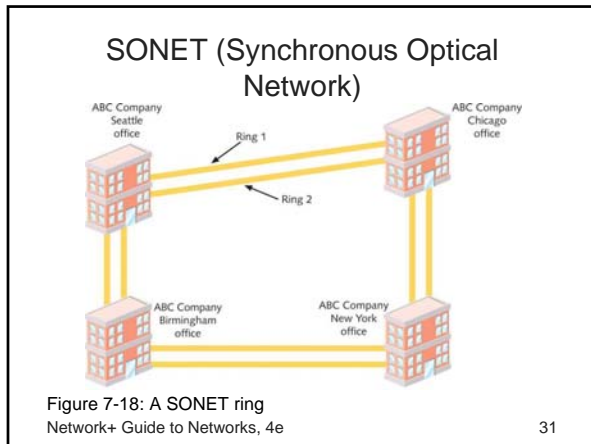


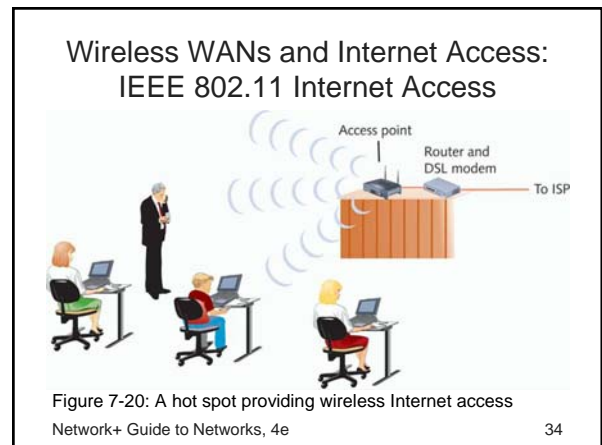
Figure 7-17: Cable infrastructure
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SONET (continued)

OC Level	Throughput (Mbps)
OC1	51.84
OC3	155.52
OC12	622
OC24	1244
OC48	2480
OC96	4976
OC192	9953
OC768	39,813

Table 7-3: SONET OC levels
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IEEE 802.16 (WiMAX) Internet Access

- Worldwide Interoperability for Microwave Access (WiMAX): IEEE 802.16a
 - Frequency ranges between 2 and 11 GHz
 - Up to 70 Mbps throughput
 - Potential option for rural and outlying areas

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Satellite Internet Access

- Satellite Orbits:
 - Geosynchronous orbit: satellites orbit earth at same rate as earth turns
 - Uplink: creation of communications channel for transmission from earth-based transmitter to orbiting satellite
 - Transponder receives uplink signal, transmits it to earth-based receiver in a downlink
 - Low earth orbiting (LEO) satellites cover smaller geographical area, require less power
 - Medium earth orbiting (MEO) satellites

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Satellite Internet Access (continued)

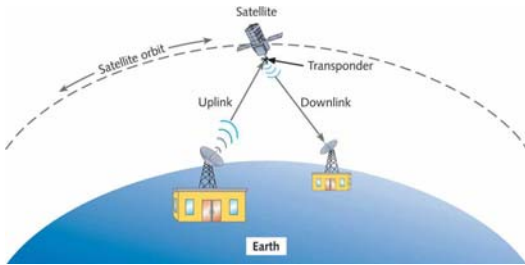


Figure 7-21: Satellite communication

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Satellite Internet Access (continued)

- Satellite frequencies:
 - L-band: 1.5 to 2.7 GHz
 - S-band: 2.7 to 3.5 GHz
 - C-band: 3.4 to 6.7 GHz
 - Ku-band: 12 to 18 GHz
 - Ka-band: 18 to 40 GHz
- Satellite Internet services:
 - Dial return arrangement: receive data via satellite downlink, send data via dial-up connection
 - Satellite return arrangement: send and receive data using satellite uplink and downlink

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Satellite Internet Access (continued)

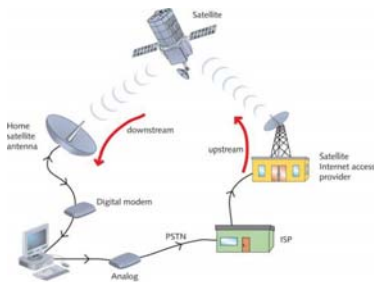


Figure 7-22: Dial return satellite Internet service

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WAN Technologies Compared

WAN Technology	Typical Media	Maximum Throughput
Dial-up over PSTN	UTP or STP	56 Kbps theoretical; actual limit is 53 Kbps
X.25	UTP/STP (DS1 or DS3)	64 Kbps or 2.048 Mbps
Frame Relay	UTP/STP (DS1 or DS3)	45 Mbps
BRI (ISDN)	UTP/STP (PSTN)	128 kbps
PRI (ISDN)	UTP/STP (PSTN)	1.944 Mbps
T1	UTP/STP (PSTN), microwave, or fiber-optic cable	1.544 Mbps
Fractional T1	UTP/STP (PSTN), microwave, or fiber-optic cable	n times 64 kbps (where n = number of channels leased)
T3	Microwave link or fiber-optic cable	45 Mbps
xDSL	UTP/STP (PSTN)	Theoretically, 1.544 Mbps–52 Mbps (depending on the type), but typical residential DSL throughputs are 1.5 Mbps or lower

Table 7-4: A comparison of WAN technology throughputs

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WAN Technologies Compared (continued)

WAN Technology	Typical Media	Maximum Throughput
Broadband Cable	Hybrid fiber-coaxial cable	Theoretically, 56 Mbps downstream, 10 Mbps upstream, but actual throughputs are approximately 1.5–3 Mbps upstream and 256–768 Kbps downstream
SONET	Fiber-optic cable	51, 155, 622, 1244, 2480, 4976, 9952, or 39813 Mbps (depending on the OC level)
IEEE 802.11b (Wi-Fi)	2.4 GHz RF	Theoretically, 11 Mbps; actual throughput is approximately 5 Mbps
IEEE 802.11g	2.4 GHz RF	Theoretically, 56 Mbps; actual throughput is approximately 20–25 Mbps
IEEE 802.16a (WiMAX)	2.4–11GHz RF	Up to 70 Mbps
Satellite – Dial Return	C- or Ku-band RF and PSTN	Advertised as 400 Kbps downstream (but often exceeds that); up to 53 kbps upstream
Satellite – Satellite Return	C- or Ku-band RF	Advertised as 400 Kbps downstream and upstream (but often exceeds that)

Table 7-4 (continued): A comparison of WAN technology throughputs

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Remote Connectivity: Dial-up Networking

- Dialing directly into private network's or ISP's remote access server to log on to a network
 - PSTN, X.25, or ISDN transmission methods
- Client must run dial-up software
 - Comes with virtually every OS
 - Credentials: typically user name and password
 - Authentication: server compares credentials with database
- Remote Access Service (RAS): Microsoft's dial-up networking software

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Remote Access Servers

- Routing and Remote Access service (RRAS): Microsoft's remote access software
 - Available with Windows Server 2003 NOS and Windows XP client OSs
 - Enables Windows Server 2003 computer to accept multiple remote client connections
 - Over any type of transmission path
 - Enables server to act as a router
 - Incorporates multiple security provisions

Remote Access Servers (continued)

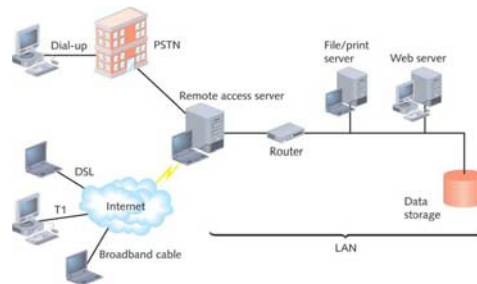


Figure 7-23: Clients connecting with a remote access server
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Remote Access Protocols

- Serial Line Internet Protocol (SLIP):
 - Carries only IP packets
 - Asynchronous transmission
- Point-to-Point Protocol (PPP):
 - Carries many types of Network layer packets
 - Performs error correction and data compression
 - Supports encryption
 - Synchronous or asynchronous transmission
- PPP over Ethernet (PPPoE): Standard for connecting home computers to ISP via DSL or broadband cable

Remote Access Protocols (continued)

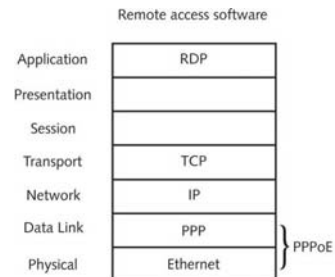


Figure 7-24: Protocols used in a remote access Internet connection
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Remote Control

- Allows remote user on client computer to control another computer (host) across a LAN or WAN
 - Host must be configured to allow access
 - Host may allow clients a variety of privileges
- Remote Desktop Software: For Windows OSs
 - Relies on Remote Desktop Protocol (RDP)
 - Application Layer protocol
- Simple to configure
- Can run over any type of connection

Terminal Services

- Popular method for gaining remote access to LANs
- Terminal server: computer running specialized software allowing it to act as a host
 - Supplies applications and resource sharing to remote clients
 - Allows multiple simultaneous connections
 - Optimized for fast processing and application handling
- Terminal services software: Microsoft Terminal Services, Citrix Metaframe
- Thin client: workstation using terminal services

Web Portals

- Web Portal: Secure, Web-based interface to an application
 - Places few requirements on client
- On host side, Web server supplies application to multiple users upon request
 - Application must be designed for Web-based access
- Requires secure transmission protocols

(VPNs) Virtual Private Networks

- WANs logically defined over public transmission systems
 - Traffic isolated from other traffic on same public lines
 - Required software usually inexpensive
 - Windows Server 2003 RRAS
 - Can be created by configuring special protocols on routers or firewalls connecting VPN sites
- Must consider interoperability and security
- Tunneling: create virtual connection (tunnel) between two VPN nodes

(VPNs) Virtual Private Networks (continued)



Figure 7-27: An example of a VPN

(VPNs) Virtual Private Networks (continued)

- Point-to-Point Tunneling Protocol (PPTP): encapsulates PPP so that any type of PPP data can traverse Internet masked as IP or IPX transmission
 - Developed by Microsoft
 - Supports encryption, authentication, and access services provided by Windows Server 2003 RRAS
- Layer 2 Tunneling Protocol (L2TP): Similar to PPTP
 - Accepted and used by multiple, different vendors
 - Can connect VPN using mix of equipment types

Summary

- WANs are distinguished from LANs by the fact that WANs traverse a wider geographical area
- Star topology WANs are more fault-tolerant than bus or ring WANs
- A mesh topology WAN consists of many directly interconnected sites
- A tiered topology WAN is one in which sites that are connected in star or ring formations are interconnected at different levels, with the interconnection points being organized into layers to form hierarchical groupings

Summary (continued)

- The PSTN is the network of lines and switching centers that provides traditional telephone service
- X.25 is an analog, packet-switched technology optimized for reliable, long-distance data transmission
- Frame Relay, like X.25, relies on packet switching, but carries digital signals
- Two types of ISDN connections are commonly used by consumers in North America: BRI and PRI

Summary (continued)

- T-carrier technology uses TDM to divide a single channel into multiple channels for carrying voice, data, video, or other signals
- DSL comes in eight different varieties, each of which is either asymmetrical or symmetrical
- Broadband cable is a dedicated service that relies on the cable wiring used for TV signals
- SONET is a high-bandwidth WAN signaling technique that specifies framing and multiplexing techniques at the Physical layer of the OSI Model

Summary (continued)

- WiMAX can achieve throughputs of up to 70 Mbps using the 2- to 10-GHz frequency range
- To exchange data, remote access servers and clients must communicate through special Data Link layer protocols, such as PPP or SLIP
- In terminal services, a special terminal server allows simultaneous LAN access for multiple remote users
- VPNs represent one way to construct a WAN from existing public transmission systems