

MIS 3360

Chapter 7: Wide Area Networks (WANs)

Figure 7-1: Wide Area Networks (WANs)

- WAN Purposes
 - Link geographically dispersed sites (usually) within the same corporation
 - Remote access for individuals who are off-site
 - Internet access for individuals or firms
- Site-to-Site Transmission within a Firm
 1. Private line networks
 2. Public switched data networks (PSDNs)
 3. Virtual Private Networks (VPNs)
 - Propagation over the Internet with added security
 - Low cost per bit transmitted

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Figure 7-1: Wide Area Networks (WANs), Continued

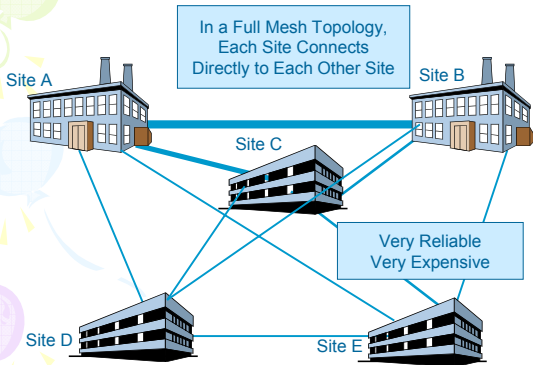
- Technologies for Individual Internet Access
 - a. Telephone modems
 - b. DSL lines
 - c. Cable modems
 - d. Wireless Internet access
- High Costs and Therefore Low Speeds
 - High cost per bit transmitted compared to LANs
 - Lower speeds (most commonly **56 kbps to a few megabits per second**)

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Site-to-Site: Private Line Networks for Voice and Data

- Three popular connection methods:
 - Private lines,
 - PSDN
 - Virtual private networks (VPN)
- Connect sites via private lines
 - User firm must do all the planning and installation
 - User firm must operate and maintain the network
 - Labor-intensive site-to-site networking ⁴

Full Mesh Topology (Figure 7-9)



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Private Line Speeds

Trunk Line	Speed	Medium
<i>North American Digital Hierarchy</i>		
56 kbps (DS0 Signaling)	56 kbps (sometimes 64 kbps)	2-pair DG* UTP
T1 (DS1 Signaling)	1.544 Mbps	2-pair DG* UTP
Fractional T1	128 kbps, 256 kbps, 384 kbps, 512 kbps, and 768 kbps	2-pair DG* UTP
Bonded T1s (multiple T1s acting like a single line)	Varies (usually up to 6 Mbps)	2-pair DG* UTP
T3 (DS3 Signaling)	44.7 Mbps	Optical Fiber

*DG = Data Grade

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Private Line Speeds, Cont'd

Trunk Line	Speed
CEPT Multiplexing Hierarchy (Europe)	
64 kbps	64 kbps
E1	2.048 Mbps
E3	34.4 Mbps
Japanese Multiplexing Hierarchy	
64 kbps	64 kbps
J1	1.544 Mbps (same as U.S. T1)
J3	32.1 Mbps
SONET/SDH*	
OC3/STM1	156 Mbps
OC12/STM4	622 Mbps
OC48/STM16	2.5 Gbps
OC192/STM64	10 Gbps
OC768/STM256	40 Gbps

Private Line Speeds, Continued

• Perspective

- Most the range of greatest demand for site-to-site transmission is 56 kbps to a few megabits per second
- So the largest market for private lines consists of T1 and fractional T1 lines or the equivalent in various countries

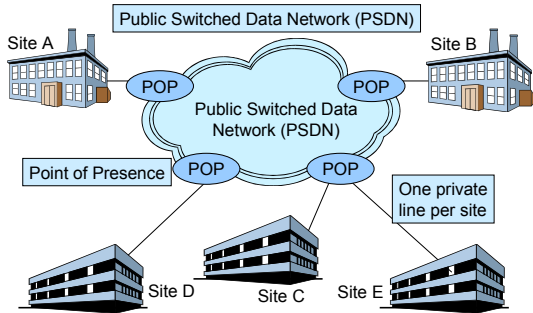
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Figure 7-11: Private Line versus Public Switched Data Networks, Continued

- Private Line Network
 - Company must plan, buy switching equipment, and operate the network. Requires much labor.
- Public Switched Data Network
 - PSDN carrier provides planning, switching, and operation of the network. This greatly reduces corporate management labor.
 - PSDN drawn as a cloud to indicate that users do not need to understand it because the PSDN handles all of the details.

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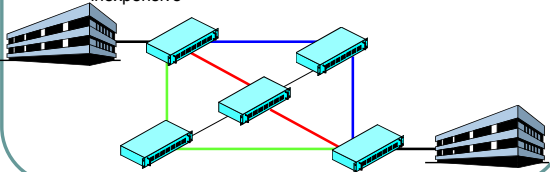
Figure 7-11: Private Line versus Public Switched Data Networks



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Figure 7-12: Virtual Circuit

- PSDN Switches Are Arranged in Meshes
 - Loops so multiple alternative paths between stations
 - Switches must consider alternative paths, making switching expensive
 - Virtual circuit is a single path (data link) between two stations
 - Set up before transmission begins, so switching is fast and inexpensive



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Figure 7-13: Frame Relay Network, Continued

- CSU/DSU
 - Channel service unit (**CSU**) protects the access line from unapproved voltage levels, etc. coming from the firm
 - Data service unit (**DSU**) converts between internal digital format and digital format of access link to Frame Relay network.
 - May have different baud rate, number of states, voltage levels, etc.



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Figure 7-13: Frame Relay Network, Continued

- Permanent Virtual Circuits (PVCs)
 - Set up once, kept in place for months or years
 - Between a firm's sites (which rarely change)
 - The most common form of virtual circuit today
- Switched Virtual Circuits (SVCs)
 - Set up at beginning of a communication session
 - Taken down at the end of the session
 - More expensive than PVCs, less common

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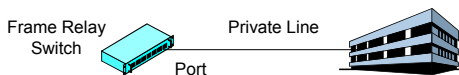
Frame Relay Network, Cont'd

- Frame Relay Pricing Recap
 - Frame relay access device at site (or router)
 - Private line from site to POP
 - 1. Port on the POP
 - Pay by port speed
 - **Usually the largest price component**
 - 2. Permanent virtual circuits (PVCs) among communicating sites
 - **Usually the second-largest component of prices**
 - Other charges

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Frame Relay Design, Continued

- Step 2: Determine the Port Speed Required
 - Vendors usually offer only a few options for port speeds



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Frame Relay Design, Continued

- Step 2: Determine Port Speed
 - Port speed must be equal to or greater than 70% of the sum of the PVCs
 - This is called oversubscription
 - 70% reflects the fact that not all PVCs will be at maximum speed all of the time
 - Pick the minimum port speed that is as high or higher than your need

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Example

- Three PVCs
 1. $1/8$ T1 = 0.193 Mbps
 2. $1/4$ T1 = 0.386 Mbps
 3. $1/3$ T1 = 0.515 Mbps
 - Sum of speeds is = 1.093 Mbps
- 70 percent is 0.766 Mbps
- Available port speeds are 0.7 Mbps and 0.8 Mbps
- **Choose: 0.8 Mbps**

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Frame Relay Design, Continued

- Some Frame Relay Vendors Use Multi-Tier Pricing
- Committed Information Rate (CIR)
 - Pretty much guaranteed
- Excess Burst Speeds
 - Faster bursts up to excess burst speeds are available if there is capacity
 - If there is congestion, frames beyond CIR are eligible to be discarded

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Asynchronous Transfer Mode (ATM)

- ATM is a faster PSDN than Frame Relay
 - Frame Relay: 56 kbps up to about 40 Mbps
 - ATM: 1 Mbps up to about 156 Mbps
 - Not Competitors. Most PSDN Vendors Offer Both to Customers
 - FR for low-speed customer needs
 - ATM for higher speeds (at higher prices)
 - As corporate demand grows, ATM may increase its market share

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ATM QoS

- Quality of Service
 - ATM provides strong QoS guarantees for **voice traffic** (latency, jitter, etc.)
 - However, ATM usually offers few or no QoS guarantees for data traffic – get what is left over after capacity reserved for voice QoS
- Manageability
 - Strong management tools (designed for the PSTN transport core)
 - So it is very expensive for small and medium firms

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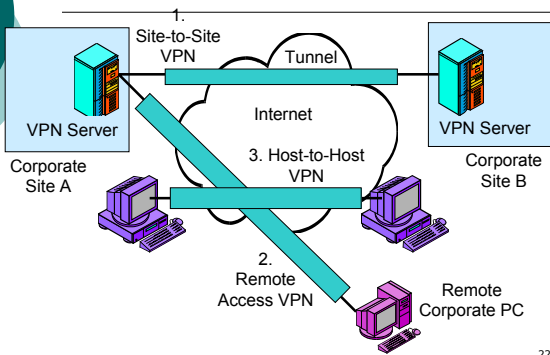
Virtual Private Network (VPN) Issues

Virtual Private Network (VPN)

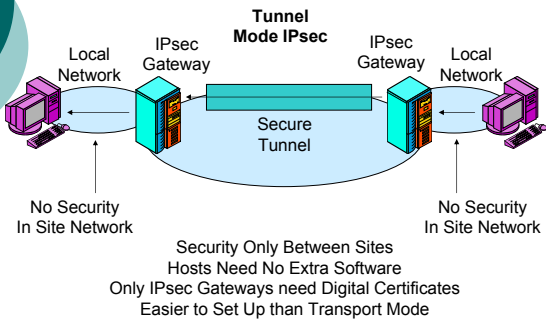
- Transmission over the Internet with added security
- Some analysts include transmission over a PSDN with added security
- Why VPNs?
 - Lower transmission cost per bit transmitted than PSDNs
 - Adequate security

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Virtual Private Network (VPN): Figure 7-16:



IPsec in Tunnel Mode



VPN Technologies, Continued

o IPsec

- For all types of VPN (remote access, site-to-site, host-to-host)
- Operates at the Internet layer
 - o Transparently protects traffic at all higher layers
- Very strong security
- Requires digital certificates for all computers
 - o Creating an infrastructure for certificates is expensive
 - o Installation and setup on individual client PCs is expensive

VPN Technologies

- SSL/TLS
 - Limited to remote access VPNs
 - SSL (Secure Sockets Layer) was its original name
 - IETF changed it to Transport Layer Security
 - Created to protect HTTP traffic in e-commerce
 - Built into every browser and webserver, so easy to implement
 - Good if all traffic over the VPN will be HTTP
 - Beginning to handle other applications
 - Moderate security

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VPN Technologies, Continued

- Point-to-Point Tunneling Protocol (PPTP)
 - For remote access VPNs
 - Operates at the data link layer
 - Transparently provides security to all messages at higher layers
 - Software exists on all client PCs, but individual PCs must be configured to work with PPTP, and this is somewhat expensive
 - Good for remote access when not all traffic is HTTP
 - SSL/TLS has pushed PPTP almost entirely aside in the marketplace (New: Since book was written)

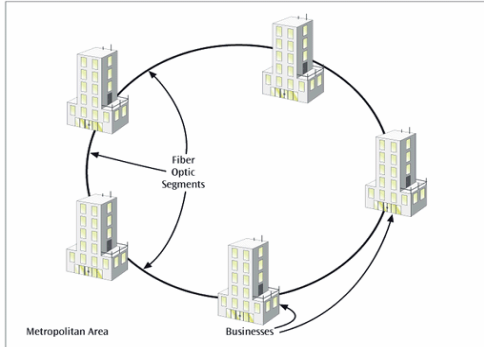
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Metropolitan Area Network Basics

- MANs have very high transfer speeds.
- MANs can recover from network faults very quickly (failover time).
- MANs are often a ring topology (not a star-wired ring).
- Some MANs can be provisioned dynamically.
 - Dynamically allocate more bandwidth

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Figure 10-1
A physical ring used to support a metropolitan area network



SONET vs. Ethernet MANs

- Most MANs are SONET network built of multiple rings (for failover purposes).
- SONET is well-proven but complex, fairly expensive, and cannot be provisioned dynamically.
- SONET is based upon T-1 rates and does not fit nicely into 1 Mbps, 10 Mbps, 100 Mbps, 1000 Mbps chunks, like Ethernet systems do.
- Ethernet MANs have high failover times.

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Figure 10-2
SONET systems are comprised of multiple rings

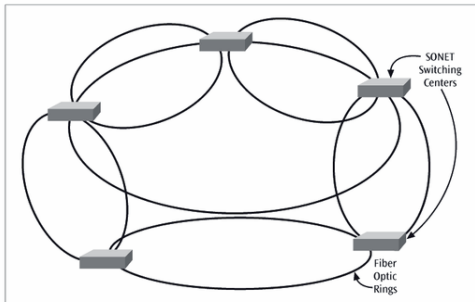
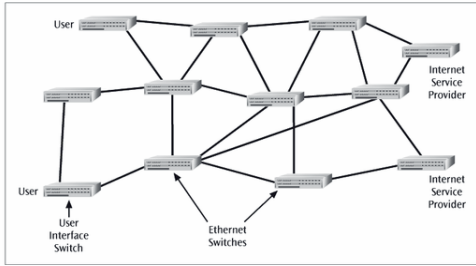


Figure 10-3
The Ethernet MAN topology

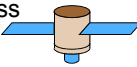



Topics Covered

- Technologies for Individual Internet Access
 - Telephone modems
 - DSL lines
 - Cable modems
 - Wireless Internet access
- Individual Internet Access
 - About two-thirds telephone modem access
 - About one-third broadband (DSL and cable modem)
 - Half broadband in large cities

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Figure 7-7: Wireless Access Systems, Continued

- Satellite Versus Terrestrial Wireless
 - Satellite 
 - Expensive because of transmission distance
 - Expensive because satellites are expensive to launch and maintain
 - Can cover large areas
 - Terrestrial 
 - Earth-based radio stations
 - Service within a city

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Figure 7-7: Wireless Access Systems,
Continued

- 3G Cellular Service
 - Telephone modem and DSL/cable modem speeds
- 802.16 WiMAX
 - One of several terrestrial wireless access standards under development
 - Fixed version being standardized first
 - 20 Mbps up to 50 km (30 miles)
 - Mobile version under development (802.16e)
 - 3 Mbps to 16 Mbps for mobile users
