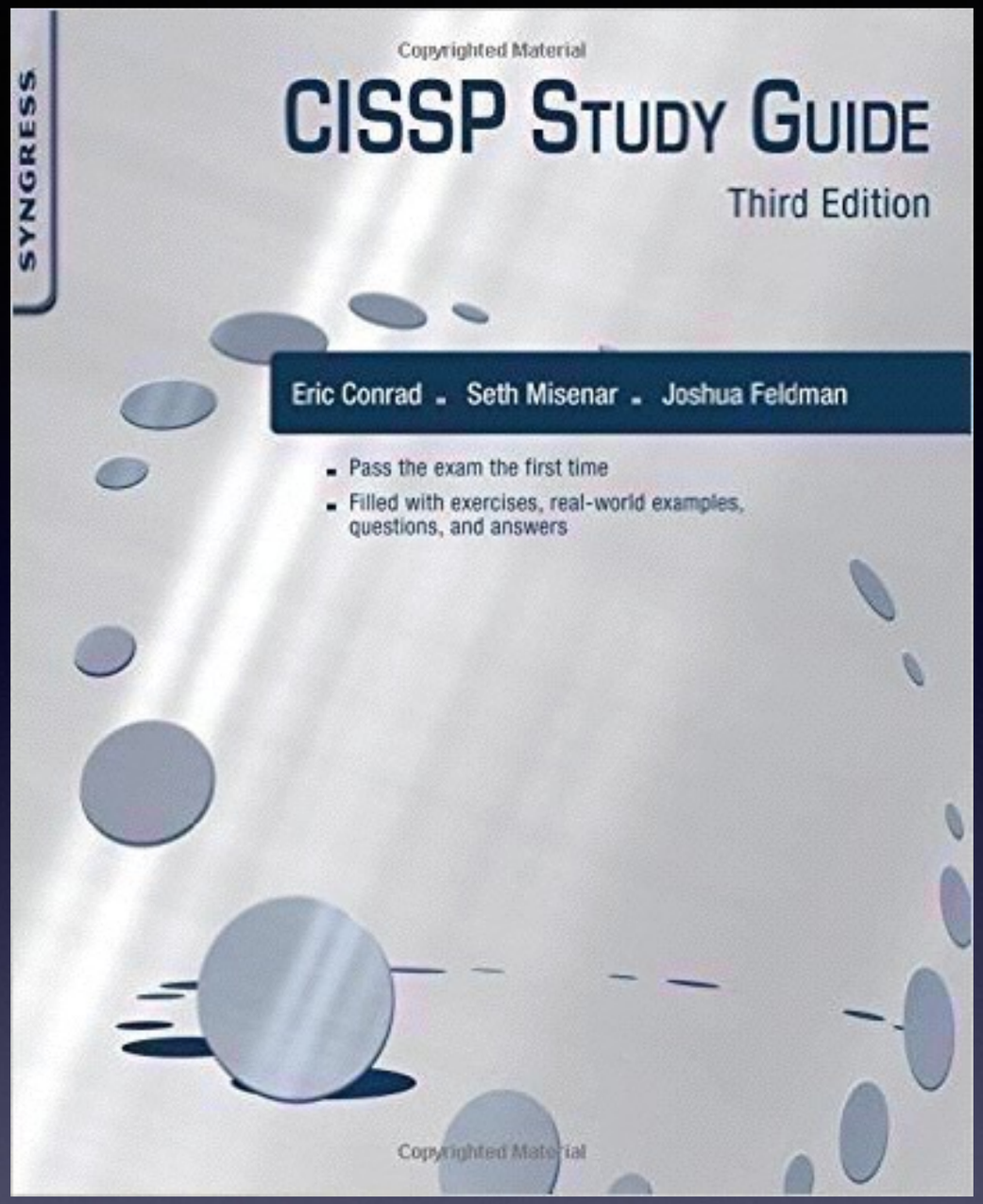
CNIT 125: Information Security Professional (CISSP Preparation)



Ch 5. Communication and Network Security (Part 2)

Network Architecture and Design (continued)

Layer 1 Network Cabling Terms

- **EMI (Electromgnetic Interference)**
  - **Caused by electricity**
  - **Causes unwanted signals (*noise*)**
  - **When a signal from one wire leaks into another wire, that's *Crosstalk***
  - ***Attenuation* is the weakening of a signal as it travels further from the source**

Twisted Pair Cabling

- **Unshielded Twisted Pair (UTP)**
  - **Twists provide some protection from EMI**
  - **Image from Wikipedia**

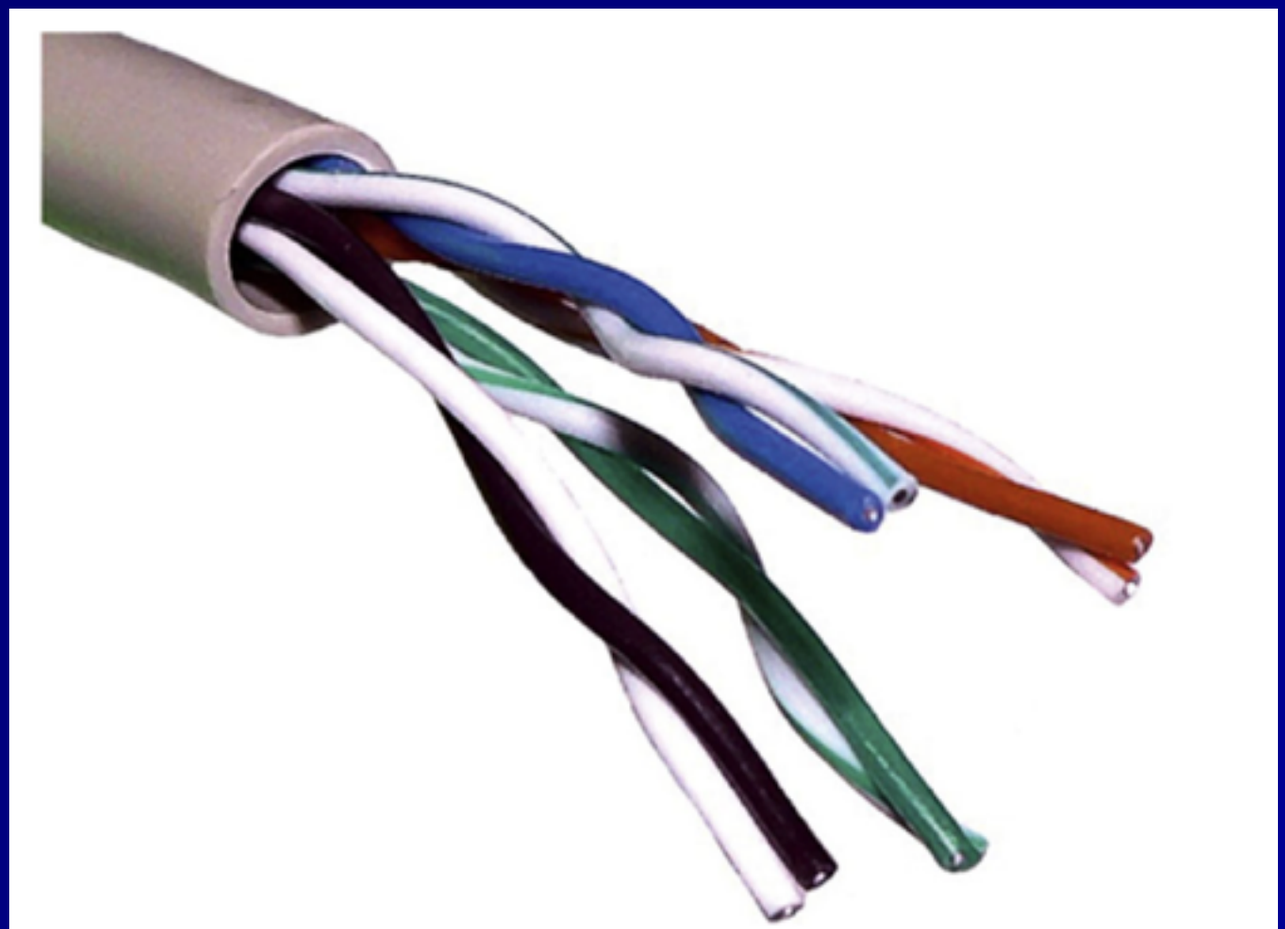


FIGURE 5.12 **UTP Cable** Source:

Category Cabling Speed and Usage

Category	Speed (Mbps)	Common use
Cat 1	< 1	Analog voice
Cat 2	4	ARCNET
Cat 3	10	10baseT Ethernet
Cat 4	16	Token Ring
Cat 5	100	100baseT Ethernet
Cat 5e	1000	1000baseT Ethernet
Cat 6	1000	1000baseT Ethernet

Shielded Twisted Pair (STP)

- **Has a layer of shielding around each pair of wires**
- **Protects it from EMI**
- **More rigid and expensive than UTP**

Coaxial Cabling

- **Inner copper core (D)**
- **Shield (B)**
- **More resistant to EMI than UTP or STP**
- **Higher bandwidth than UTP or STP**

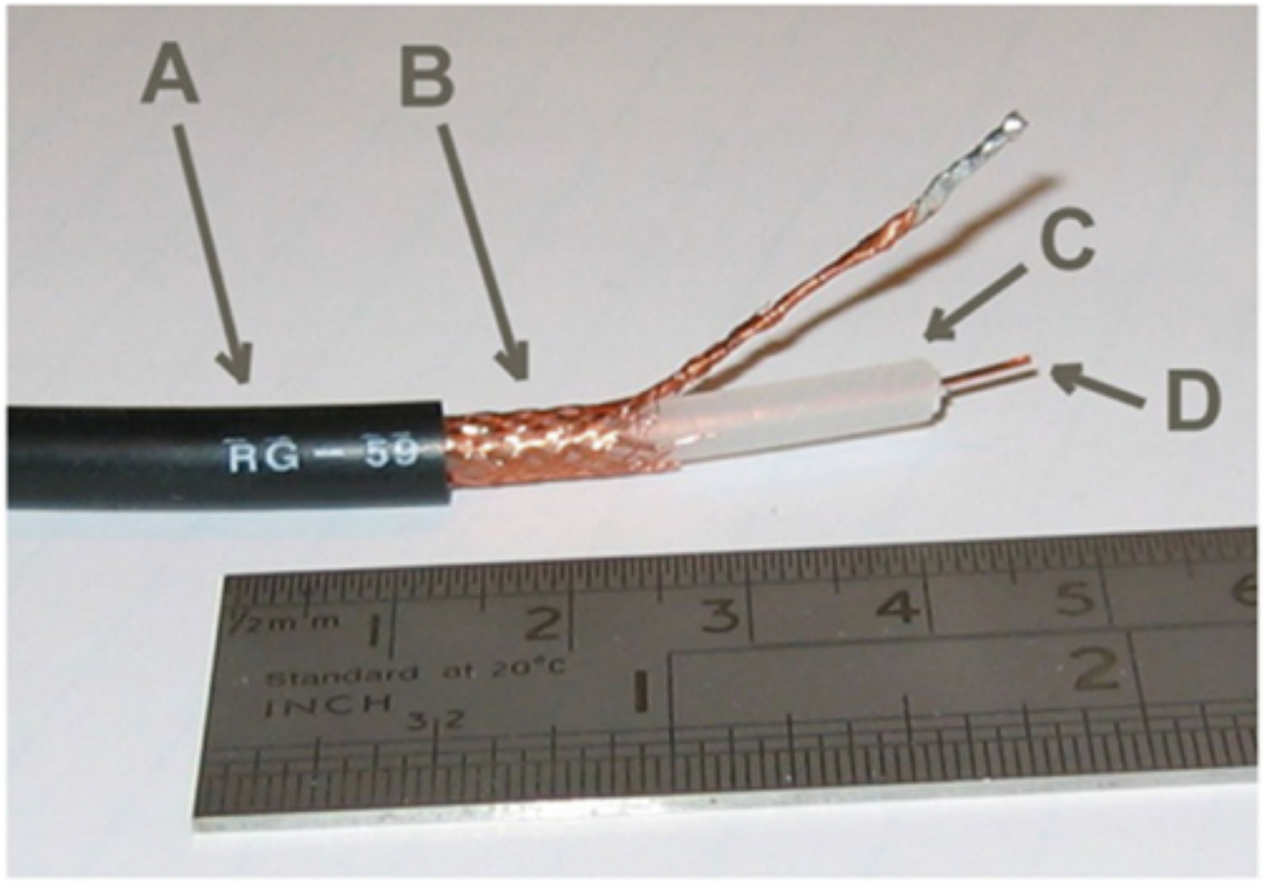


FIGURE 5.13 **Coaxial Cable** Source:

Fiber Optic Network Cable

- **Uses light pulses**
- **Cable is made of glass**
- **Immune to EMI**
- **Much faster and lower attenuation than coax**
- **Can send a signal 50 miles**
- **Disadvantages: cost and complexity**

Types of Fiber

- **Multimode fiber**
  - **Many modes (paths) of light**
  - **Shorter distance, lower bandwidth**
- **Singlemode fiber**
  - **One mode (path)**
  - **Long-haul, high-speed**
- **Wavelength Division Multiplexing**
  - **Sends multiple signals over different colors of light**
  - **Can exceed 10 Gbps**

LAN Technologies and Protocols

Ethernet

- **Originally used a physical bus topology with coaxial cables**
- **Now uses physical star topology with twisted-pair cables**
- **Baseband (one channel)**
  - **Frames can *collide* if two nodes transmit simultaneously**

Types of Ethernet

Name	Type	Speed	Max. Distance
10Base2 'Thinnet'	Bus	10 megabits	185 Meters
10Base5 'Thicknet'	Bus	10 megabits	500 Meters
10BaseT	Star	10 megabits	100 Meters
100BaseT	Star	100 megabits	100 Meters
1000BaseT	Star	1000 megabits	100 Meters

CSMA/CD

- **Carrier Sense Multiple Access/Collision Detection**
  - **Monitor network to see if it is idle**
  - **If not idle, wait a random period of time**
  - **If idle, transmit**
  - **While transmitting, monitor the network**
  - **If an unusual voltage level is detected, another station must be sending: a *collision***

Collision

- **Send Jam signal to tell all nodes to stop transmitting**
- **Wait a random amount of time before retransmitting**

CSMA/CA

- **Carrier Sense Multiple Access/Collision Avoidance**
  - **Used in wireless networks**
  - **Because collisions cannot be detected**
  - **Uses acknowledgements for each frame**
  - **If no acknowledgement received, the node will wait and retransmit**
  - **Less efficient than CSMA/CD**

ARCNET & Token Ring

- **Attached Resource Computer Network**
  - **Ran at 2.5 Mbps**
- **Token Ring**
  - **Ran at 16 Mbps**
- **Two legacy LAN technologies**
- **Both use *tokens***
  - **Only node with the token can send or receive data**
  - **No collisions**

FDDI

- **Fiber Distributed Data Interface**
  - **Another legacy LAN technology**
  - **Used two fiber rings**
    - **Secondary ring sent data in the opposite direction**
    - ***Fault tolerant***
    - **A single cut in the ring does not stop service**
    - **Runs at 100 Mbps**

LAN Physical Network Topologies

Bus

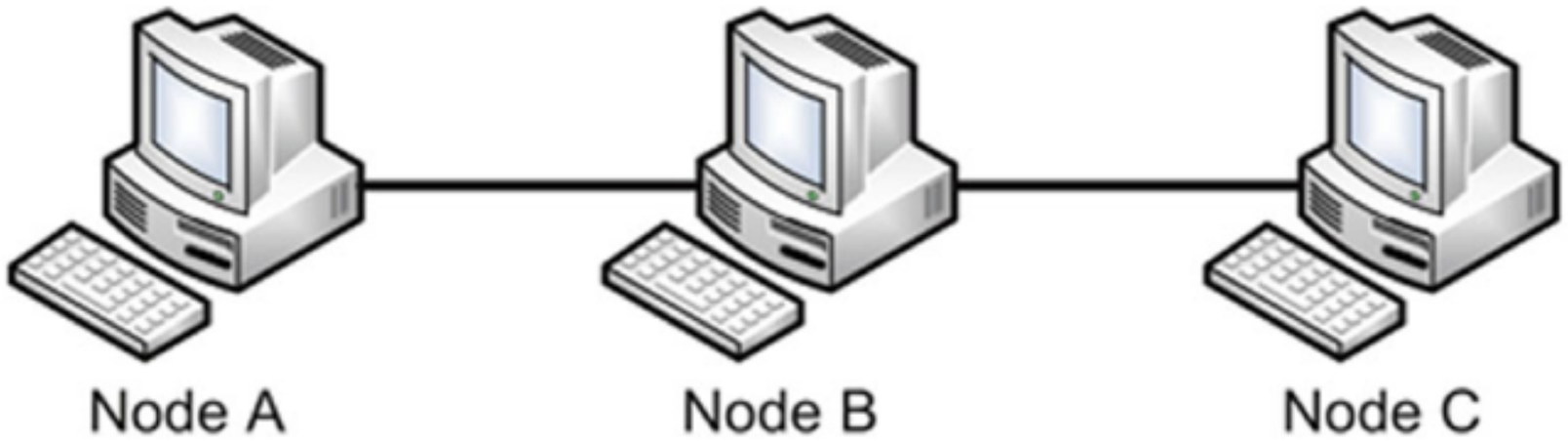


FIGURE 5.14 Bus

- **A single cable break brings the whole network down**

Tree or Hierarchical

- **Root node controls all traffic**
- **Legacy network**
- **Root was often a mainframe**

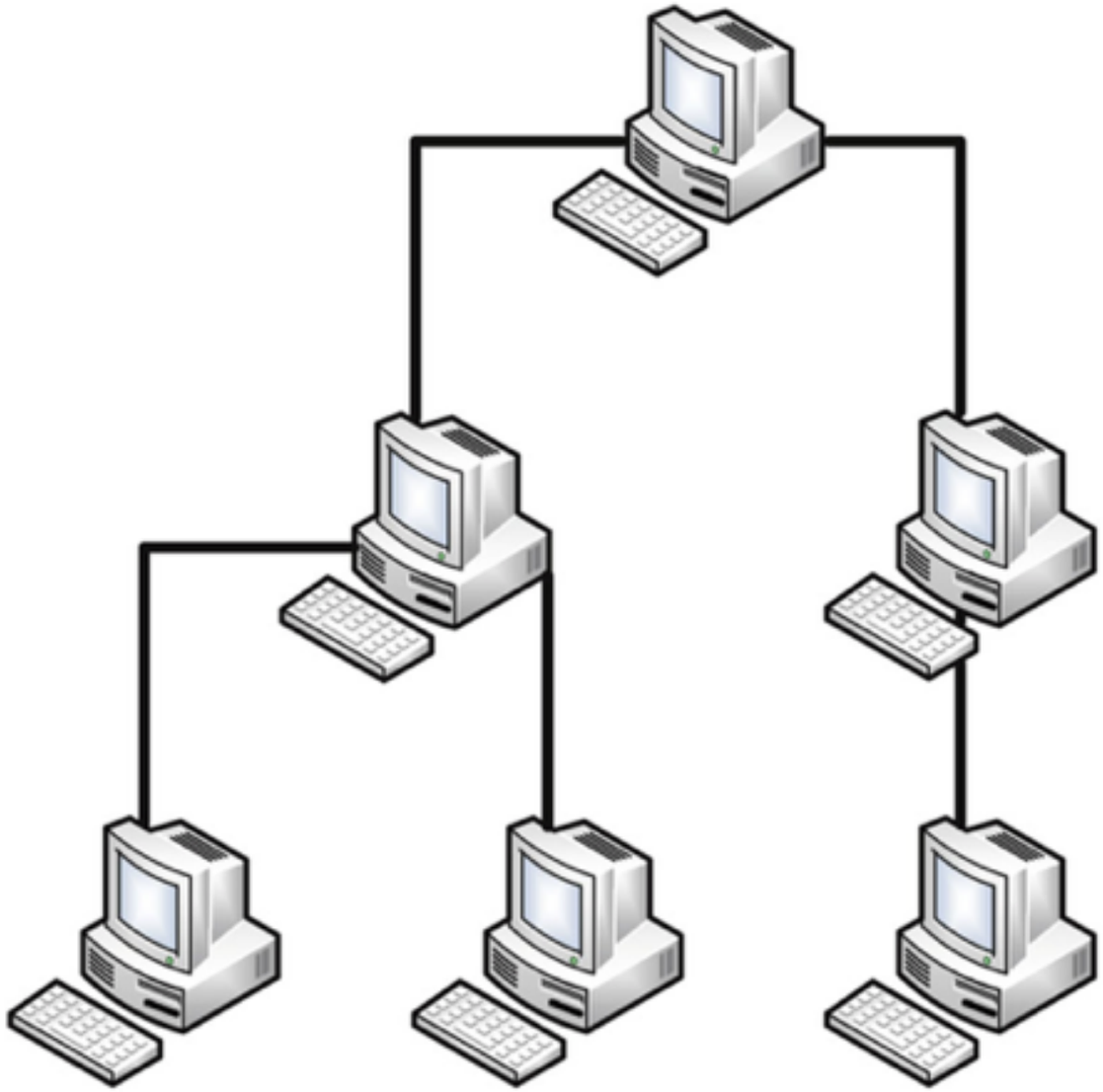


FIGURE 5.15 Tree Topology

Ring

- **FDDI used both a logical and physical ring**

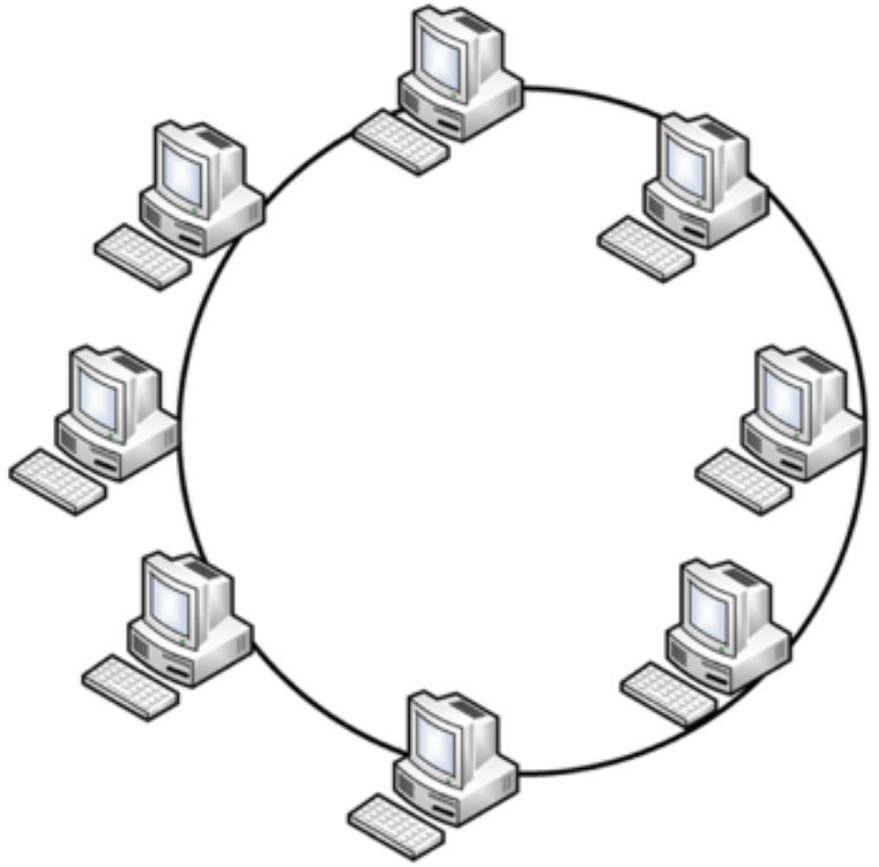


FIGURE 5.16 Ring Topology

Star

- **Ethernet uses a star**
- ***Fault tolerant***
- **A cable break only affects one node**
- **Token Ring used a physical star and a logical ring**

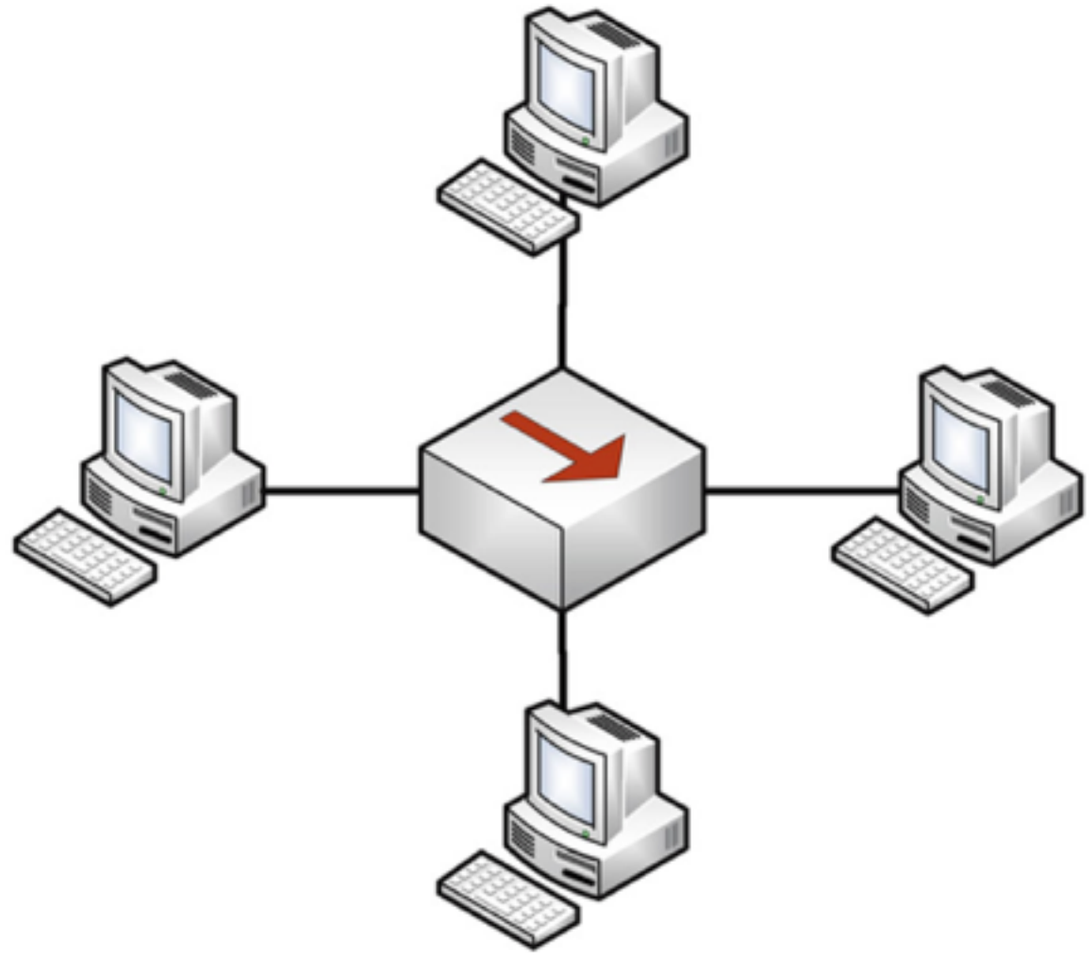


FIGURE 5.17 Star Topology

Mesh

- **Superior availability**

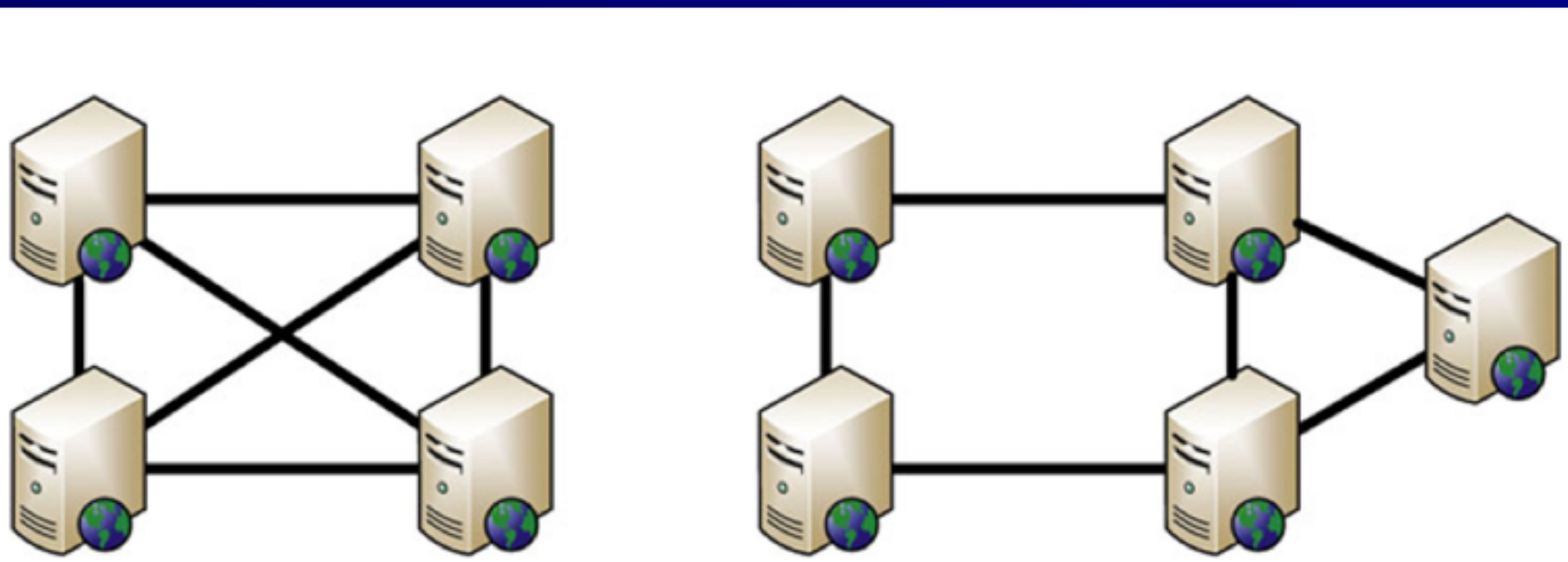


FIGURE 5.18 **Fully Connected and Partially Connected Mesh Topologies**

1

WAN Technologies and Protocols

T1, T3, E1, E3

- **T1 (DS1) provides 1.5 Mbps dedicated circuit**
  - **Contains 24 64 kbps lines (DS0)**
- **T3 (DS3) contains 28 T1s**
  - **45 Mbps**
- **E1 provides 2 Mbps in 30 channels**
- **E3 contains 16 E1s for 34 Mbps**

SONET

- **Synchronous Optical Networking**
- **Contains multiple T-carrier circuits**
- **Via fiber optic cabling**
- **Ring topology for redundancy**

Frame Relay

- **Packet-switched layer 2 protocol**
- **No error recovery**
- **Focuses on speed**
- **Multiplexes multiple logical connections over a single physical connection**
- **To create Virtual Circuits**
- **An alternative to dedicated lines such as T1s**

Frame Relay

- **PVC (Permanent Virtual Circuit)**
  - **Always connected like a T1**
- **SVC (Switched Virtual Circuit)**
  - **Sets up for a call, terminates after the call**
- **Frame Relay addresses circuits with Data Link Connection Identifiers (DLCI)**

X.25

- **Older packet-switched WAN protocol**
- **Cost-effective in 1970s through 1990s**

ATM

- **Asynchronous Transfer Mode**
- **WAN technology**
- **Fixed-size 53-byte cells**
  - **5 bytes of address, 48 bytes of data**
- **SDMS (Switched Multimegabit Data Service)**
  - **Older and similar to ATM**
  - **Also used 53-byte cells**

MPLS

- **Multiprotocol Label Switching**
- **Forwards WAN data using labels**
- **Via a shared MPLS cloud network**
- **Can carry many types of traffic**
  - **ATM, Frame Relay, IP, and more**
- **Traffic decisions are based on labels**

SDLC and HDLC

- **Synchronous Data Link Control**
  - **Layer 2 WAN protocol**
  - **Uses polling, similar to token passing**
  - **Primary node polls secondary nodes to request their data**
- **High-Level Data Link Control**
  - **Successor to SDLC**
  - **Adds error correction and flow control**
  - **Three modes (next slide)**

HDLC: Three Modes

- **Normal Response Mode (NRM)**
  - **Secondary nodes can transmit when given permission by the primary**
- **Asynchronous Response Mode (ARM)**
  - **Secondary nodes can initiate transmission with the primary**
- **Asynchronous Balanced Mode (ABM)**
  - **Compiled mode: nodes may act s either primary or secondary, initiating transmissions without receiving permission**

Converged Protocols

- **Multiple services over the same Ethernet network**
  - **Industrial controls, storage, voice, ...**

DNP3

- **Distributed Network Protocol 3**
- **Open standard**
- **Used primarily by energy sector**
- **For interoperability between various vendors' SCADA and smart grid applications**
- **"Smart Grid" technology brings utility electricity delivery into the 21st century**
- **More energy-efficient**

DNP3

- **Multilayer protocol**
- **May be carried over TCP/IP**
- **Recent improvements allow "Secure Authentication"**
- **Original specification was vulnerable to spoofing and replay attacks, and pre-shared keys only**
- **The current standard is IEEE 1815-2012**
  - **Supports Public Key Infrastructure (PKI)**

Storage Protocols

- **Fibre Channel over Ethernet (FCoE)**
- **Internet Small Computer System Interface (iSCSI)**
- **Used for SANs (Storage Area Networks)**
- **Allows block-level file access over a network**
- **Just like a directly attached hard drive**

Fibre Channel over Ethernet (FCoE)

- **Fibre Channel uses special cable and hardware**
  - **Including Host Bus Adapters (HBAs)**
- **FCoE uses standard ethernet**
  - **But not TCP/IP**
- **Fibre Channel over IP (FCIP)**
  - **Encapsulates Fibre Channel frames via TCP/IP**

Internet Small Computer System Interface (iSCSI)

- **Uses higher layers of the TCP/IP suite for communication**
- **Can be routed**
- **Allows access to storage over a WAN**
- **Uses Logical Unit Numbers (LUNs) to address storage across the network**

Virtual SAN

- **Storage Area Networks (SANs)**
  - **Historically used proprietary hardware and software**
- **Virtual SAN is analogous to a VLAN**

VoIP

- **Voice over Internet Protocol**
- **Uses two protocols**
  - **Real-time Transport Protocol (RTP)**
    - **Carries audio and video**
  - **Session Initiation Protocol (SIP)**
    - **For signals like "phone ringing"**
- **Secure Real-time Transport Protocol (SRTP)**
  - **Uses AES and SHA-1 to provide confidentiality, integrity, and secure authentication**

VoIP

- **Saves money**
  - **No need for separate phone and IT networks**
- **Exposes phone traffic to network attacks**
- **RTP provodes little or no security by default**
  - **Wireshark can eavesdrop on a call**

Software-Defined Networks

- **Separates a router's control plane from the data (forwarding) plane**
  - **Control plane makes routing decisions**
  - **Data plane forwards packets through the router**
- **With SDN routing decision are made remotely**
- **Allows customization of networks**

OpenFlow

- **Most well-known SDN protocol**
- **Allows a central controller to control switching rules**
- **Uses TCP and TLS encryption**

2

Wireless Local Area Networks

DoS & Availability

- **An attacker in physical proximity to a WLAN can launch D0S attacks**
  - **Polluting the wireless spectrum with noise**
  - **Sending Deauth frames**
- **There is no defense**

Unlicensed Bands

- **Industrial, Scientific, and Medical (ISM) bands**
- **No FCC license needed to use them**
- **Cordless phones, 802.11, and Bluetooth all use ISM bands**
- **Two common bands used internationally**
  - **2.4 GHz**
  - **5 GHz**

FHSS, DHSS, and OFDM

- **Frequency Hopping Spread Spectrum (FHSS) hops across many channels**
- **Direct Sequence Spread Spectrum (DSSS) spreads the signal across a whole band**
  - **Both maximize throughput and minimize effects of interference**
- **Orthogonal Frequency Division Multiplexing (OFDM) uses simultaneous transmissions that do not interfere with each other**

Type	Top Speed	Frequency
802.11	2 Mbps	2.4 GHz
802.11a	54 Mbps	5 GHz
802.11b	11 Mbps	2.4 GHz
802.11g	54 Mbps	2.4 GHz
802.11n	72-600 Mbps	2.4 GHz and/or 5 GHz
802.11ac	422 Mbps-1.3 Gbps	5 GHz

Wireless NIC Modes

- **Managed**
- **Master**
- **Ad-Hoc**
- **Monitor**

Managed and Master Modes

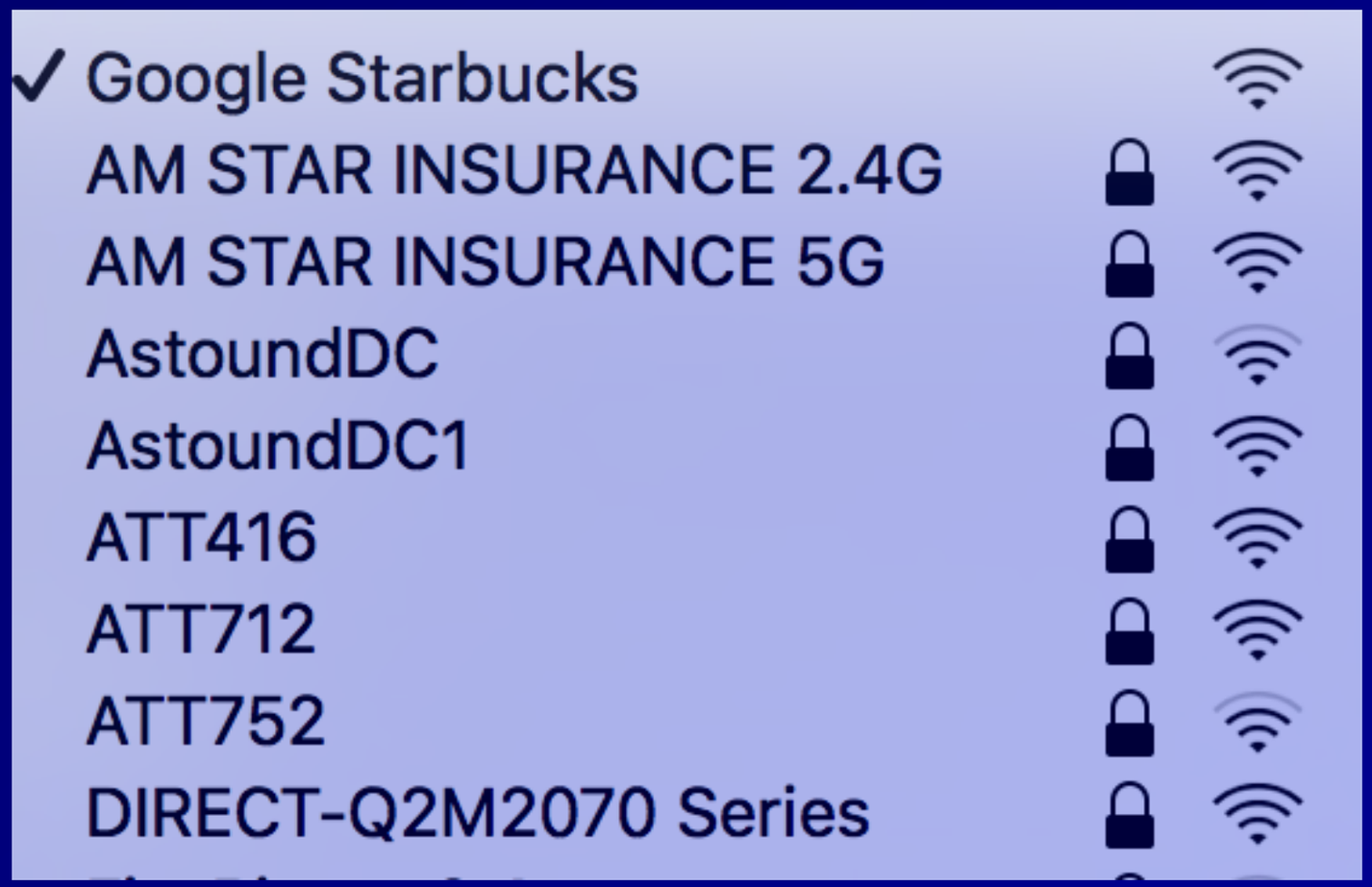
- **Managed mode**
  - **Client mode, obeys commands from the Master**
- **Master mode**
  - **Access point**
  - **Clients connect to it**

Ad Hoc and Monitor Mode

- **Ad Hoc**
  - **Peer-to-peer network**
  - **No central access point**
- **Monitor mode**
  - **Used to sniff WLAN traffic**
  - **Including traffic between other devices**

SSID

- **Service Set Identifier**
- **Network name**
- **Normally broadcast by access point**
- **Disabling SSID broadcasts is a weak security measure**



MAC Address Filtering

- **A weak security measure**
- **MACs can be sniffed and spoofed**

WEP

- **Wired Equivalent Privacy**
  - **Weak, unsafe encryption protocol**
  - **Designed specifically to avoid export munition laws**
- **Too weak to use**

802.11i

- **Defines a Robust Security Network (RSN)**
  - **Also called WPA2 (Wi-Fi Protected Access 2)**
  - **Uses AES encryption for confidentiality**
  - **Uses CCMP for integrity**
    - **Counter Mode CBC MAC Protocol, which makes a Message Integrity Check (MIC)**

WPA

- **Designed for access points too weak to implement 802.11i**
  - **Uses RC4 encryption for confidentiality**
  - **Uses TKIP for integrity**
  - **Considered weaker than WPA2**

Bluetooth

- **IEEE 802.15**
- **Personal Area Network (PAN)**
- **Uses 2.4 GHz band**
- **v. 2.1 and earlier ran at 3 Mbps or less**
- **v3 is much faster**
- **Class 3: under 10 meters**
- **Class 2: 10 meters**
- **Class 1: 100 meters**

Bluetooth

- **Uses the 128-bit E0 symmetric stream cipher**
  - **Cryptanalysis has shown that E0 is weak**
    - **True strength is 38 bits or less**
- **Disable automatic discovery when not in use**
- **But attacker can discover the device by guessing its MAC address**

RFID

- **Radio Frequency Identification**
  - **Tags for animals or objects**
- **Active, semi-passive, or passive**
- ***Active* RFID tag has a battery & broadcasts a signal**
- ***Semi-passive***
  - **Has a battery & also relies on the reader for power**
- ***Passive***
  - **Powered by reader, shorter range, cheaper**

Faraday Cage

- **Shields an object with wire mesh**
- **Blocks radio signals**
- **Can be made by wrapping aluminum foil around an object**

3

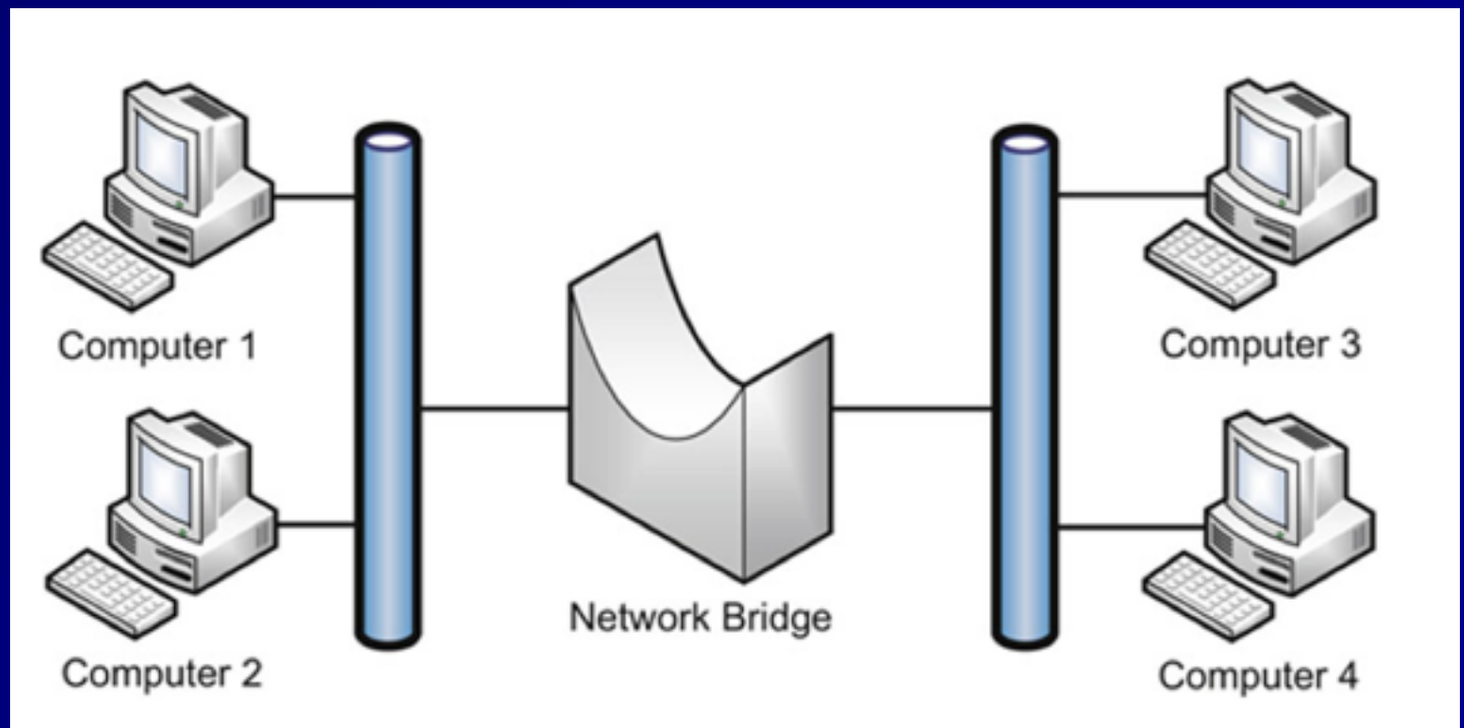
Secure Network Devices and Protocols

Repeaters and Hubs

- **OSI Layer 1**
- **Repeater has 2 ports**
  - **Receives bits on one port**
  - **Repeats them out the other port**
- **Hub**
  - **Multiport repeater**
  - **No traffic isolation**
  - **No security, no confidentiality or integrity**
  - **Half-duplex: cannot send and receive simultaneously**
  - **One collision domain**

Bridges

- **Has two ports**
- **Connects two network segments together**
- **Learns MAC addresses of the nodes**
- **Forwards frames to the correct port**



Switches

- **Multiport bridge**
- **Isolates traffic using MAC address**
- **Normally has no collisions**
- ***Trunks* connect multiple switches**

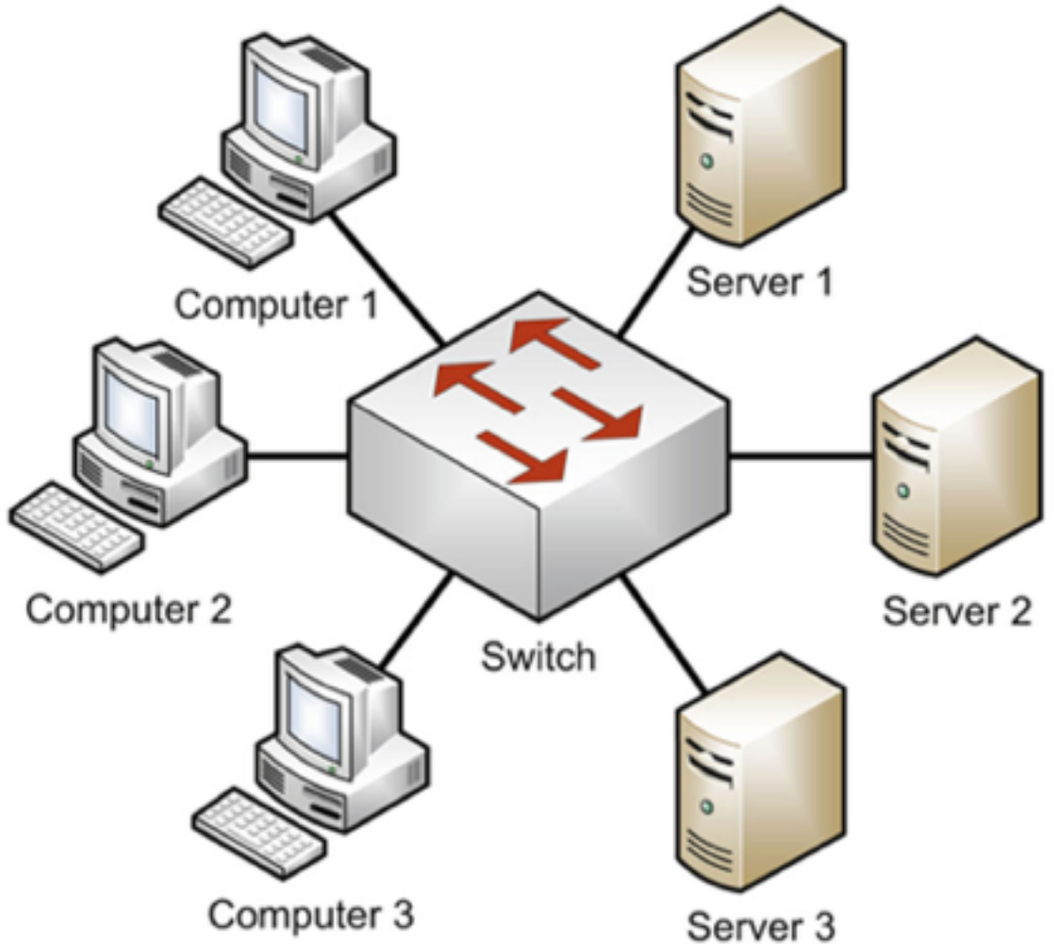


FIGURE 5.21 Network Switch

VLANs

- **Virtual LAN, like a virtual switch**
- **Separates broadcast domains**
- **Segments traffic**
- **Provides defense in depth**

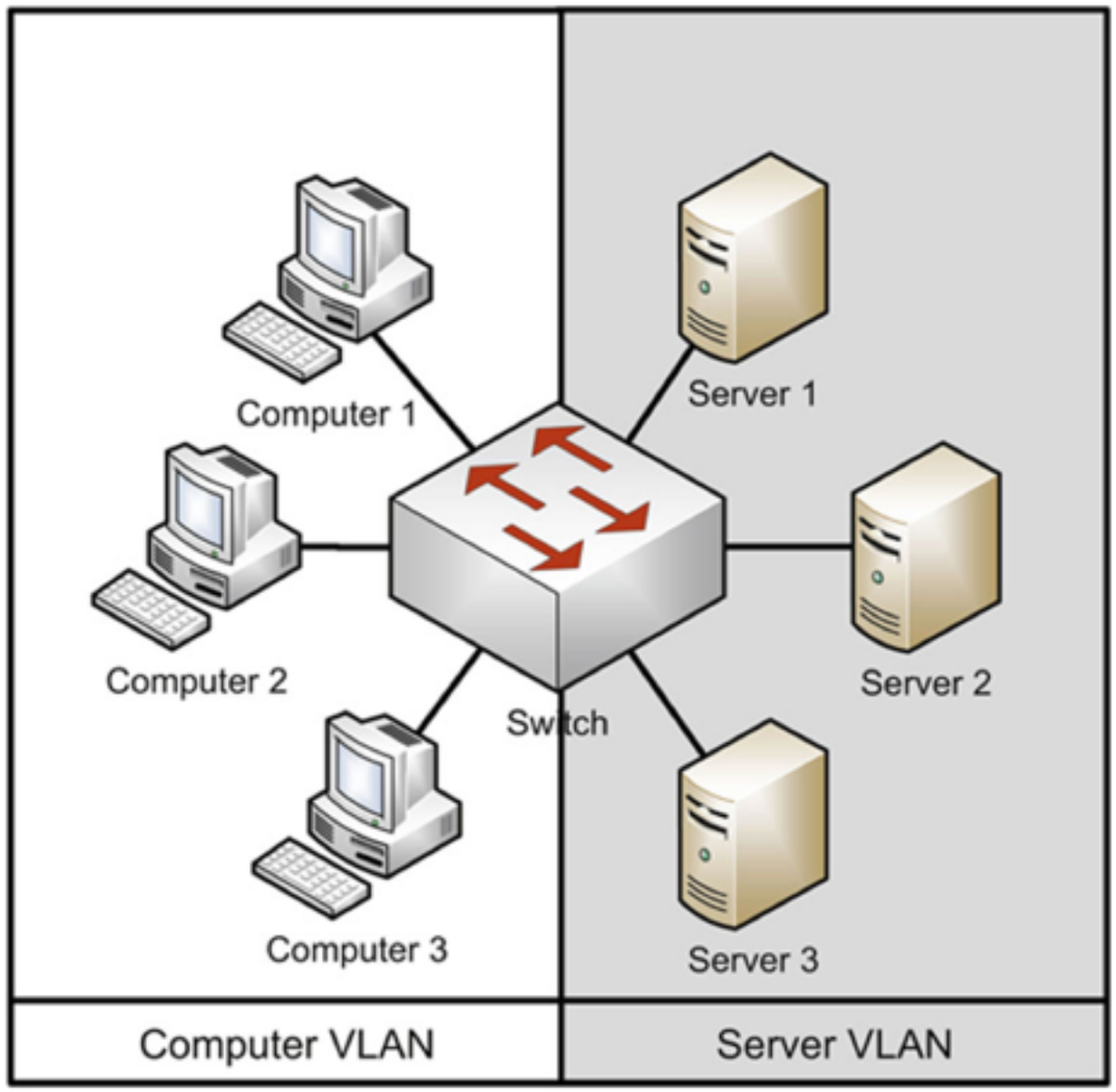


FIGURE 5.22 Switch VLAN

Port Isolation

- **Traditionally only one port on a managed switch could communicate to the uplink**
  - **Forms a Private VLAN (PVLAN)**
  - **Makes lateral movement much more difficult for an attacker**

Port Isolation

- **Very useful in modern multi-tenant environments**
- **Isolates customers from one another**
  - **Even when they are all serviced by the same hypervisor**

SPAN Ports

- **Switched Port Analyzer Port**
  - **Allows a NDS to see all traffic passing through the switch**
  - **Also called a "mirror" port**
    - **SPAN port may not have enough bandwidth to deliver all the frames**
      - **Some will be missed**

Network Taps

- **A device that can see all traffic on the network**
- **Preferred way to connect a sniffer or NIDS**
- **Can "fail open", so network traffic passes if the tap fails**
- **Gives visibility to malformed frames**
- **Can have memory buffer to cache traffic bursts**

Routers

- **OSI Layer 3**
- **Router traffic from one LAN to another**
- **Based on IP addresses**
- **Static Routes**
  - **Typed in by network manager**
  - **Don't change often**
  - **Sufficient for small networks**
- **Default route or Default Gateway**
  - **Used if no other route is defined for that IP**

Home Network

To the Internet

Network:
192.168.1.0

IP Address
Subnet Mask
Default Gateway

Hub

A

192.168.1.1
255.255.255.0
147.144.51.1

B

192.168.1.101
255.255.255.0
192.168.1.1

C

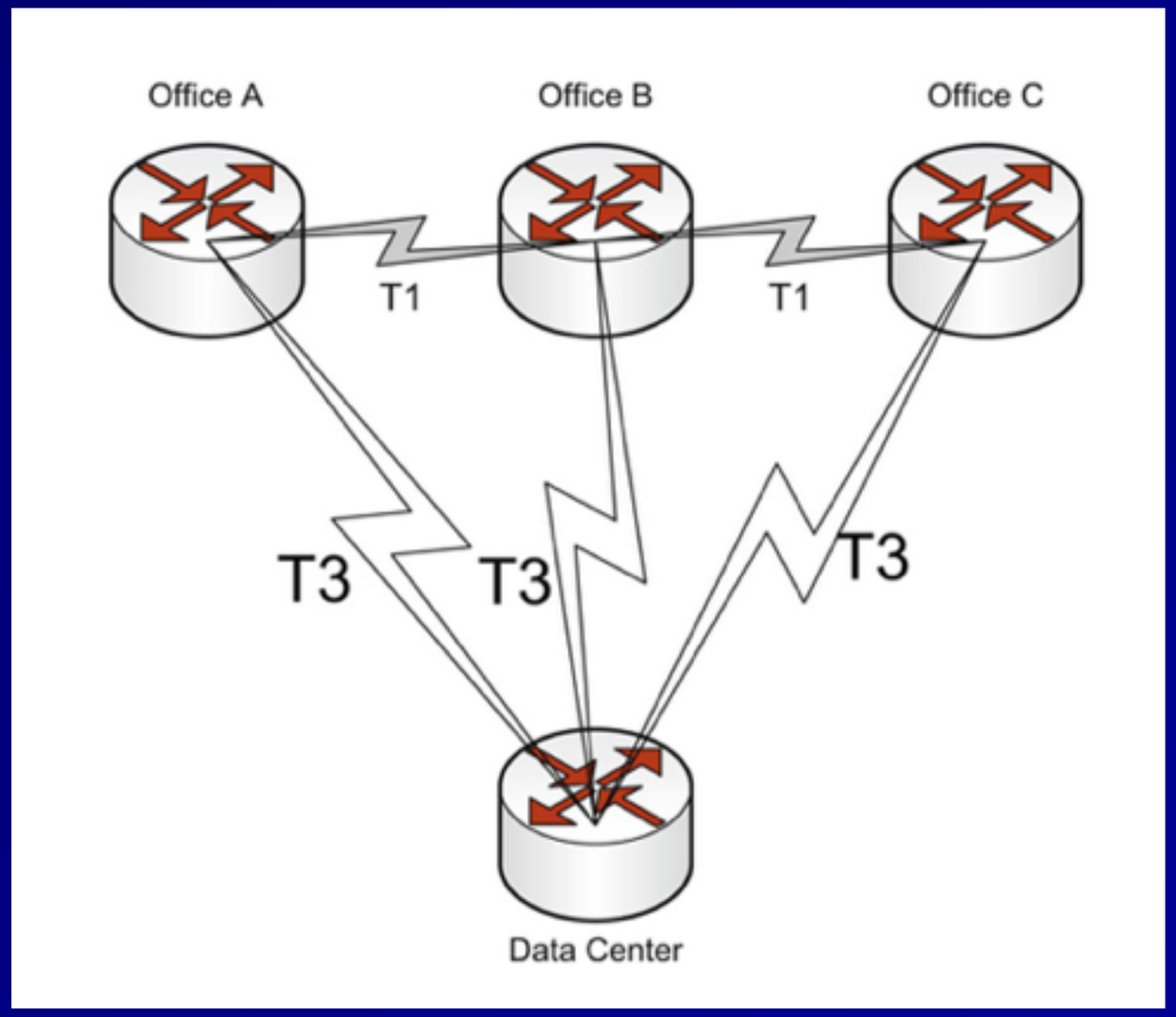
192.168.1.102
255.255.255.0
192.168.1.1

D

192.168.1.103
255.255.255.0
192.168.1.1

Routing Protocols

- **If a link goes down, the network automatically detects that and adjusts to route around it**
- **A network *converges* when the adjustment is complete**



Routing Protocols

- **Interior Gateway Protocols (IGPs)**
  - **Used by private networks like Intranets**
  - **Ex: RIP, OSPF**
- **Exterior Gateway Protocols (EGPs)**
  - **Used on the Internet**
  - **Ex: BGP**

Distant-Vector Routing Protocols

- **Routers don't know the whole network map**
- **Just a distance *metric* and direction**
- **Example**
  - **AT&T is 2 hops out port 1**
  - **CCSF is 3 hops out port 2**
- **Prone to inefficient decisions**
  - **Like using a slower link with fewer hops**
  - **And routing loops**

Routing Loops

- **Packets hop back and forth, never getting to their destination**
- **Can persist for several minutes with RIP**

```
14 pwm-core-03.inet.example.com (10.11.37.141) 165.484 ms 164.335 ms 175.928 ms
15 pwm-core-02.inet.example.com (10.11.23.9) 162.291 ms 172.713 ms 171.532 ms
16 nyc-core-01.inet.example.com (10.11.5.101) 212.967 ms 193.454 ms 199.457 ms
17 bos-core-01.inet.example.com (10.11.5.103) 206.296 ms 212.383 ms 189.592 ms
18 nyc-core-01.inet.example.com (10.11.5.101) 210.201 ms 225.674 ms 208.124 ms
19 bos-core-01.inet.example.com (10.11.5.103) 189.089 ms 201.505 ms 201.659 ms
20 nyc-core-01.inet.example.com (10.11.5.101) 334.19 ms 320.39 ms 245.182 ms
21 bos-core-01.inet.example.com (10.11.5.103) 218.519 ms 210.519 ms 246.635 ms
```

RIP (Routing Information Protocol)

- **Old and inefficient, for weak routers**
- **Distance-Vector**
- **Uses hop count as metric**
- **Sends updates every 30 seconds**
- **Convergence is slow**
- **Max. hop count is 15; 16 is "infinity"**
- **RIPv1 uses classful networks only**
- **RIPv2 supports CIDR**

RIP Countermeasures v. Routing Loops

- **Split Horizon**
  - **A router doesn't echo a route back to the router that originated it**
  - **Prevents out-of-date information from erasing new information**
- **Poison Reverse**
  - **Bad routes are marked with metric 16**
- **Hold-down timer**
  - **Route can't change more often than once each 180 seconds**

Link State Routing Protocols

- **Each router knows the whole network diagram**
- **Can use additional metrics to determine best route**
  - **Including bandwidth**
- **Much better than RIP, but requires more processing power from the routers**

OSPF

- **Open Shortest Path First**
  - **An open link-state routing protocol**
- **Routers send updates when events occur**
- **Converges much faster than RIP**

BGP

- **Border Gateway Protocol**
- **Used on the Internet**
- **Routes between Autonomous Systems**
  - **Networks with multiple Internet connections**
- **A path-vector protocol**

4

Firewalls

Packet Filter

- **Simplest, fastest**
- **Each filtering decision is based on a single packet: "stateless"**
- **Often allow unwanted traffic through**

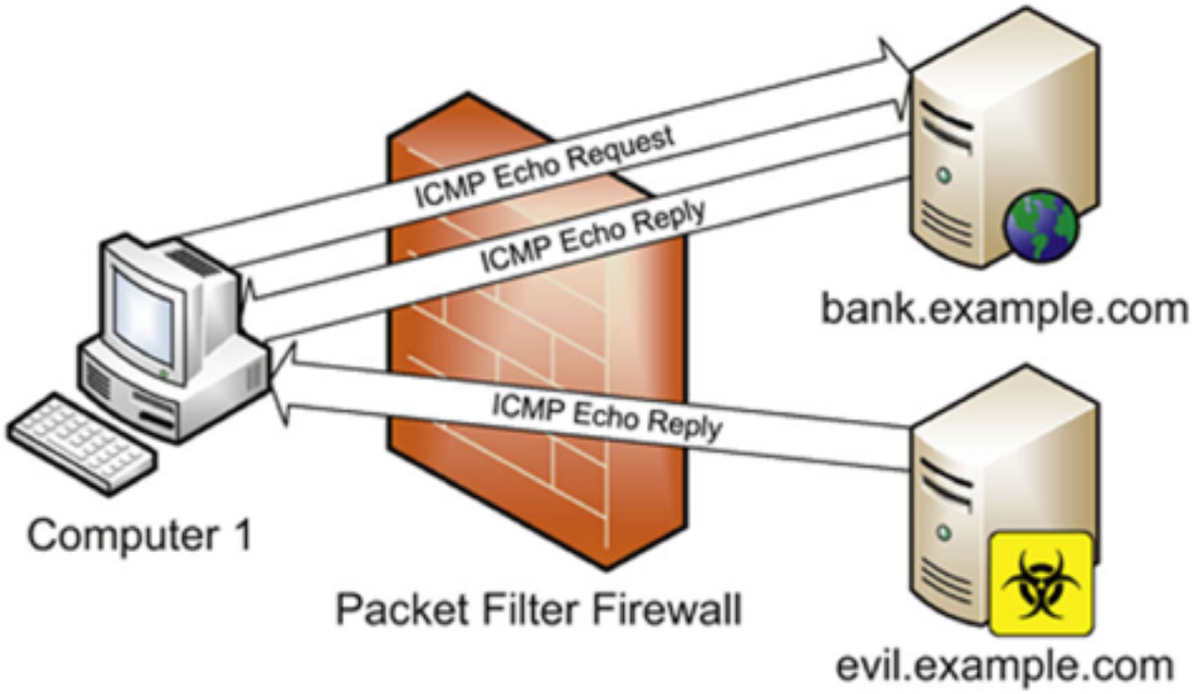
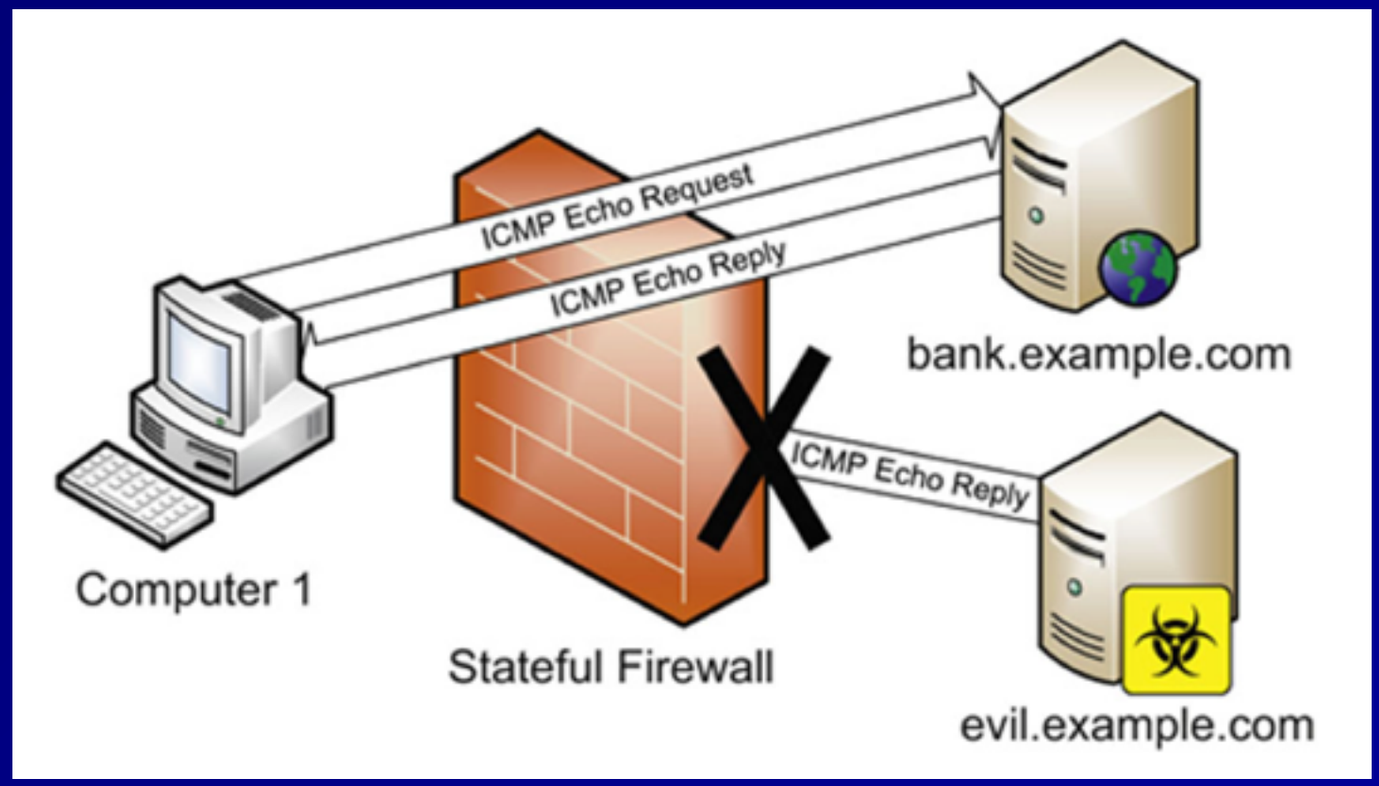


FIGURE 5.25 Packet Filter Firewall Design

Stateful Firewalls

- **Has a state table**
- **Slower than packet filters, but more secure**
- **Blocks echo reply because there was no**
- **echo request**



Proxy Firewalls

- **Hides the origin of a connection**

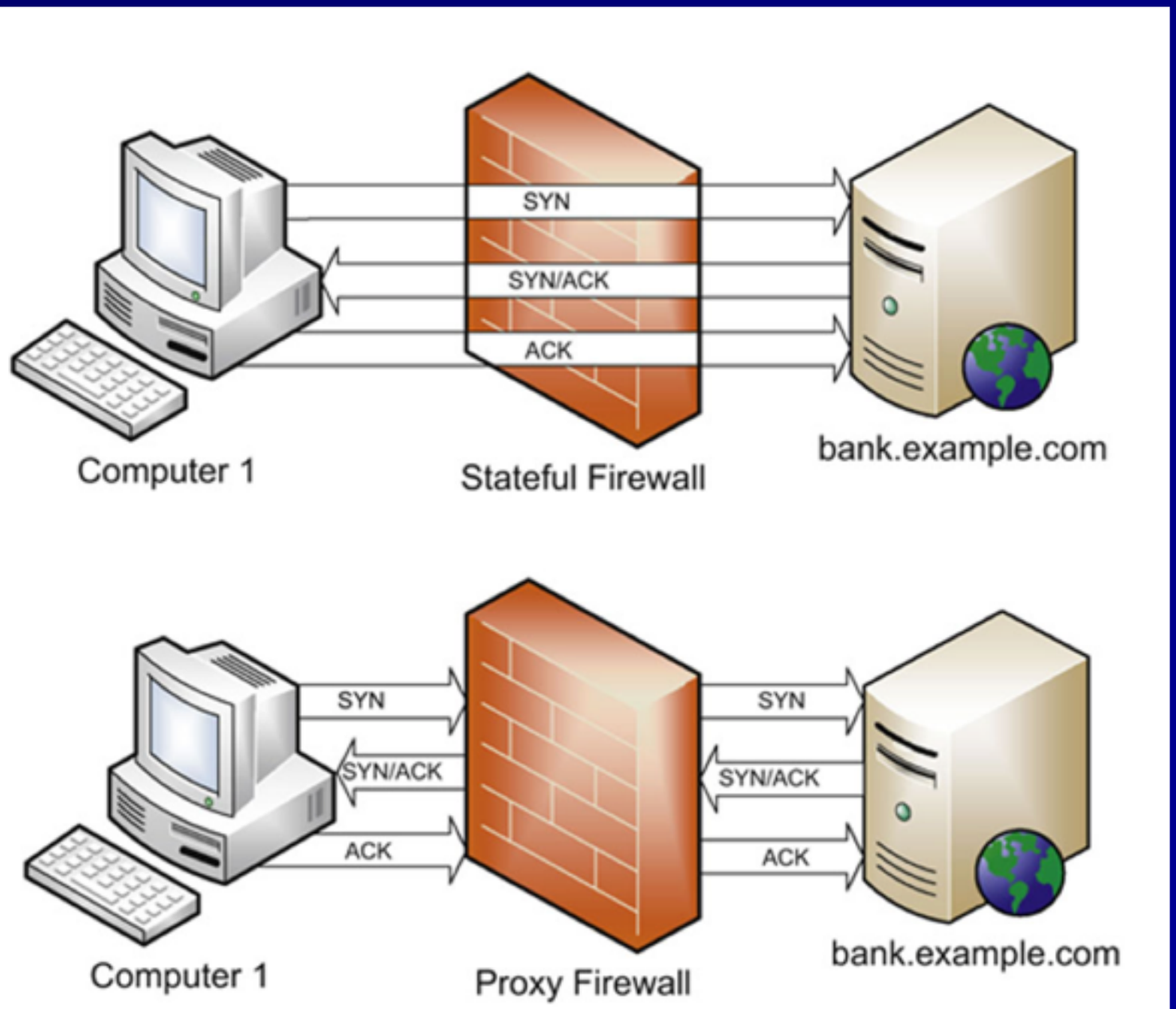


FIGURE 5.27 **Stateful vs. Proxy Firewalls**

Application-Layer Proxy Firewalls

- **Can use application-layer data to filter traffic**
  - **Such as URLs**
- **Often specialized to a certain protocol**
  - **FTP proxy**
  - **HTTP proxy**

Circuit-Level Proxies Including SOCKS

- **Operate at OSI layer 5 (Session)**
- **Below application-layer proxies**
- **Application-layer data is just passed along**
- **Can forward many protocols**
- **SOCKS uses port TCP 1080**
- **Tor uses SOCKS**

Bastion Host

- **A host placed on the Internet but not protected by another device, such as a firewall**
- **Must protect itself**
- **Must be hardened**
- **Usually provide a specific service, all others are disabled**

Dual-Homed Hosts

- **Sits between two networks**
- **Does not route**
- **Internet user must log into the host first, and then access the trusted network from there**
- **Used before modern firewalls became common in the 1990s**

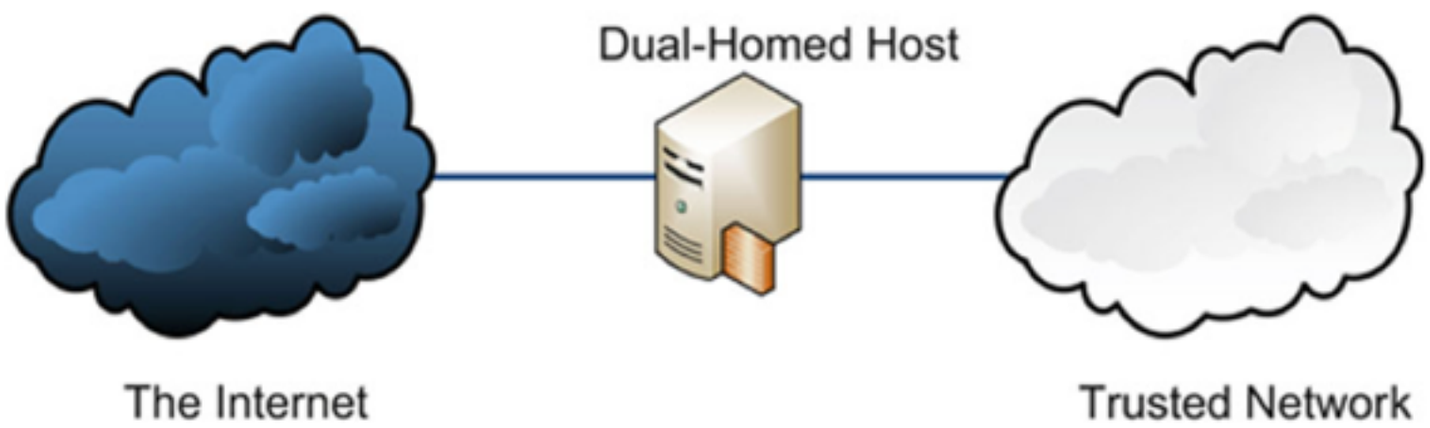


FIGURE 5.28 **Dual-Homed Host**

Screened Host Architecture

- **Router forces traffic to go only to Bastion Host, which can access LAN**
- **If Bastion Host fails, network is unprotected**
  - **Lacks Defense in Depth**

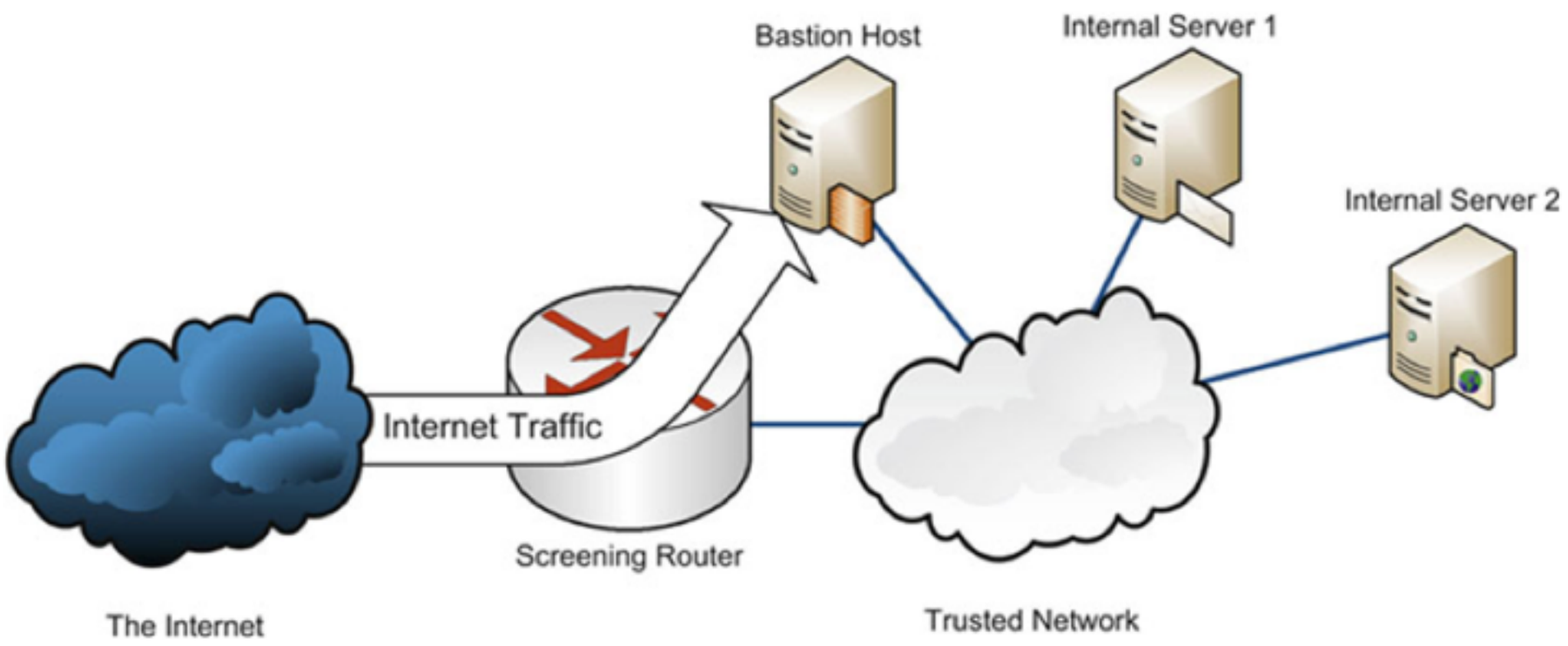


FIGURE 5.29 Screened Host Network

DMZ

- **Screened subnet between two firewalls contains high-risk servers, like Web server**

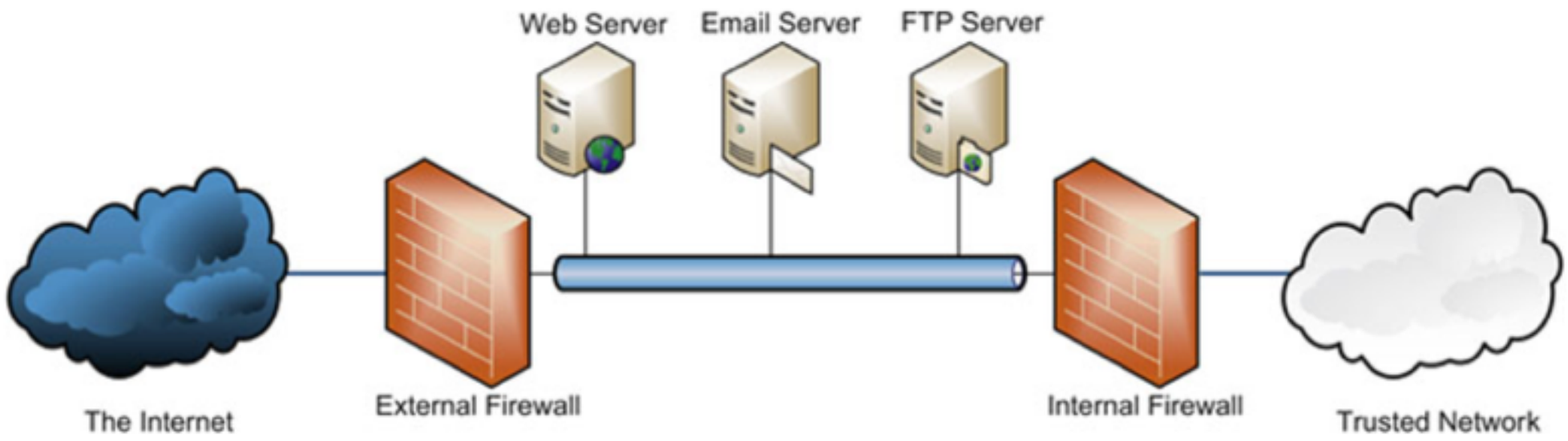


FIGURE 5.30 Screened Subnet Dual Firewall DMZ Design

DMZ with One Firewall

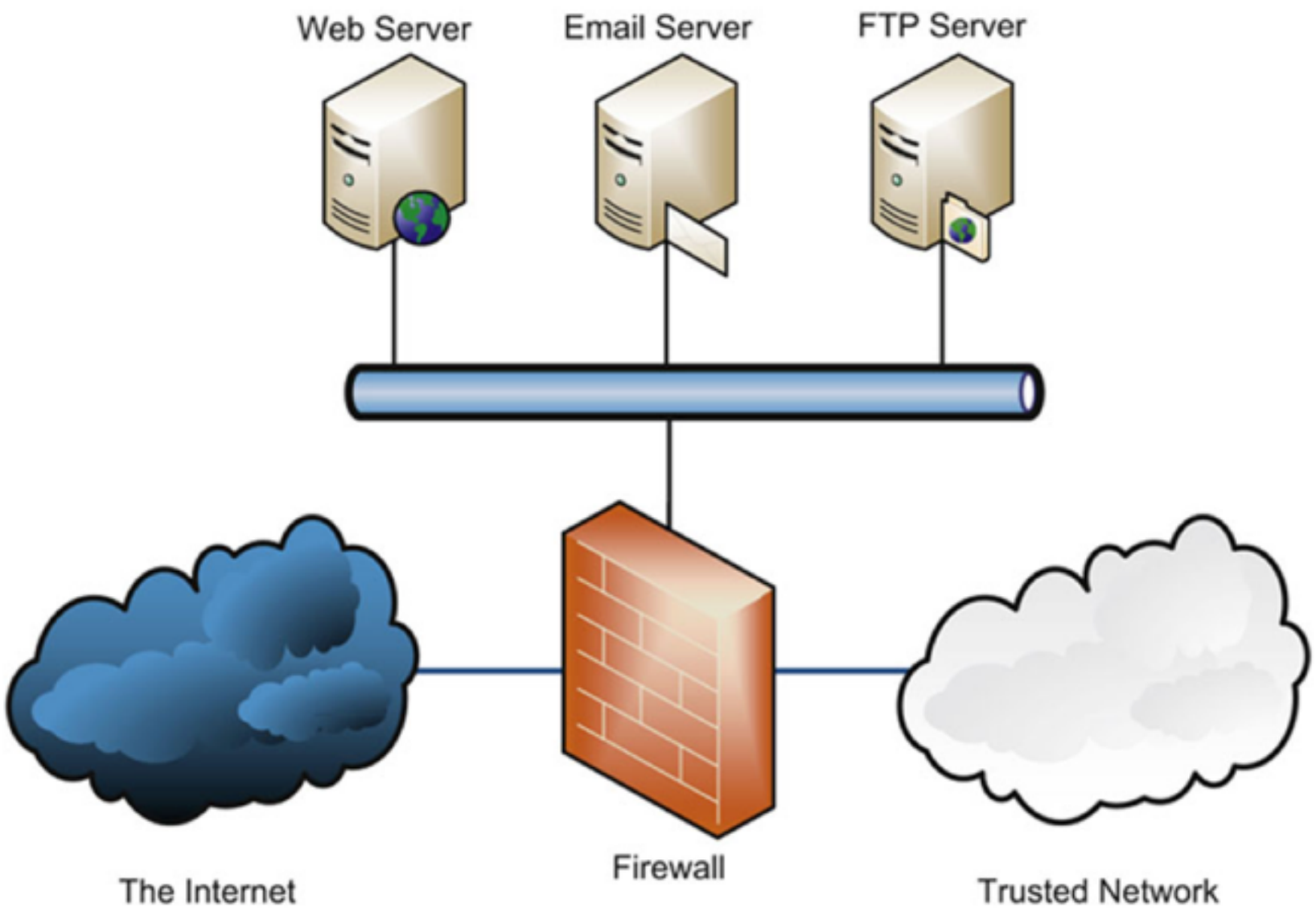


FIGURE 5.31 Single Firewall DMZ Design

Modem

- **Modulator/Demodulator**
- **Translates binary data into analog sound that can be carried on phone networks**
- **Asynchronous devices**
- **No clock signal**

DTE/DCE

- **Data Terminal Equipment (DTE)**
  - **A user machine, like a laptop or phone**
- **Data Circuit-Terminating Equipment (DCE)**
  - **The end of an ISP's network, such as a router**
- **Demarc**
  - **The point where the DCE meets the DTE, where the ISP's responsibility ends**

CSU/DSU

- **Circuit carried by DCE/DTE is synchronous**
  - **Uses a clock signal provided by the DCE**
- **DCE device is a modem or a CSU/DSU (Channel Service Unit/Data Service Unit)**

Secure Communications

Authentication Protocols and Frameworks

PAP (Password Authentication Protocol)

- **Sends passwords in cleartext**
- **Subject to sniffing and replay**
- **Insecure, should not be used**

CHAP (Challenge-Handshake Authentication Protocol)

1. **Server sends a challenge**
2. **User adds challenge to password and hashes the result, sends the hash**
3. **Server can identify correct hash by calculating it**

- **Resists sniffing and replay attacks**
- **Does not expose password**
- **Requires plaintext storage of passwords on servers**

802.1X

- **Port Based Network Access Control**
  - **Includes EAP (Extensible Authentication Protocol)**
- **Supplicant: an 802.1X client**
- **Authentication Server (AS)**
  - **A server that authenticates a supplicant**
- **Authenticator**
  - **A device such as an access point that allows a supplicant to authenticate and connect**

802.1X Authentication

- **EAPOL: EAP Over LAN**

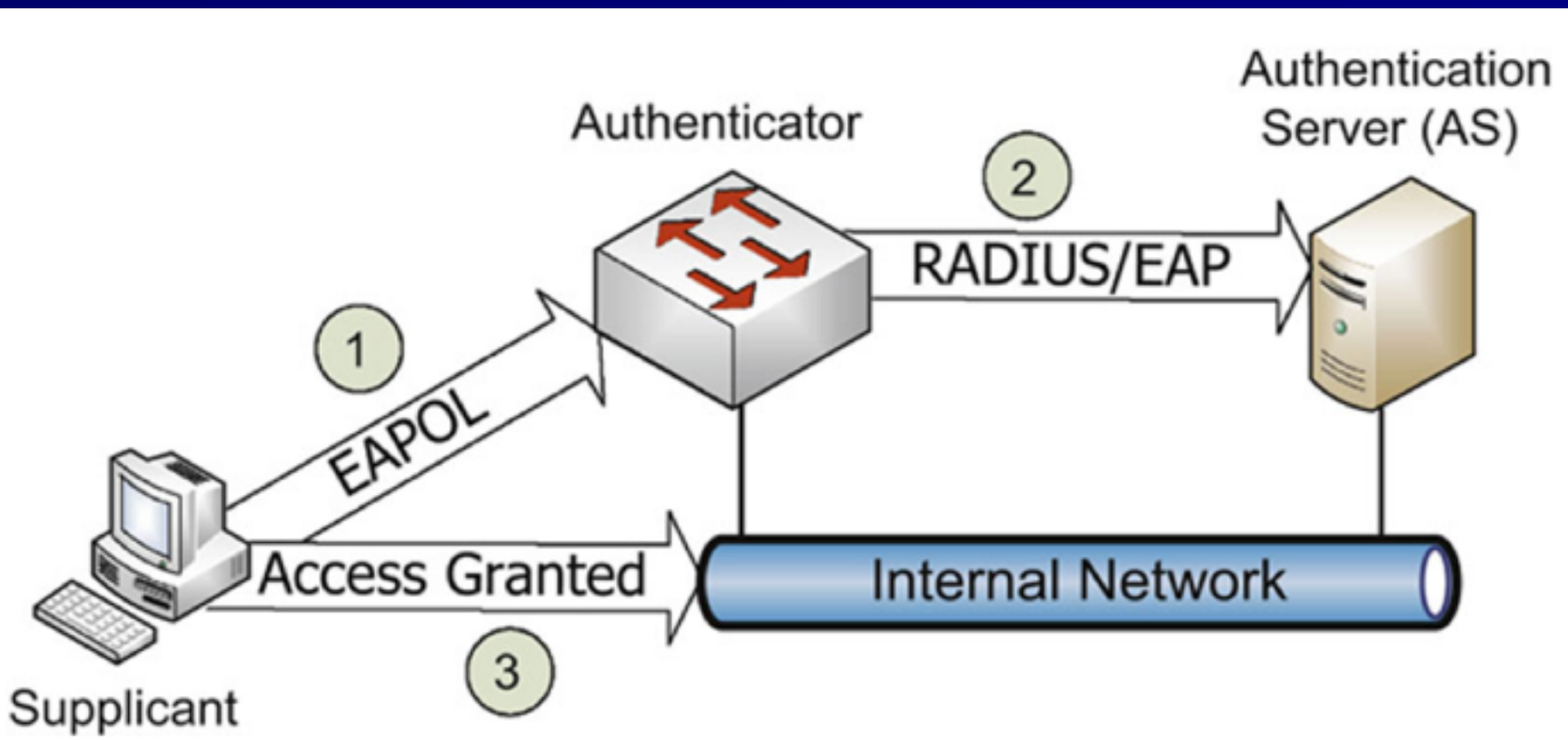


FIGURE 5.32 Successful 802.1X Authentication

Types of EAP

- **EAP-MD5**
  - **Weak, vulnerable to MITM attacks and password-cracking**
  - **Only allows client-to-server authentication; all other methods listed below allow *mutual authentication***
- **LEAP (Lightweight Extensible Authentication Protocol)**
  - **Cisco-proprietary; unsafe, should not be used**

Types of EAP

- **EAP-FAST**
  - **EAP-Flexible Authentication via Secure Tunneling**
- **Designed by Cisco to replace LEAP**
- **Uses a Protected Access Credential (PAC) as a pre-shared key**

Types of EAP

- **EAP-TLS**
  - **EAP-Transport Layer Security**
- **Uses PKI**
- **Requires both client-side and server-side certificates**
- **Very secure, but complex and costly**

Types of EAP

- **EAP-TTLS**
  - **EAP-Tunnelled Transport Layer Security**
  - **Allows a client to use a password instead of a certificate**
  - **Easier to deploy than EAP-TLS, but less secure**

Types of EAP

- **PEAP**
  - **Protected EAP**
  - **Similar to EAP-TTLS**

5

VPN (Virtual Private Network)

VPN Goal

- **Create a secure link over the Internet**
- **As secure as a dedicated leased line like a T1**
- **Uses secure authentication, hashes, and ciphers**

SLIP and PPP

- **Serial Line Internet Protocol (SLIP)**
  - **Layer 2 protocol from 1988**
  - **No confidentiality, integrity or authentication**
- **Point-to-Point Protocol (PPP)**
  - **Replaced SLIP**
  - **Uses HDLC**
  - **Adds confidentiality, integrity and authentication**

PPTP

- **Point-to-Point Tunneling Protocol**
  - **Uses GRE (General Routing Encapsulation)**
  - **To pass PPP via IP**
    - **Uses TCP port 1723 for a control channel**
- **Old and unsafe**

L2TP

- **Layer 2 Tunneling Protocol**
  - **Provides authentication but not confidentiality**
- **Used with IPsec, provides confidentiality**
- **Can be used on non-IP networks, such as ATM**

IPsec

- **Two main protocols**
  - **Encapsulating Security Payload (ESP)**
    - **Layer 4 protocol 50**
  - **Authentication Header (AH)**
    - **Layer 4 protocol 51**

IPsec Architectures

- **Host-to-gateway**
  - **Client mode**
- **Gateway-to-gateway**
  - **Point-to-point**
- **Host-to-host**

Tunnel and Transport Modes

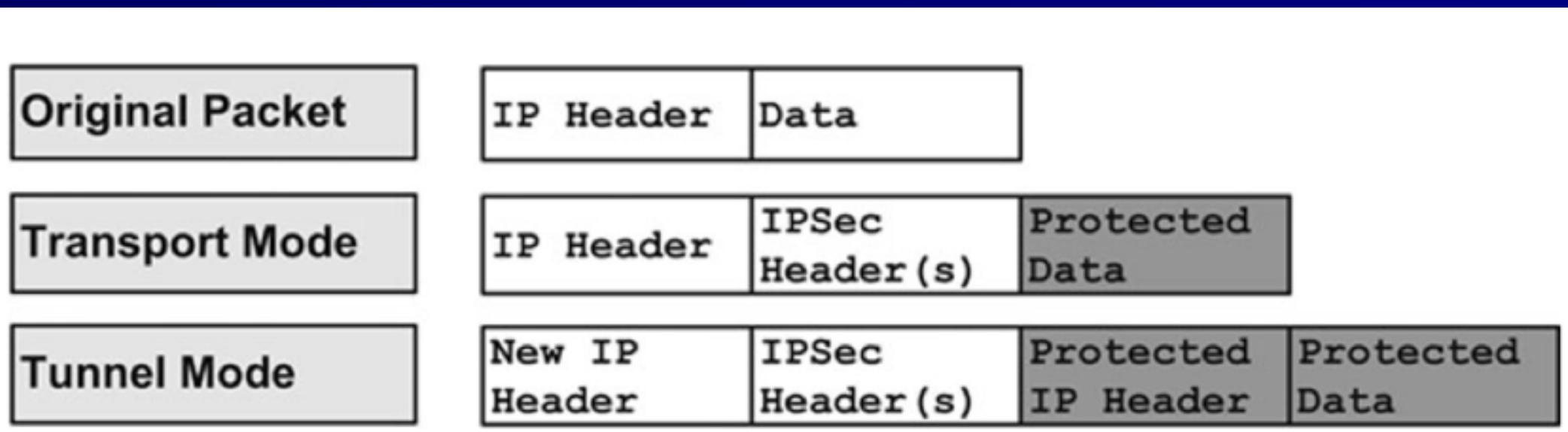


FIGURE 5.33 IPSec Tunnel and Transport Modes

SSL and TLS

- **Secure Sockets Layer (SSL)**
  - **Now deprecated, replaced by TLS**
- **Transport Layer Security (TLS)**
  - **Port TCP 443**
- **TLS VPNs are simpler to use than IPsec**

Remote Access

ISDN

- **Integrated Services Digital Network**
- **Provides digital service over copper-wire phone lines**
- **Basic Rate Interface (BRI)**
  - **Provides two 64 Kbps channels and one 16 Kbps signaling channel**
- **Primary Rate Interface (PRI)**
  - **Provides 23 64 Kbps channels and one 16 Kbps signaling channel**

DSL

- **Digital Subscriber Line**
  - **Popular and fast: up to 10 Mbps or more**
- **Symmetric DSL**
  - **Upload and download speeds the same**
- **Asymmetric DSL**
  - **Download faster than upload**
- **High-data-rate DSL**
- **Very high-rate DSL**

DSL Speed and Distances [10]

Type	Download Speed	Upload Speed	Distance from CO
ADSL	1.5 to 9 Mbps	16 to 640 Kbps	18,000 feet
SDSL	1.544 Mbps	1.544 Mbps	10,000 feet
HDSL	1.544 Mbps	1.544 Mbps	10,000 feet
VDSL	20-50+ Mbps	Up to 20 Mbps	< 5,000 feet

Cable Modems

- **Internet access via broadband cable TV**
- **Bandwidth shared with neighbors**
- **Only available in cities, where the cables are**

Callback & Caller ID

- **Callback**
  - **A modem-based authentication system**
  - **User calls to initiate a connection**
  - **System hangs up and calls back at a preconfigured number**
- **Caller ID**
  - **Verifies that the user is calling from the correct phone number**
  - **BUT caller ID can be easily forged**

Remote Desktop Console Access

- **rlogin & rsh are old Unix remote access systems**
  - **Cleartext and poorly authenticated**
  - **Used TCP 513 and 514, respectively**
- **Two modern remote access protocols**
  - **Virtual Network Computing (VNC)**
    - **TCP port 5900**
  - **Remote Desktop Protocol (RDP)**
    - **TCP port 3389**

GoToMyPC and LogMeIn

- **Use reverse tunnel over HTTPS**
- **Agent installed on computer connects to a central server**
- **User authenticates to that server**

Desktop and Application Vitualization

- **Virtual Desktop Infrastructure (VDI)**
  - **A centralized infrastructure hosts a desktop image**
  - **Remotely deployed to workforce**
- **Application virtualization**
  - **Users access the application on the central server**
  - **Allows strict access control and patch management**

Screen Scraping

- **Packetizes and transmits information needed to draw the screen**
- **Used by VNC but not by RDP**

Instant Messaging

- **Real-time chat**
- **Often with audio an video conferencing**
- **IRC (Internet Relay Chat)**
- **From 1988 and still popular**
- **Uses TCP port 6667 by default**
- **Many IRC servers use nonstandard ports**
- **Used by malware to phone home**

Other Chat Protocols

- **AOL Instant Messenger (AIM)**
- **ICQ**
- **Extensible Messaging and Presence Protocol (XMPP)**
  - **Formerly called Jabber**
- **Security risks**
  - **Unpatched old chat clients**
  - **File sharing can be used to leak confidential documents**

Remote Meeting Technology

- **GoToMeeting by Citrix**
- **Microsoft Office Live Meeting**
- **Allow sharing Powerpoint slides and documents**
- **Sometimes also audio or video**
- **Sometimes allow users to remotely control a PC**
- **Tunnel through outbound TLS traffic**
- **May bypass existing controls and violate policy**

PDAs

- **Personal Digital Assistants**
  - **Apple Newton and Palm Pilot**
- **"Mobile device" is a more modern term than PDA**
- **Most have converged with smartphones**
  - **iPhone, Blackberry, Android**

PDA Security Issues

- **Loss of data due to theft of device**
  - **Sensitive data on a PDA should be encrypted**
  - **PIN code should be used to lock it**
  - **Remote Wipe capability helps to control data loss**
- **Wireless security**
  - **Should use secure wireless connections and consider risks of Bluetooth**

Wireless Application Protocol (WAP)

- **Designed to provide secure Web services to handheld devices such as smartphones**
- **Based on HTML**
- **Includes HDML (Handheld Device Markup Language)**
- **Authentication uses WTLS (Wireless Transport Layer Security)**
  - **Based on TLS**

WAP

- WAP browser is a microbrowser
- Simpler than a full Web browser
- Connects to a WAP gateway
  - A proxy server designed to translate Web pages
- Accesses sites written in, or converted to WML (Wireless Markup Language)
  - Based on XML

Content Delivery Networks (CDN)

- **A series of caching servers**
- **Improve performance and lower latency of downloaded online content**
- **Automatically use servers closest to end users**
- **Examples**
  - **Akamai, Amazon CloudFront, CloudFlare, Microsoft Azure**
- **Can increase availability and resist DoS attacks**

6