# Top-Down Network Design

Chapter Ten

## Selecting Technologies and Devices for Campus Networks



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## Selecting Technologies and Devices

- Physical network design involves the selection of LAN and WAN technologies for campus and enterprise network designs
- An effective design process is to develop campus solutions first followed by remote-access and WAN solutions
- We now know what the network will look like
- We also know what capabilities the network will need
- We are now ready to start picking out technologies and devices
- This chapter has guidelines for campus networks

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## Campus Network Design Steps

- Develop a cabling plant design
- Select the types of cabling
- Select the data-link-layer technologies
- Select internetworking devices

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## Cabling Plant Design Considerations

- Campus and building cabling topologies
- The types and lengths of cables between buildings
- Within buildings
  - The location of telecommunications closets and cross-connect rooms
  - The types and lengths of cables for vertical cabling between floors
  - The types and lengths of cables for horizontal cabling within floors
  - The types and lengths of cables for work-area cabling going from telecommunications closets to workstations

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## Centralized vs. Distributed Cabling Topologies

- A centralized cabling scheme terminates most or all of the cable runs in one area of the design environment.
  - A star topology is an example of a centralized system.
- A distributed cabling scheme terminates cable runs throughout the design environment.
  - Ring, bus, and tree topologies are examples of distributed systems.

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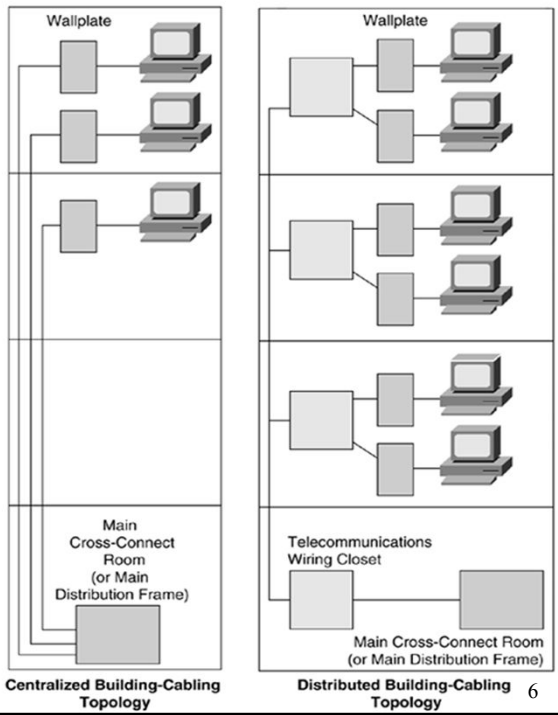
## Intra-Building

Centralized Campus Cabling

Vs.

Distributed Campus Cabling

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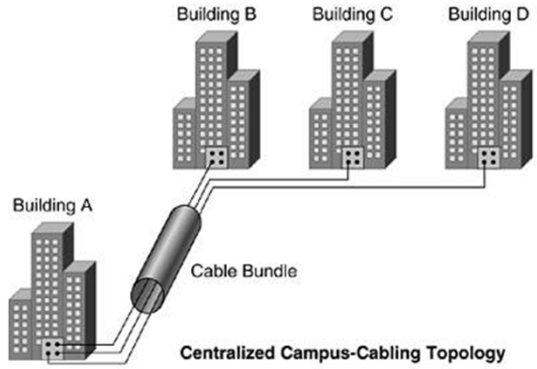
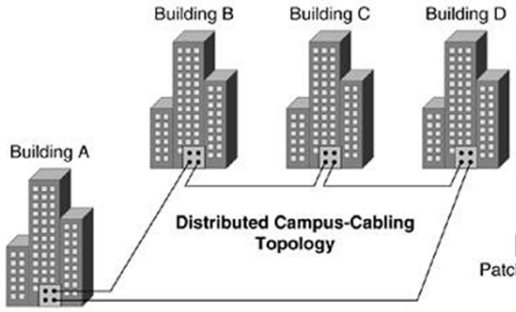
## Inter-Building




Centralized Campus-Cabling Topology

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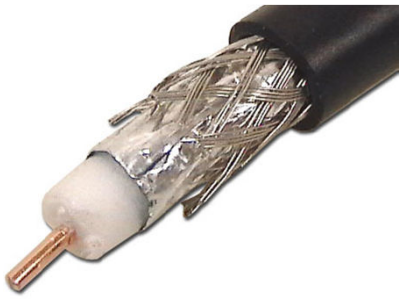
## Types of Media Used in Campus Networks

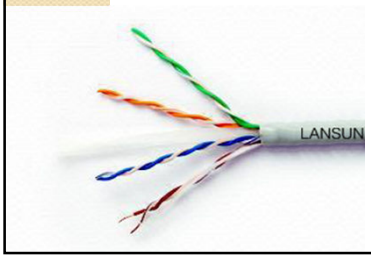
Copper media

Coaxial

UTP

STP



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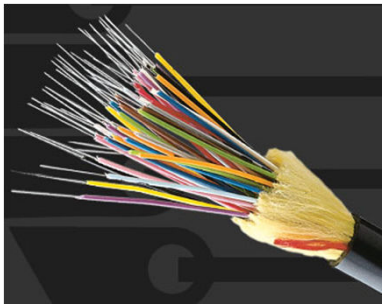
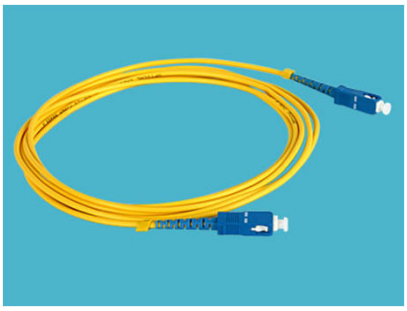
## Types of Media Used in Campus Networks

Optical media





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## Wireless Media

- IEEE 802.11a, b, g, and n
- Laser
- Microwave
- Cellular
- Satellite

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## Copper Media Advantages

- Conducts electric current well
- Does not rust
- Can be drawn into thin wires
- Easy to shape
- Hard to break

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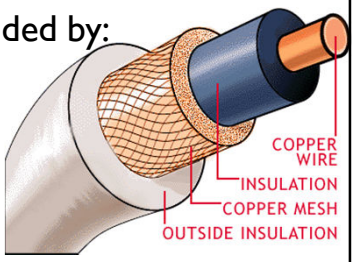
## Coaxial Cable

- Solid copper conductor, surrounded by:
  - Flexible plastic insulation
  - Braided copper shielding
  - Outer jacket




- Can be run without as many boosts from repeaters, for longer distances between network nodes, than either STP or UTP cable
  - Nonetheless, it's no longer widely used

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## Twisted-Pair Cabling

- A "twisted pair" consists of two copper conductors twisted together
- Each conductor has plastic insulation
- Shielded Twisted Pair (STP)
  - Has braided-mesh covering that encases each pair
- Unshielded Twisted Pair (UTP)
  - No braided-mesh covering around pairs, so it's less expensive

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## UTP Categories

- Category 1. Used for voice communication
- Category 2. Used for voice and data, up to 4 Mbps
- Category 3. Used for data, up to 10 Mbps
- Category 4. Used for data, up to 16 Mbps
- Category 5. Used for data, up to 100 Mbps
- Category 5e. Used in Gigabit Ethernet
- Category 6. Used in Gigabit Ethernet and future technologies

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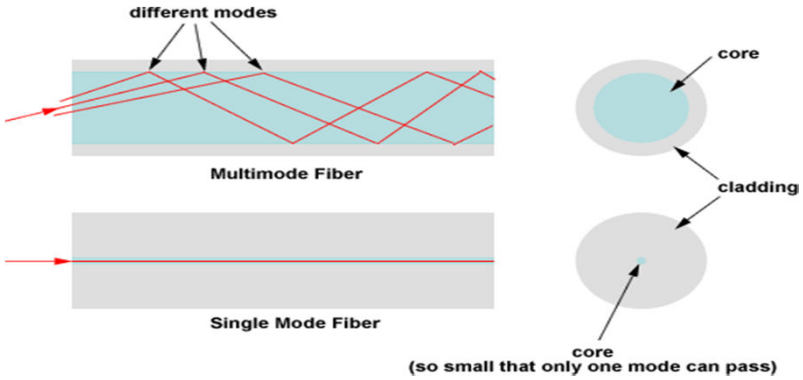
## Fiber-Optic Cable




Contains glass or plastic fibers at core surrounded by layer of glass or plastic cladding. Reflects light back to core

- Multimode Fiber (MMF)
- Single-mode Fiber (SMF)

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## Multimode

- Large core diameter
- Beams of light bounce off cladding in multiple ways
- Usually uses LED source
- Less expensive
- Short distances

## Single-mode

- Small core diameter
- Less bouncing around; single, focused beam of light
- Usually uses LASER source
- More expensive
- Very long distances

 

## Copper Vs. Fiber-Optic Cabling

- Twisted-pair and coax cable transmit network signals in the form of current
- Fiber-optic cable transmits network signals in the form of light
- Fiber-optic cable is made of glass
  - Not susceptible to electromagnetic or radio frequency interference
  - Not susceptible to attenuation, which means longer cables are possible
  - Supports very high bandwidth (10 Gbps or greater)
  - For long distances, fiber costs less than copper

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## Cabling Guidelines

- At the access layer use
  - Copper UTP rated for Category 5 or 5e, unless there is a good reason not to
  - To future proof the network
    - Use 5e instead of 5
    - Install UTP Category 6 rated cable and terminate the cable with Cat 5 or 5e connectors
    - Then only the connectors need to be changed to move up in speed
  - In special cases
    - Use MMF for bandwidth intensive applications
    - Or install fiber along with the copper

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## Cabling Guidelines

- At the distribution layer use
  - MMF if distance allows
  - SMF otherwise
  - Unless unusual circumstances occur and cable cannot be run, then use a wireless method
  - To future proof the network
    - Run both MMF and SMF

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## LAN Technologies

- Half-duplex Ethernet (becoming obsolete)
- Full-duplex Ethernet
- 10-Mbps Ethernet (becoming obsolete)
- 100-Mbps Ethernet
- 1000-Mbps (1-Gbps or Gigabit) Ethernet
- 10-Gbps Ethernet
- Metro Ethernet
- Long Range Ethernet (LRE)
- Cisco's EtherChannel

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## Metro Ethernet

- Service offered by providers and carriers that traditionally had only classic WAN offerings
- The customer can use a standard Ethernet interface to reach a MAN or WAN
- The customer can add bandwidth as needed with a simple configuration change

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## Long-Reach Ethernet

- Enables the use of Ethernet over existing, unconditioned, voice-grade copper twisted-pair cabling
- Used to connect buildings and rooms within buildings
  - Rural areas
  - Old cities where upgrading cabling is impractical
  - Multi-unit structures such as hotels, apartment complexes, business complexes, and government agencies

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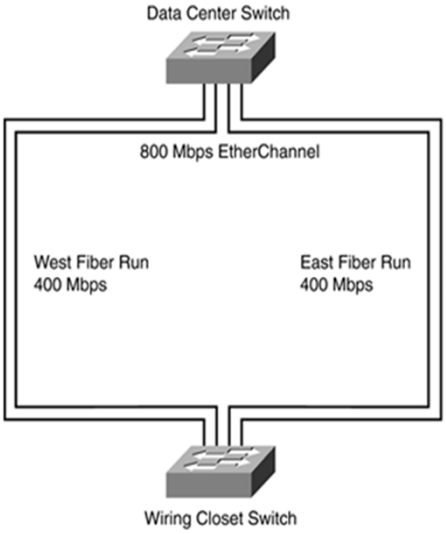
## Cisco's EtherChannel

- A trunking technology that groups links together so that the links can provide extremely high speeds, support load sharing, and back each other up if one link fails
- XOR operation on the last two bits of the source and destination addresses in a frame.
- The XOR operation can result in one of four values that are mapped to the four possible links

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## Internetworking Devices for Campus Networks

- Switches
- Routers
- Wireless access points
- Wireless bridges

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## Selection Criteria for Internetworking Devices

- The number of ports
- Processing speed
- The amount of memory
- Latency when device relays data
- Throughput when device relays data
- LAN and WAN technologies supported
- Media supported

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## More Selection Criteria for Internetworking Devices

- Cost
- Ease of configuration and management
- MTBF and MTTR
- Support for hot-swappable components
- Support for redundant power supplies
- Quality of technical support, documentation, and training
- Etc.

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# Top-Down Network Design

Chapter Eleven

## Selecting Technologies and Devices for Enterprise Networks



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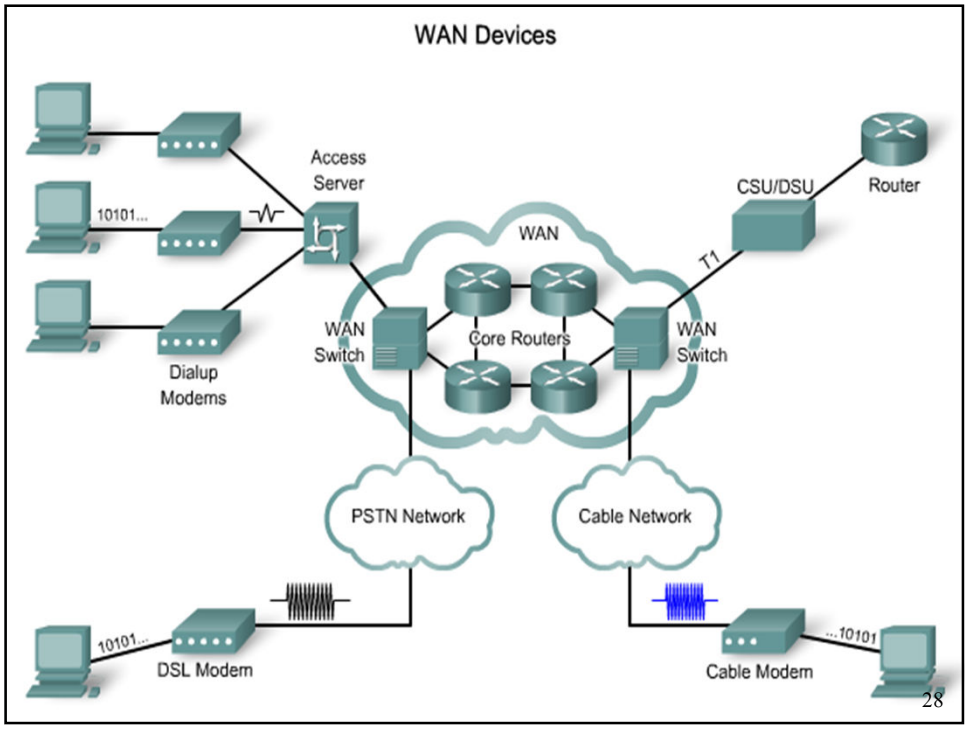


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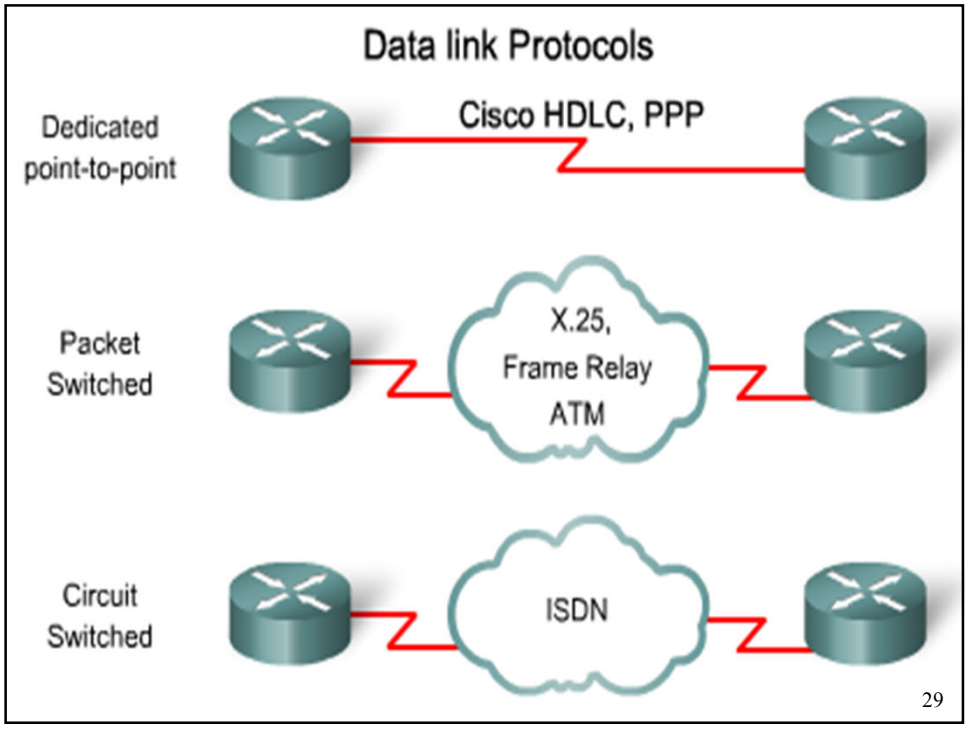


## Enterprise Technologies and Devices

- Remote access networks
- Wide area networks (WANs)
- Devices
  - End user remote access devices
  - Central site remote access devices
  - VPN concentrators
  - Routers

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## Selection Criteria

- Business requirements and constraints
- Cost
- Technical goals
- Bandwidth requirements
- QoS requirements
- Network topology
- Traffic flow and load
- Etc.

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## Remote Access Technologies

- The Point-to-Point Protocol (PPP)
- Integrated Services Digital Network (ISDN)
- Cable modems
- Digital Subscriber Line (xDSL)

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## Point-to-Point Protocol (PPP)

- Used with synchronous, asynchronous, dial-up, and ISDN links
- Defines encapsulation scheme for transport of different network-layer protocols
- Supports authentication:
  - Password Authentication Protocol (PAP)
  - Challenge Handshake Authentication Protocol (CHAP)
    - CHAP more secure than PAP

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## Point-to-Point Protocol (PPP)

HDLC is the default encapsulation method between Cisco routers.

Use PPP encapsulation to connect to a non-Cisco router.

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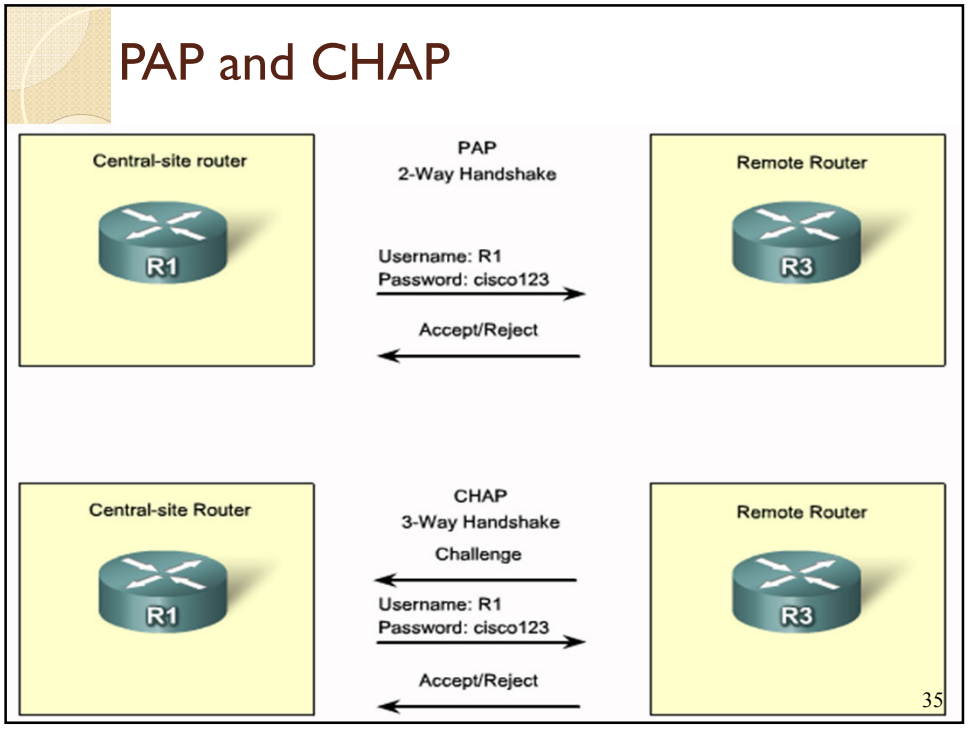


## Line types and Bandwidth

| Line Type | Bit Rate Capacity |
|---|---|
| 56 | 56 kb/s |
| 64 | 64 kb/s |
| T1 | 1.544 Mb/s |
| E1 | 2.048 Mb/s |
| J1 | 2.048 Mb/s |
| E3 | 34.064 Mb/s |
| T3 | 44.736 Mb/s |
| OC-1 | 51.84 Mb/s |
| OC-3 | 155.54 Mb/s |

| Line Type | Bit Rate Capacity |
|---|---|
| OC-9 | 466.56 Mb/s |
| OC-12 | 622.08 Mb/s |
| OC-18 | 933.12 Mb/s |
| OC-24 | 1244.16 Mb/s |
| OC-36 | 1866.24 Mb/s |
| OC-48 | 2488.32 Mb/s |
| OC-96 | 4976.64 Mb/s |
| OC-192 | 9953.28 Mb/s |
| OC-768 | 39813.12 Mb/s |

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## ISDN

- Digital data-transport service offered by regional telephone carriers (telcos)
- Circuit-switched service that carries voice and data
- Cost-effective remote-access solution for telecommuters and remote offices
  - Cost of an ISDN circuit is usually based on a monthly fee plus usage time
- Good choice as a backup link for another type of link, for example, Frame Relay

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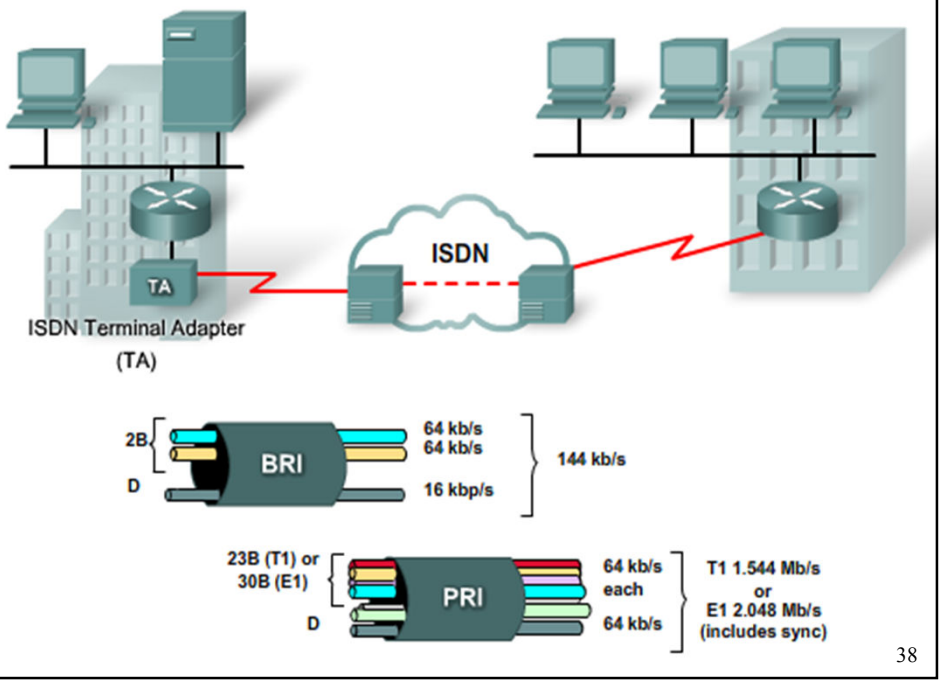


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## Cable Modem Service

- Operates over the coax cable used by cable TV
- Much faster than analog modems, and usually much faster than ISDN (depending on how many users share the cable)
  - 25 to 50 Mbps downstream from the head end
  - 2 to 3 Mbps upstream from end users
- Standard = Data Over Cable Service Interface Specification (DOCSIS). DOCSIS is a standard for certification of cable equipment vendor devices

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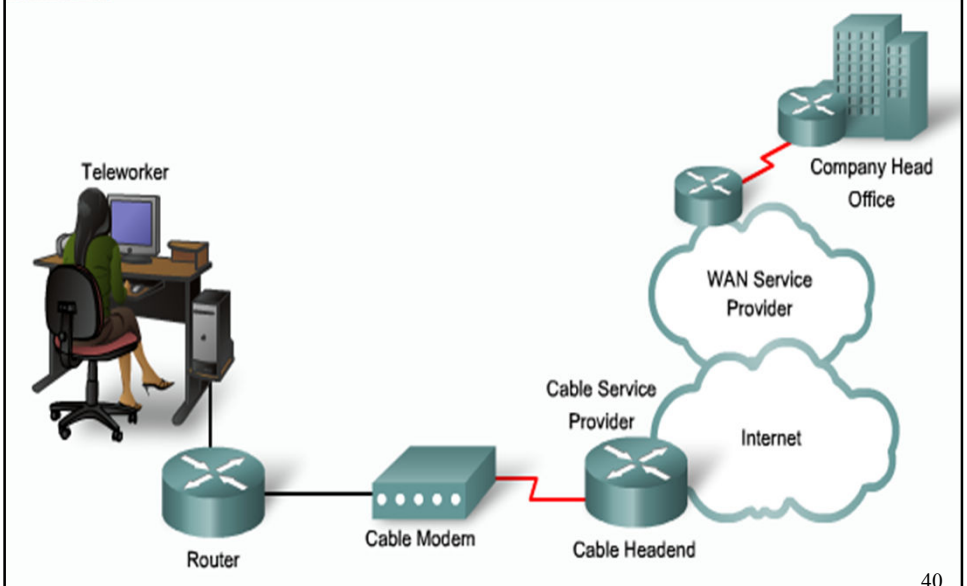
## Cable Modem Service

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## Digital Subscriber Line (DSL)

- High-speed digital data traffic over ordinary telephone wires
- Sophisticated modulation schemes mean higher speeds than ISDN
  - Speeds range from 1.544 to 9 Mbps
- Actual bandwidth depends on type of DSL service, DSL modem, and many physical-layer factors
- Asymmetric DSL (ADSL) very popular
  - Downstream faster than upstream
- SDSL, VDSL, ...

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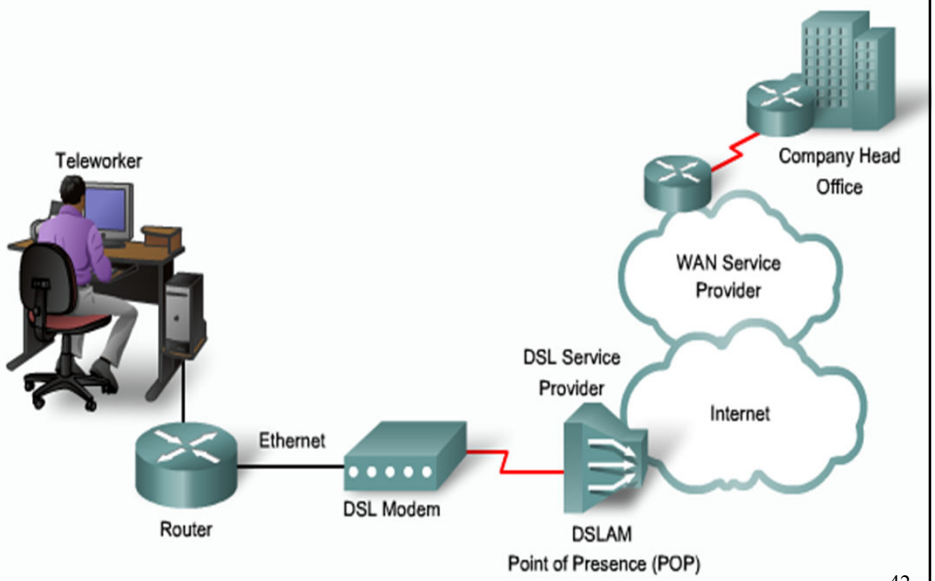
## DSL

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## WAN Technologies

- Leased lines
- Frame Relay
- Asynchronous Transfer Mode (ATM)

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## Leased Lines

- Dedicated digital, copper circuits that a customer leases from a carrier for a predetermined amount of time, usually for months or years
- Speeds range from 64 Kbps to 45 Mbps
- Enterprises use leased lines for both voice and data traffic

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## Frame Relay

- Industry-standard data-link-layer protocol for transporting traffic across wide-area virtual circuits
- Optimized for efficiency on circuits with low error rates
- Attractively-priced in most parts of the world
- Carriers agree to forward traffic at a Committed Information Rate (CIR)
- Frame Relay offers data rates up to 45 Mbps

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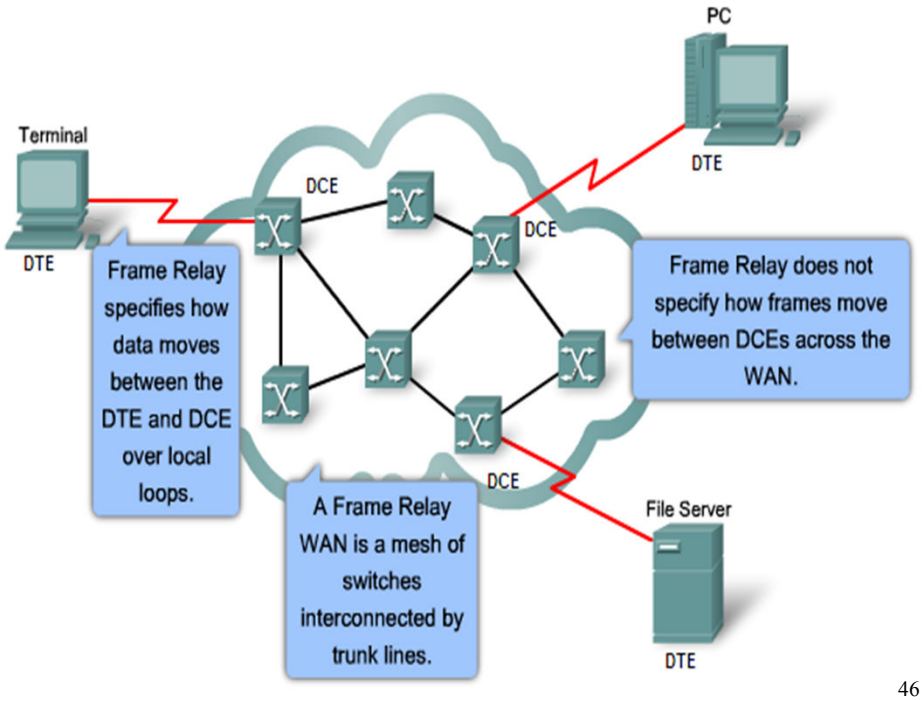


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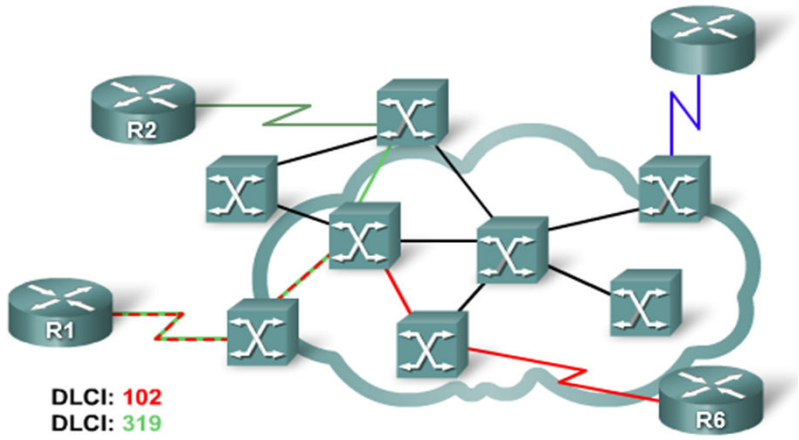
## Frame Relay (continued)




Multiple VCs on the same access link are distinguishable by the DLCI.

DLCI - Data Link Connection Identifier.
Value that specifies a PVC or SVC in a FR network

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## Asynchronous Transfer Mode (ATM)

- Used in service provider internal networks
- Gaining popularity within private networks, both WANs and sometimes LANs
- Supports very high bandwidth requirements
  - ATM was designed to be extremely scalable and can support link speeds of T1/E1 to OC-12 (622 Mb/s) and higher.

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## ATM (continued)

- Provides efficient sharing of bandwidth among applications with various Quality of Service (QoS) requirements
  - Cell-based system inherently better for QoS than frames
- Application can specify upon connection establishment the QoS it requires
- Peak and minimum cell rates, cell-loss ratio, and cell-transfer delay

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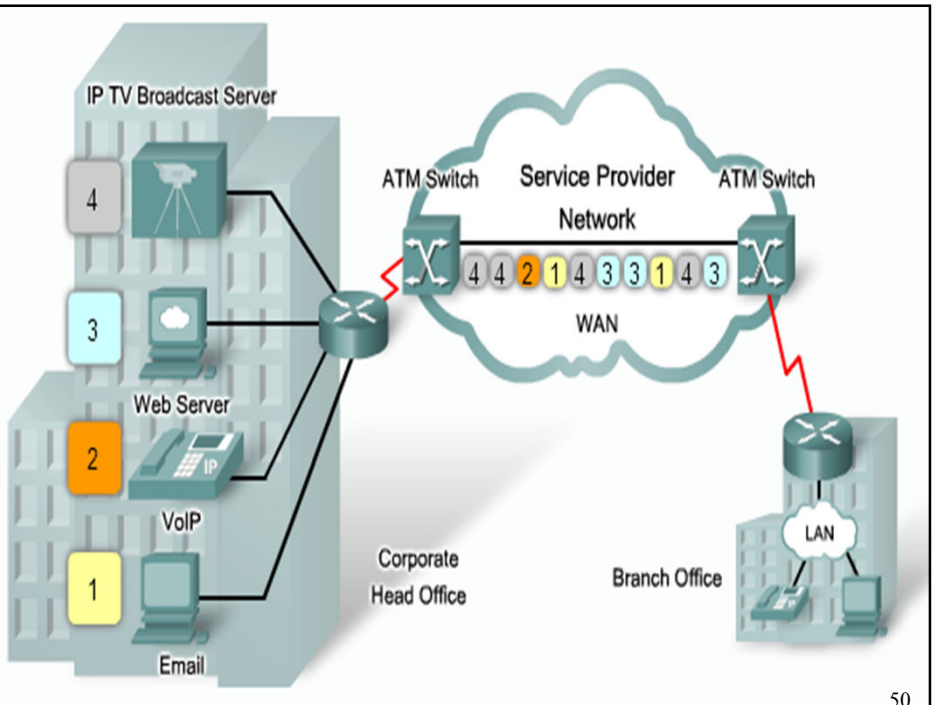


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## Ethernet over ATM

- ATM router interfaces are expensive
- Some providers allow a customer to use an Ethernet interface to access the provider's ATM WAN
- May require a converter
- Expected to gain popularity because it has the advantages of both worlds
  - Easy-to-use LAN
  - QoS-aware WAN

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## Selection Criteria for Remote Access Devices

- Support for VPN features
- Support for NAT
- Reliability
- Cost
- Ease of configuration and management
- Support for one or more high-speed Ethernet interfaces
- If desired, wireless support
- Etc.

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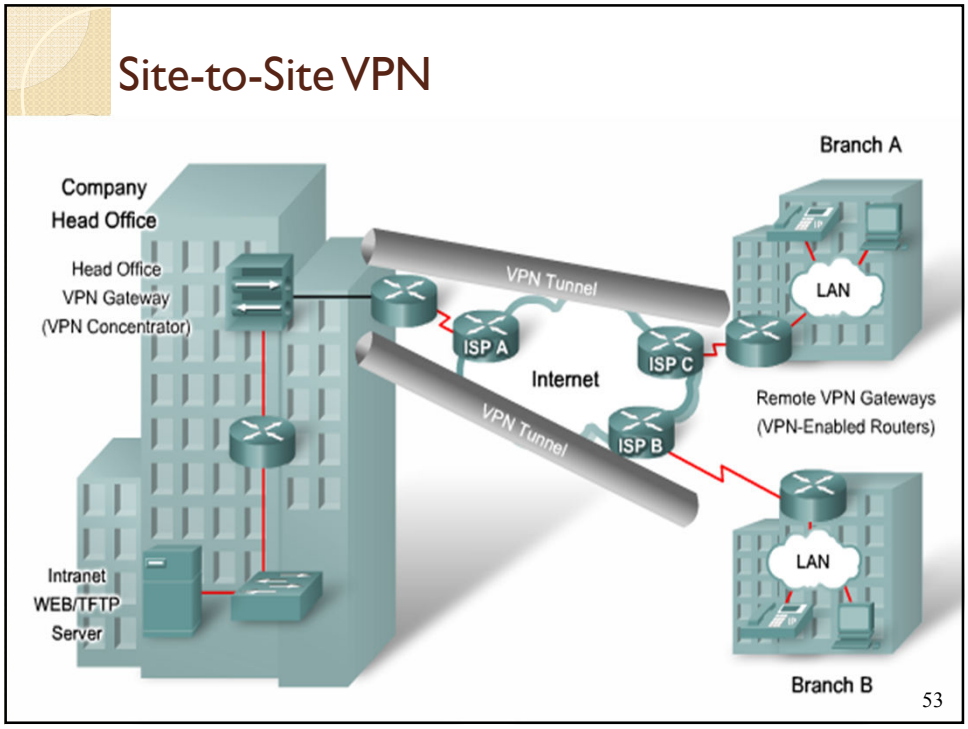
Site-to-Site VPN
Branch A
Company
Head Office
Head Office
VPN Gateway
(VPN Concentrator)
VPN Tunnel
LAN
ISP A
ISP C
Internet
Remote VPN Gateways
(VPN-Enabled Routers)
VPN Tunnel
ISP B
LAN
Intranet
WEB/TFTP
Server
Branch B
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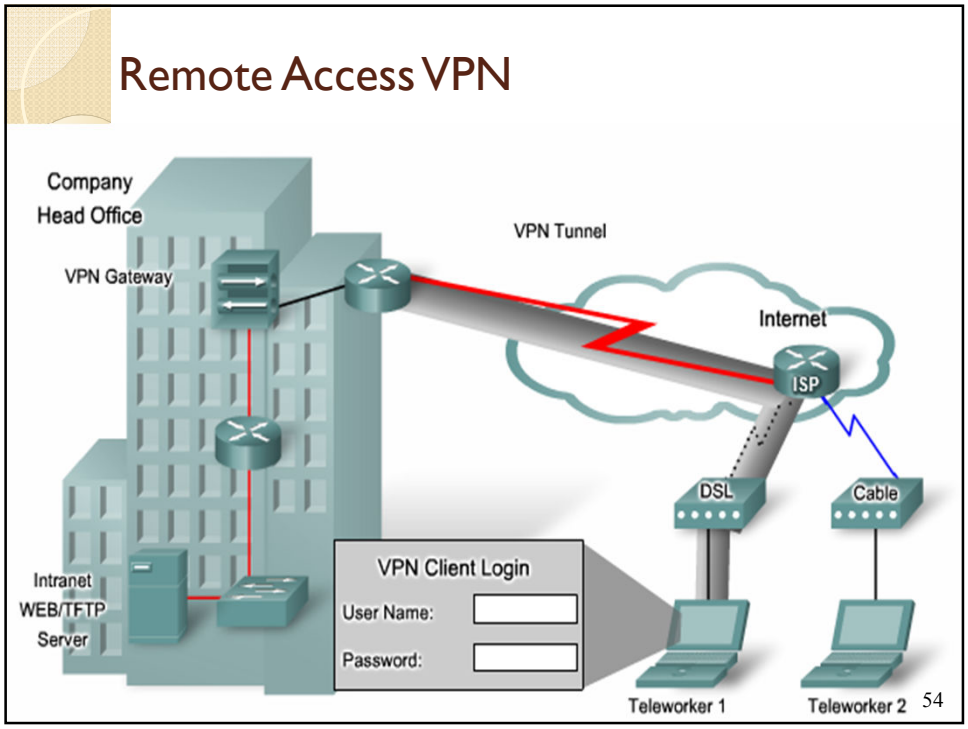
Remote Access VPN
Company
Head Office
VPN Tunnel
VPN Gateway
Internet
ISP
DSL
Cable
VPN Client Login
User Name:
Password:
Intranet
WEB/TFTP
Server
Teleworker 1
Teleworker 2
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## Selection Criteria for VPN Concentrators

- Support for:
  - Tunneling protocols such as IPSec, PPTP, and L2TP
  - Encryption algorithms such as 168-bit Triple DES, Microsoft Encryption (MPPE), RC4, AES
  - Authentication algorithms, including MD5, SHA-1, HMAC
  - Network system protocols, such as DNS, RADIUS, Kerberos
  - Routing protocols
  - Certificate authorities
  - Network management using SSH or HTTP with SSL
  - Etc.

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## Selection Criteria for Enterprise Routers

- Number of ports
- Processing speed
- Media and technologies supported
- MTTR and MTBF
- Throughput
- Optimization features
- Etc

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## Selection Criteria for a WAN Service Provider

- Extent of services and technologies
- Geographical areas covered
- Reliability and performance characteristics of the provider's internal network
- The level of security offered by the provider
- The level of technical support offered by the provider
- The likelihood that the provider will continue to stay in business

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## Selecting a Provider (continued)

- The provider's willingness to work with you to meet your needs
- The physical routing of network links
- Redundancy within the network
- The extent to which the provider relies on other providers for redundancy
- The level of oversubscription on the network
- QoS support
- Etc.

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## Summary

- Once the logical design is completed, the physical design can start
- A major task during physical design is selecting technologies and devices for campus networks
  - Media
  - Data-link layer technology
  - Internetworking devices
- Also, at this point, the logical topology design can be developed further by specifying cabling topologies

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## Summary

- A major task during the physical design phase is selecting technologies and devices for enterprise networks
  - Remote access networks
  - WANs
  - Service providers
  - Devices
    - End user remote access devices
    - Central site remote access devices
    - VPN concentrators
    - Routers

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## Review Questions

- What are three fundamental media types used in campus networks?
- What selection criteria can you use to select an Ethernet variety for your design customer?
- What selection criteria can you use when purchasing internetworking devices for your design customer?
- Some people think Metro Ethernet will replace traditional WANs. Do you agree or disagree and why?

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## Review Questions

- Compare and contrast technologies for supporting remote users.
- Compare and contrast WAN technologies.
- What selection criteria can you use when purchasing internetworking devices for enterprise network customers?
- What criteria can you use when selecting a WAN service provider?

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