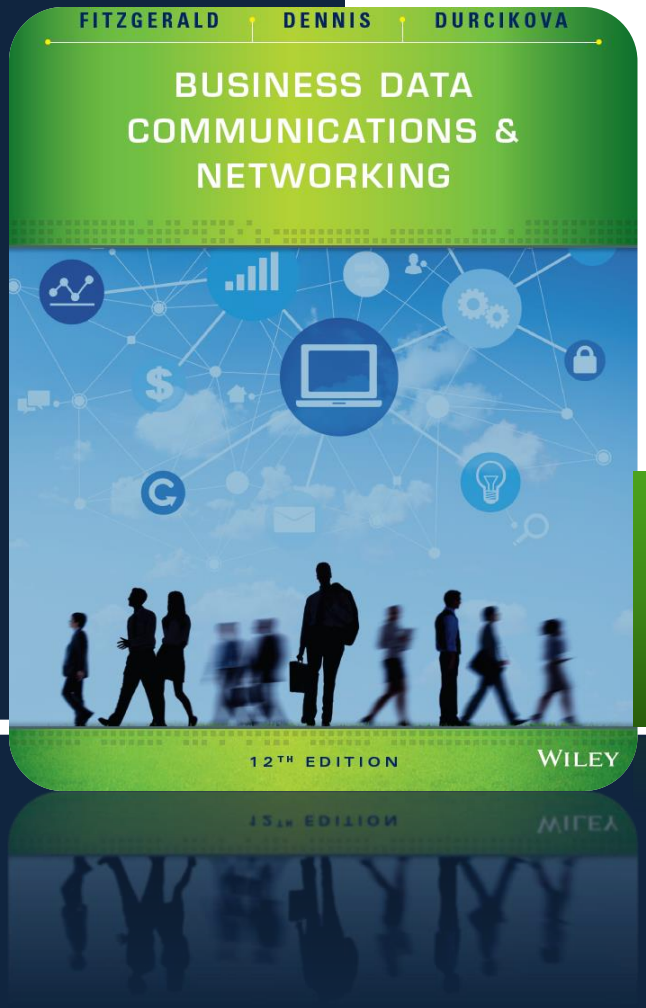

BUSINESS DATA COMMUNICATIONS & NETWORKING

Chapter 10

The Internet

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Outline

- Background
- Internet Architecture
- Internet Access Technologies
  - DSL
  - Cable
  - Fiber to the Home
  - Wireless
- Internet Governance
- Implications for Management

The Internet

- Most used network in the world
- Network of networks
  - Various networks managed by for-profit, non-profit, and government organizations
- Organizations use standardized protocols to communicate
- Few controls over content and applications

The Internet

- The **World Wide Web (WWW)** ≠ the Internet
- WWW is about content, specifically hyperlinked content
- The Internet is the transport mechanism that enables the WWW and other services

Internet Architecture

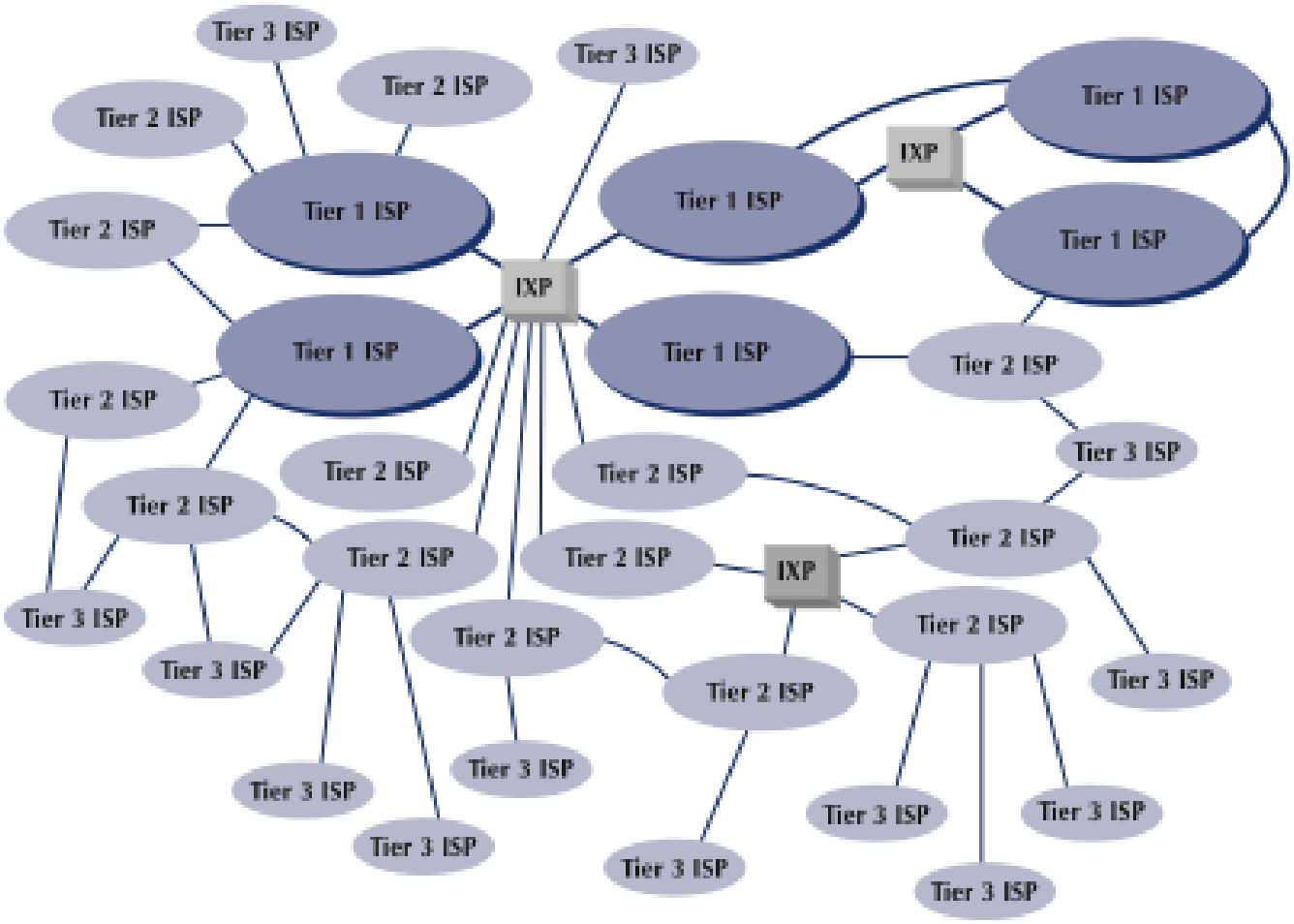
- **Internet service providers (ISPs)** connect the networks of their customers to the Internet
- Hierarchy of ISPs by size
  - Tier 1 - National ISPs
  - Tier 2 - Regional ISPs
  - Tier 3 - Local ISPs

Internet Architecture

- Connections between ISPs
  - Historically, lower-tier ISPs purchased connections to higher-tier ISPs
  - Most interconnections between ISPs occurs at **Internet exchange points (IXPs)**

Internet Architecture

FIGURE 10-2 Basic Internet architecture.
ISP = Internet service provider and IXP = Internet exchange point



Internet Architecture

- ISPs are **autonomous systems** and share routing info using BGP
- Service charges
  - Higher-tier ISPs charge lower-tier ISPs for data transfer
  - ISPs at the same tier typically do not charge each other
    - Called ***peering***
    - One of the primary reasons for IXPs

Internet Architecture

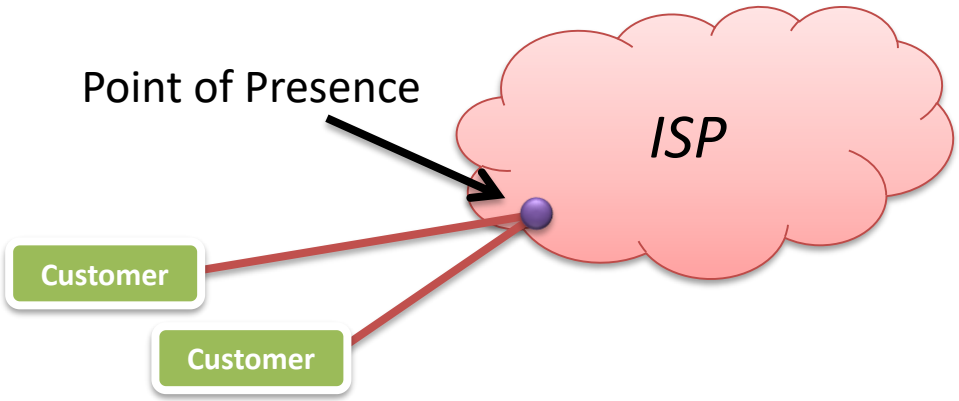
FIGURE 10-3 A typical Internet backbone of a major ISP

Internet Architecture

- ISP backbone
  - Larger backbone connections operating at OC-192 (10 Gbps) and experimenting with OC-768 (40 Gbps) and OC-3072 (160 Gbps)
  - Require faster backbone switches and routers
  - Internet peak traffic estimated to reach 1 Pbps by 2018

Connecting to an ISP

- A **point of presence (POP)** is the location where an ISP provides service to its customers
- The POP connects to the rest of the ISP's network
- Authentication is performed at the POP



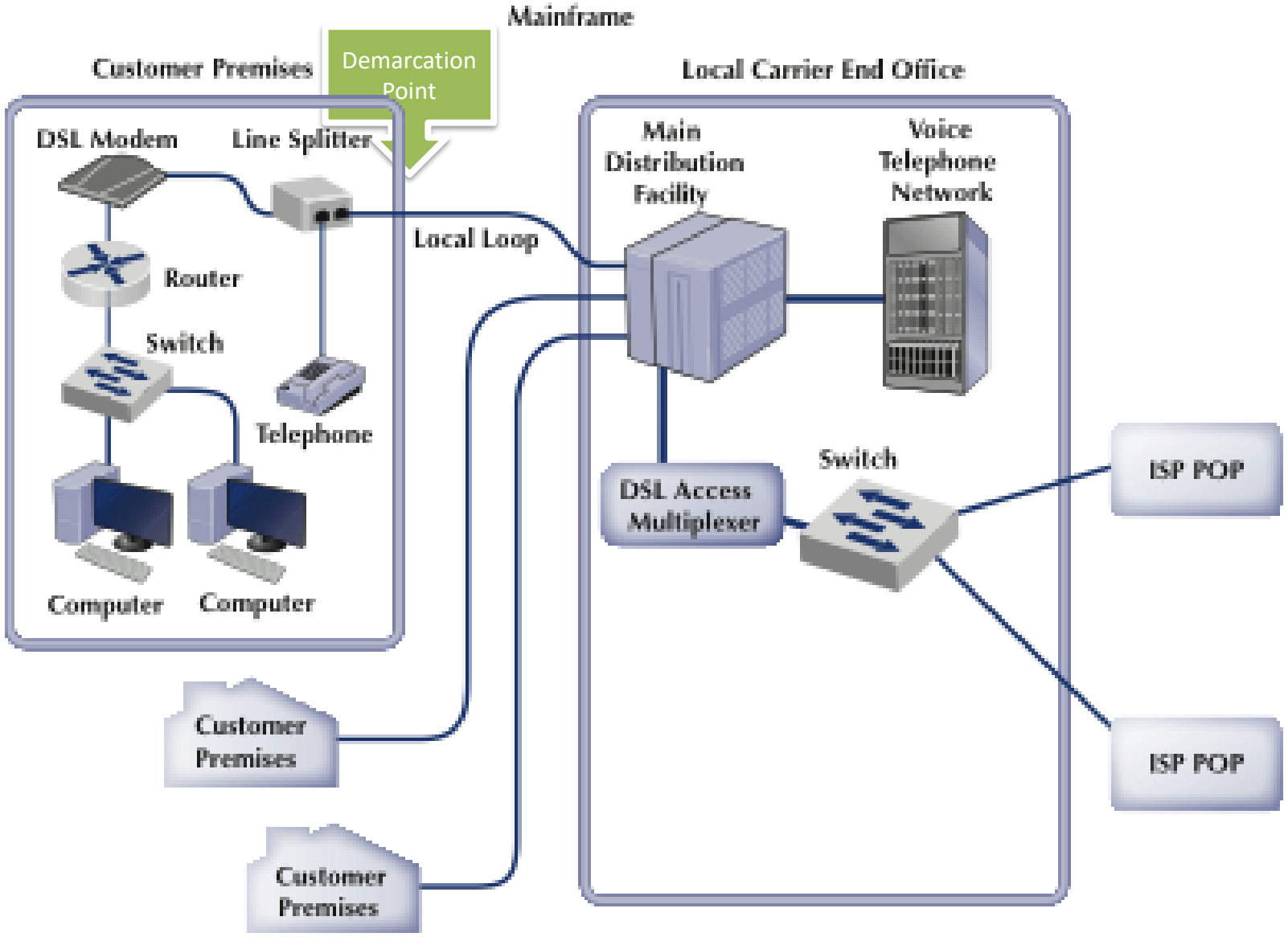
Internet Access Technologies

- Some organizations use WAN technologies to connect to their ISP
- Common **broadband technologies** to connect to ISPs include:
  - Digital subscriber line (DSL)
  - Cable
  - Fiber to the Home (FTTH)
  - Wireless (e.g., WiMAX)

Digital Subscriber Line (DSL)

- A family of point-to-point technologies usually offered by telephone companies
- Provides high-speed transmissions over traditional telephone wires
- **Customer premises equipment (CPE)** includes a **DSL modem** and **line splitter**
- The **local loop** (or last mile) is the circuit from the customer premises to the ISP's office containing the **main distribution facility (MDF)**

FIGURE 10-4 Digital subscriber line (DSL) architecture. ISP = Internet service provider and POP = point of presence



Digital Subscriber Line (DSL)

- Many DSL technologies exist, but the most commonly implemented include:
  - **Asymmetric DSL (ADSL)**
    - 3 channels of different width (voice, downstream, upstream)
    - Downstream bandwidth greater than upstream
    - Bandwidth dependent on distance from equipment
  - **Very-high-data-rate DSL (VDSL)**
    - Similar to ADSL, but with higher data rates and shorter range
    - Often paired with fiber circuits to the node
    - May be used for high definition television in addition to data and voice transmission

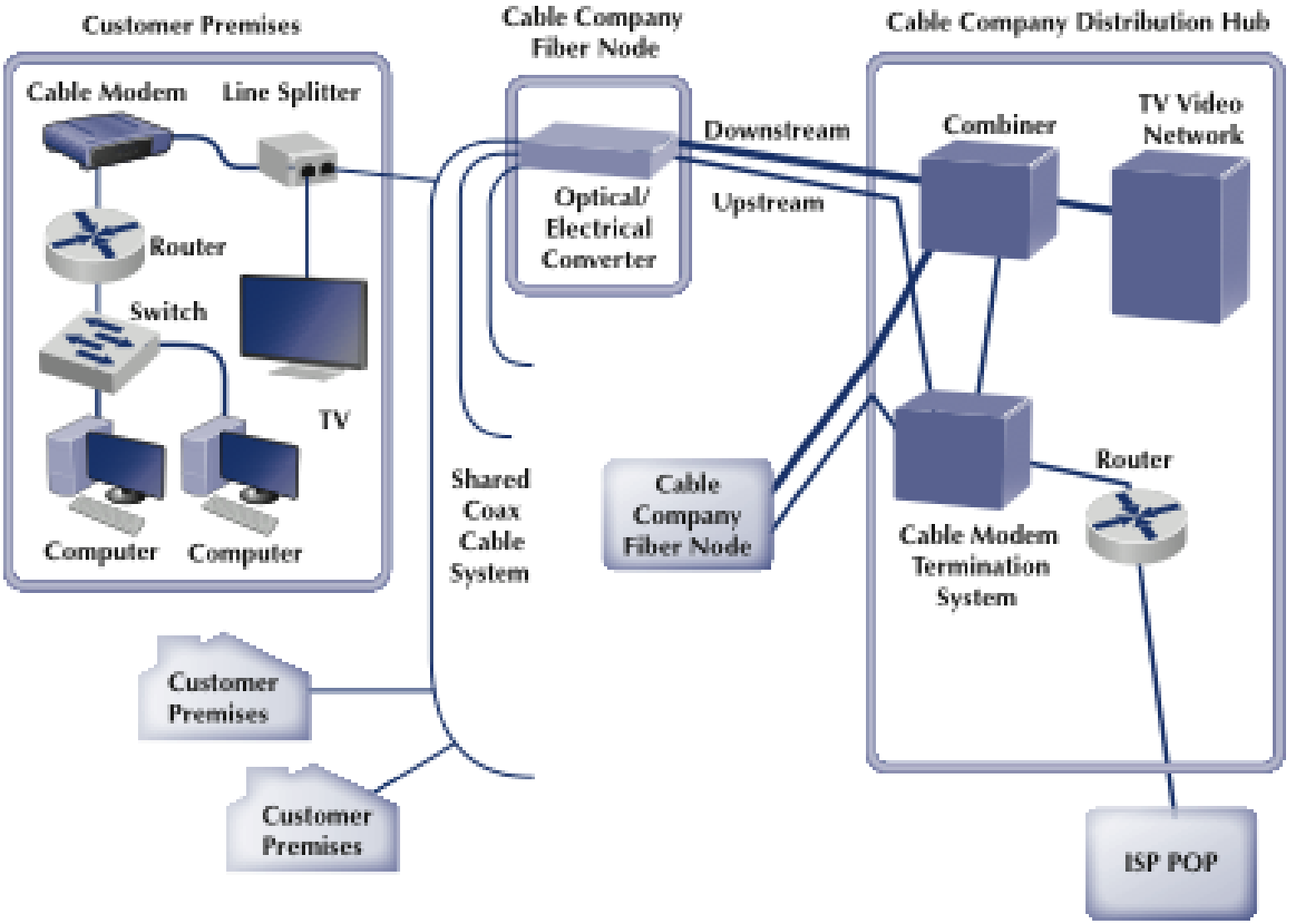
Cable

- Alternative to DSL offered by cable television companies
- Most cable ISPs use **hybrid fiber coaxial (HFC)** networks with coaxial cables in the customer premises
- Cable networks are multipoint (shared) while DSL is point-to-point
  - Shared bandwidth
  - Potential issues with security

Cable

- **Data over cable service interface specification (DOCSIS)** is a set of standards used by cable ISPs
- The newest DOCSIS standards support data rates over 1 Gbps, but few ISPs have deployments that support these speeds
- The **cable modem** at the customer's premises are configured to "cap" the bandwidth at a maximum rate specified by contract

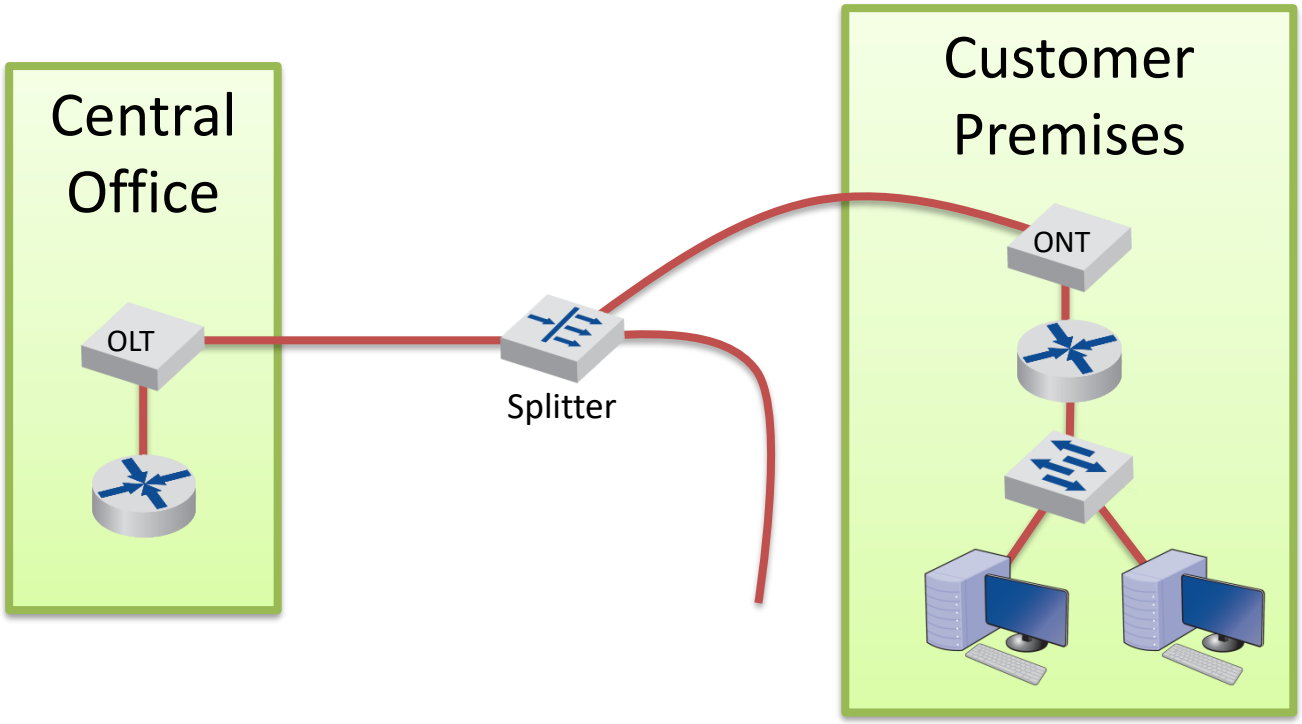
FIGURE 10-6 Cable modem architecture.
ISP = Internet service provider and POP = point of presence



Fiber to the Home (FttH)

- A dedicated point-to-point fiber optic service
- Architecturally similar to DSL and cable
- Expensive to deploy and these networks are emerging slowly

Fiber to the Home (FttH)



Wireless

- **Worldwide interoperability for microwave access (WiMax)**
  - 802.16 wireless standard fixed/mobile
  - Similar to the 802.11 WiFi standards, but with longer range
  - One implementation of 4G mobile wireless
  - Maximum theoretical range is ~30 miles
  - Maximum theoretical data rate is ~70 Mbps
  - The WiMax standard includes possible use 2-66 GHz frequency bands, but only 2.3, 2.5, 3.5, and 5.8 GHz bands are used in North America

Wireless

- **Long-term evolution (LTE)** and **LTE advanced**
  - A 3GPP wireless standard for mobile devices
  - Upgrade to GSM and CDMA data networks
  - Frequencies from 700 MHz – 2.7 GHz are used in various countries
- **Satellite**
  - Primarily used by rural customers
  - Issues of high latency and low data rates
  - Two-way vs. one-way

Internet Governance

- No single organization governs the Internet
- The Internet Society (ISOC)
  - Internet Architecture Board (IAB)
  - Internet Engineering Task Force (IETF)
  - Internet Engineering Steering Group (IESG)
  - Internet Research Task Force (IRTF)
- Internet Corporation for Assigned Names and Numbers (ICANN)
- Internet Governance Forum (IGF)
- International Telecommunication Union (ITU)

Internet Governance

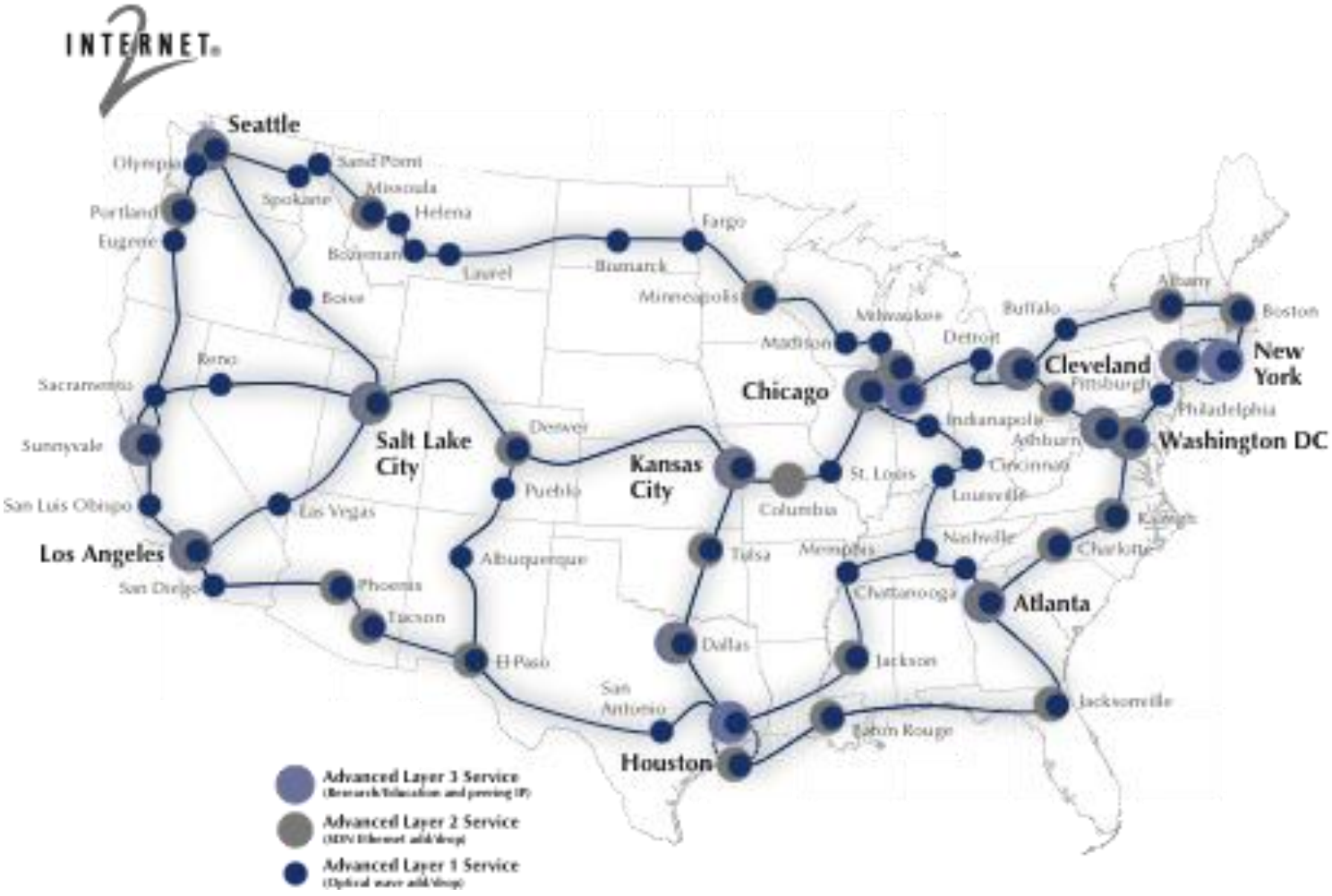
- Issue of **Net neutrality**
  - Should all messages on the Internet be treated equally?
  - Can ISPs regulate (or discriminate) data that runs through their networks based on source, destination, protocol, or content?

Building the Future Internet

- Internet continues to evolve and improve, often through a combination of commercial and governmental research projects
- Internet2
  - US National Science Foundation (NSF) project started in 1996
  - Used by more than 500 organizations to develop advanced networks and network management tools

Building the Future Internet

FIGURE 10-7 Internet2 network map. Reproduced by permission of Internet2®



Implications for Management

- The Internet continues to increase its capacity
- Broadband Internet data rates continue to increase
- Mobile Internet access is rapidly growing, disrupting the ISP market