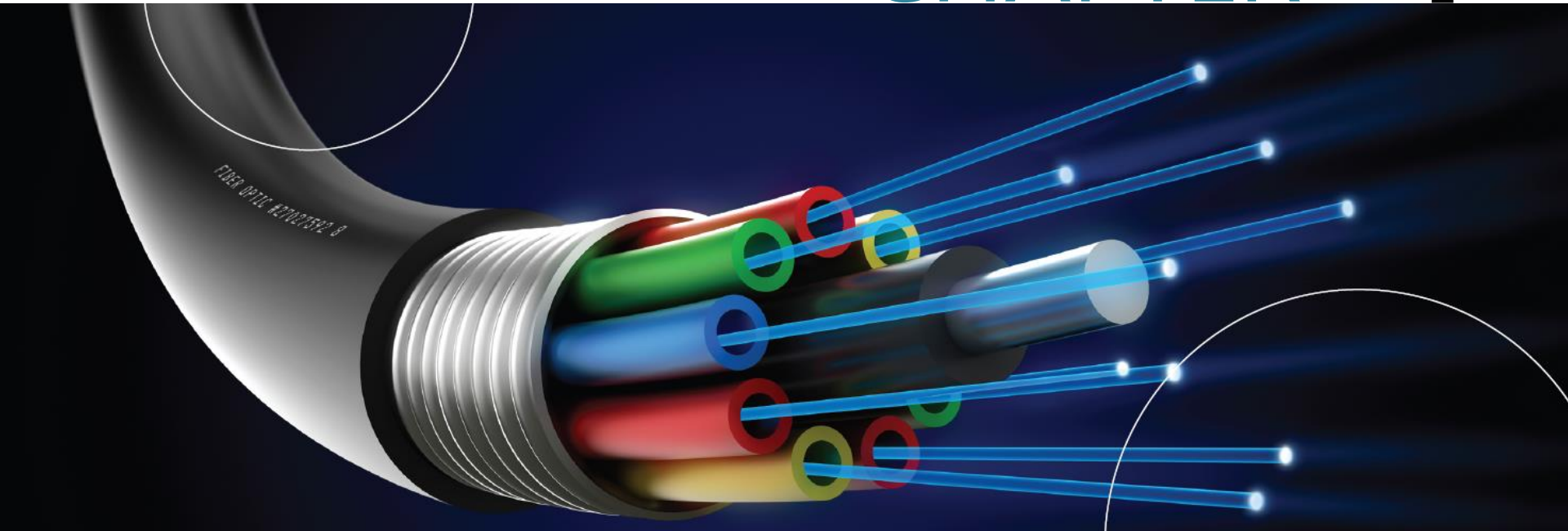# Telecommunications and Networking

# CHAPTER OUTLINE

1. What Is a Computer Network?
2. Network Fundamentals
3. The Internet and the World Wide Web
4. Network Applications: Discovery
5. Network Applications: Communication
6. Network Applications: Collaboration
7. Network Applications: Education

# LEARNING OBJECTIVES

1. Compare and contrast the major types of networks.
2. Describe the wireline communications media and transmission technologies.
3. Describe the most common methods for accessing the Internet.
4. Explain the impact that discovery network applications have had on business and everyday life.

5. Explain the impact that communication network applications have had on business and everyday life.

6. Explain the impact that collaboration network applications have had on business and everyday life.

7. Explain the impact that educational network applications have had on business and everyday life.

# 4. Introduction

- **Computer networks are essential to modern organizations for many reasons.**
  - First, networked computer systems enable organizations to become more flexible so that they can adapt to rapidly changing business conditions.
  - Second, networks allow companies to share hardware, computer applications, and data across the organization and among different organizations.
  - Third, networks make it possible for geographically dispersed employees and workgroups to share documents, ideas, and creative insights. This sharing encourages teamwork, innovation, and more efficient and effective interactions. In addition, networks are a critical link between businesses, their business partners, and their customers.
- **Networks are essential tools for modern businesses**
- **Networking and the Internet are the foundations for commerce in the twenty-first century**

# 4.1 What Is a Computer Network?

- **Computer Network**
  - a system that connects computers and other devices (e.g., printers) via communications media so that data and information can be transmitted among them.
- **Bandwidth**
  - refers to the transmission capacity of a network; it is stated in bits per second.
  - Bandwidth ranges from narrowband (relatively low transmission capacity) to broadband (relatively high network capacity).
- **Broadband**
  - based on the Federal Communications Commission (FCC) 2010 definition, broadband is the transmission capacity of a communications medium faster than 25 megabits per second (Mbps) for download and 4 Mbps for upload.
  - The definition of broadband remains fluid.

# 4.1 What Is a Computer Network?

- Types of computer networks
  - personal area networks (PANs), local area networks (LANs), metropolitan area networks (MANs), wide area networks (WANs),
- Local Area Networks
  - connects two or more devices in a limited geographical region, usually within the same building, so that every device on the network can communicate with every other device.
- Wide Area Networks
  - a network that covers a large geographical area. WANs typically connect multiple LANs. They are generally provided by common carriers such as telephone companies and the international networks of global communications services providers.
  - WANs have large capacity, and they typically combine multiple channels (e.g., fiber-optic cables, microwave, and satellite). The Internet is an example of a WAN.
  - WANs also contain routers—a communications processor that routes messages from a LAN to the Internet, across several connected LANs, or across a WAN such as the Internet.
- Enterprise Networks
  - organizational interconnected networks consisting of multiple LANs and may also include multiple WAN's.

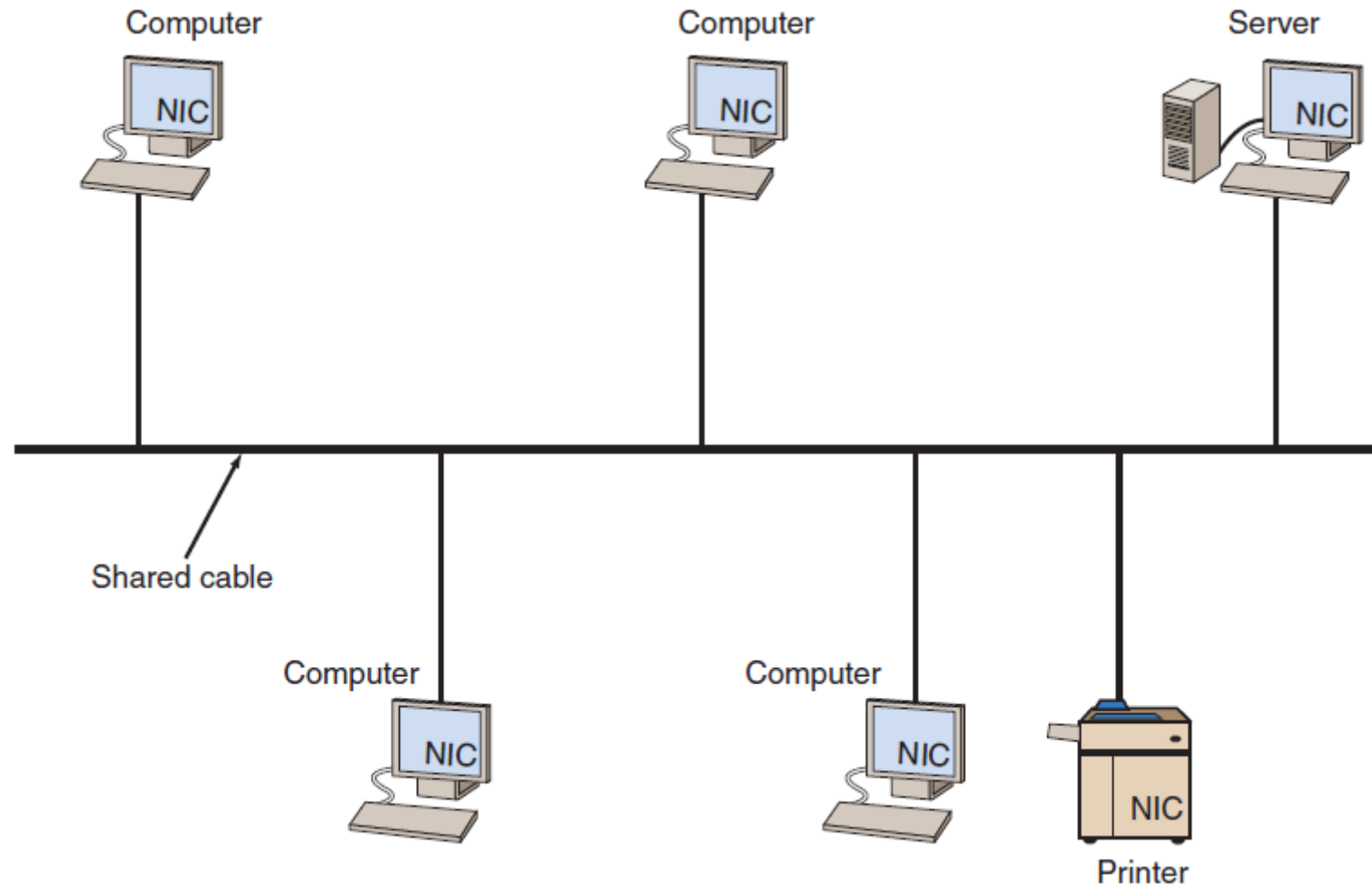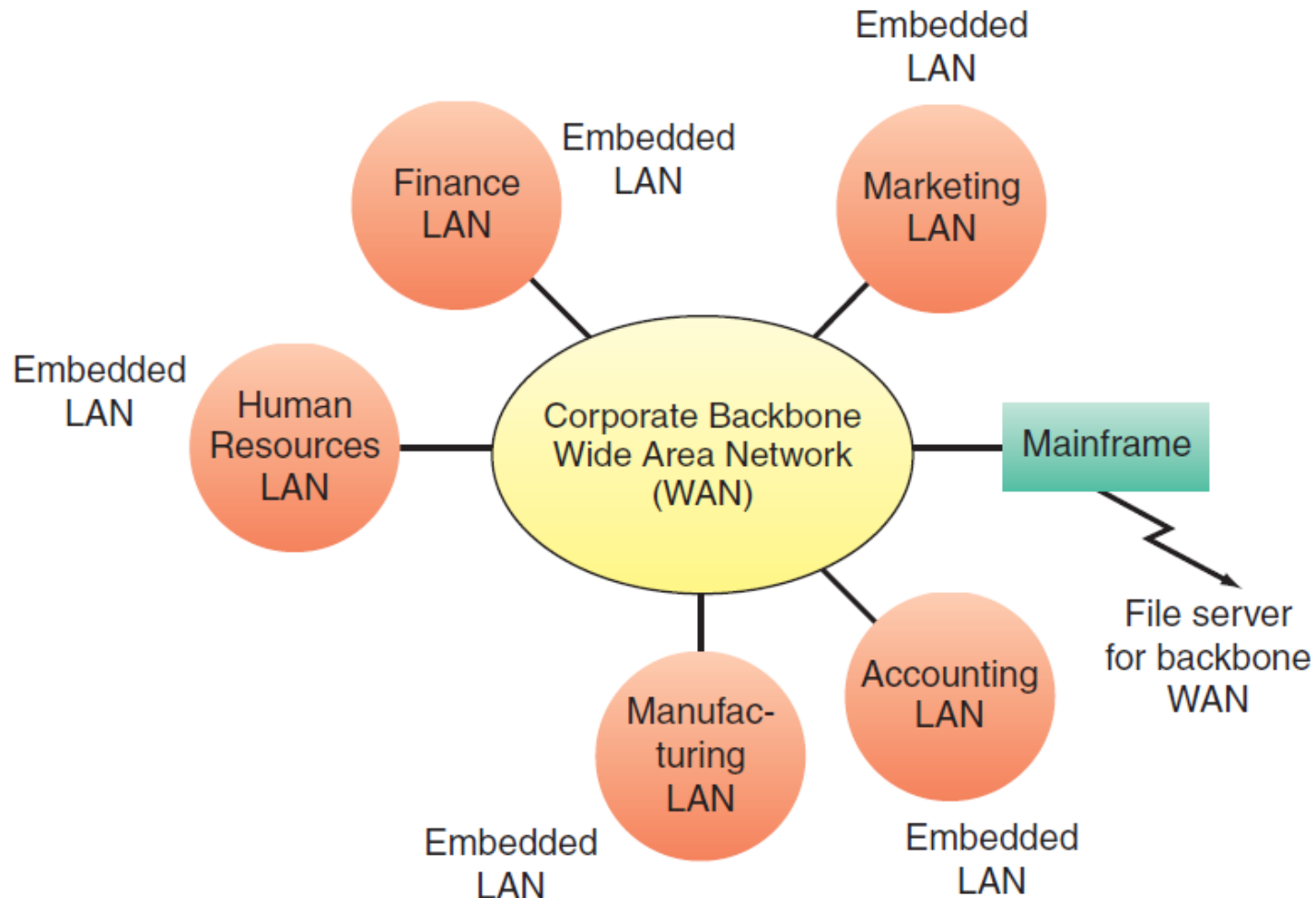# Figure 4.1: Ethernet Local Area Network (LAN)

# Figure 4.2: Enterprise Network

# 4.1 What Is a Computer Network?

- Traditional Networks
  - Traditional networks can be rigid and lack the flexibility to keep pace with increasing business networking requirements.
  - The reason for this problem is that the functions of traditional networks are distributed across physical routers and devices (i.e., hardware).
  - This process means that to implement changes, each network device must be configured individually. In some cases, devices must be configured manually. Wide Area Networks
- Software-defined Networks(SDN)
  - an emerging technology that is becoming increasingly important to help organizations manage their data flows across their enterprise networks.
  - With SDN, decisions controlling how network traffic flows across network devices are managed centrally by software. The software dynamically adjusts data flows to meet business and application needs.

# 4.2 Network Fundamentals

- Communications Media and Channels
- Network Protocols
- Types of Network Processing

# 4.2 Network Fundamentals

- computer networks communicate via [digital signals](), which are discrete pulses that are either on or off, representing a series of *bits* (0s and 1s).
- public telephone system (called the plain old telephone system or POTS) was originally designed as an [analog]() network to carry voice signals or sounds in an analog wave format
- In order for this type of circuit to carry digital information, that information must be converted into an analog wave pattern by a *dial-up modem*.
- *Modem*
  - Modulation: process that digital signals are converted into analog signals
  - Demodulation: process that alnalog signals are converted into digital signals
- *Cable modems* are modems that operate over [coaxial cable]()—for example, cable TV.
  - Cable modem services share bandwidth among subscribers in a locality. That is, the same cable line connects to many households.
- *DSL(digital subscriber line) modems* operate on the same lines as voice telephones and dial-up modems. DSL modems always maintain a connection, so an Internet connection is immediately available.

# Communications Media and Channels

- **Communications Channel:**
  - a pathway or medium communicating data from one location to another.
- **Communications Media:**
  - is the physical media used to send data It is comprised of two types of media: cable (twisted-pair wire, coaxial cable, or fiber-optic cable) and broadcast (microwave, satellite, radio, or infrared).
- **Twisted-Pair Wire:**
  - the most prevalent form of communications wiring used for almost all business telephone wiring and As the name suggests, it consists of strands of copper wire twisted in pairs. It is relatively inexpensive to purchase, widely available, and easy to work with.
- **Coaxial Cable:**
  - a single strand of insulated copper wire. It is much less susceptible to electrical interference, and it can carry much more data than twisted-pair. It is commonly used to carry high-speed data traffic as well as television signals.
- **Fiber-Optic Cable:**
  - consists of thousands of very thin filaments of glass fibers that transmit information via light pulses generated by lasers. The fiber-optic cable is surrounded by cladding, a coating that prevents the light from leaking out of the fiber.

# Table 4.1: Advantages and Disadvantages of Wireline Communications Channels

| Channel | Advantages | Disadvantages |
|---|---|---|
| Twisted-pair wire | Inexpensive | Slow (low bandwidth) |
| | Widely available | Subject to interference |
| | Easy to work with | Easily tapped (low security) |
| Coaxial cable | Higher bandwidth than twisted-pair | Relatively expensive and inflexible |
| | | Easily tapped (low to medium security) |
| | Less susceptible to electromagnetic interference | Somewhat difficult to work with |
| Fiber-optic cable | Very high bandwidth | Difficult to work with (difficult to splice) |
| | Relatively inexpensive | |
| | Difficult to tap (good security) | |

# Communications Media: Twisted-Pair Wire
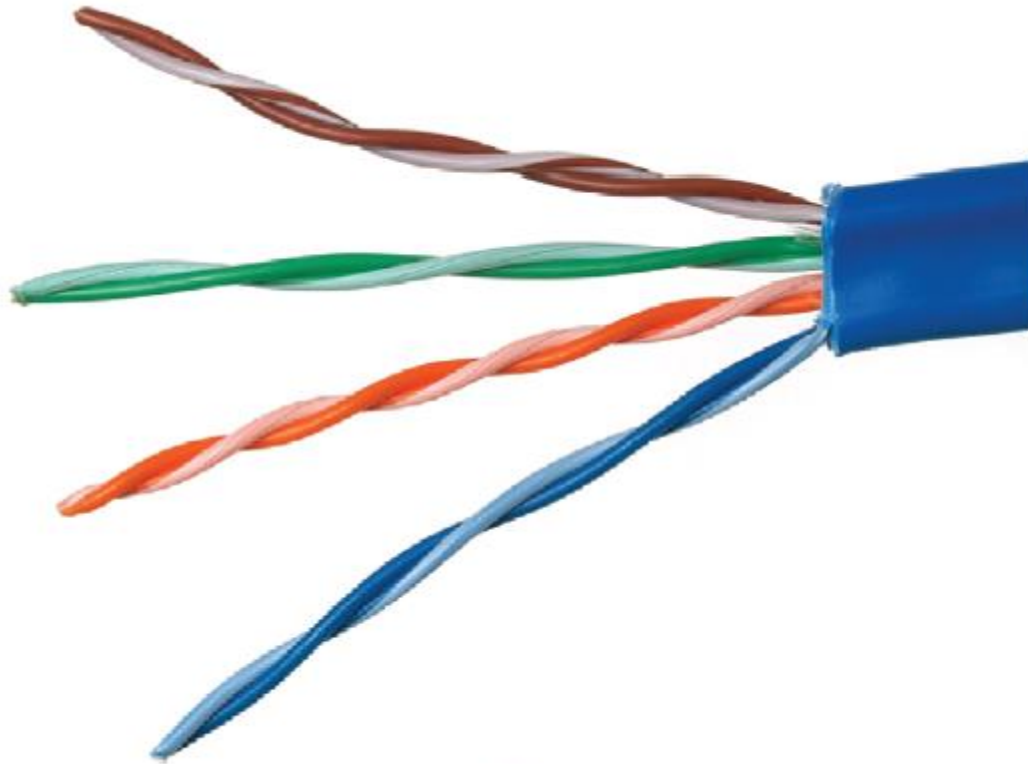


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# Communications Media: Coaxial Cable
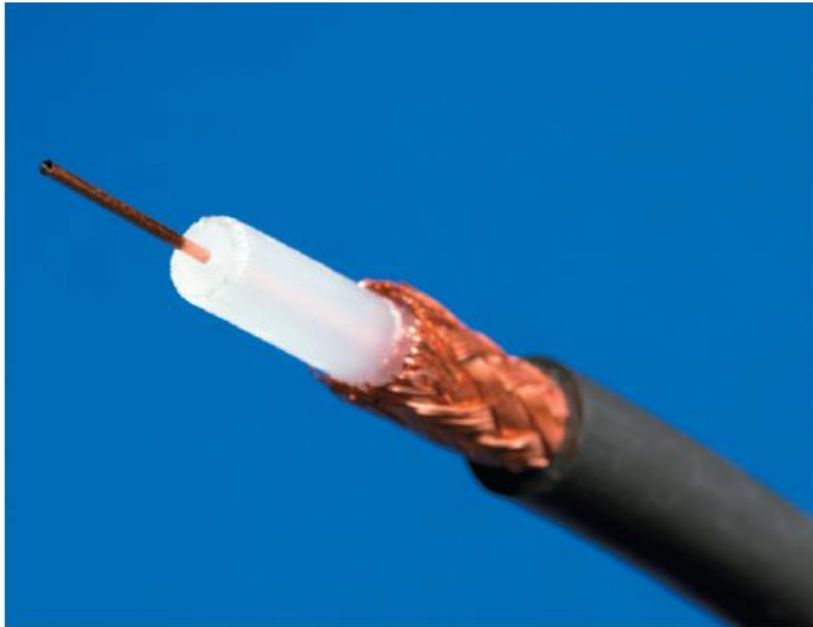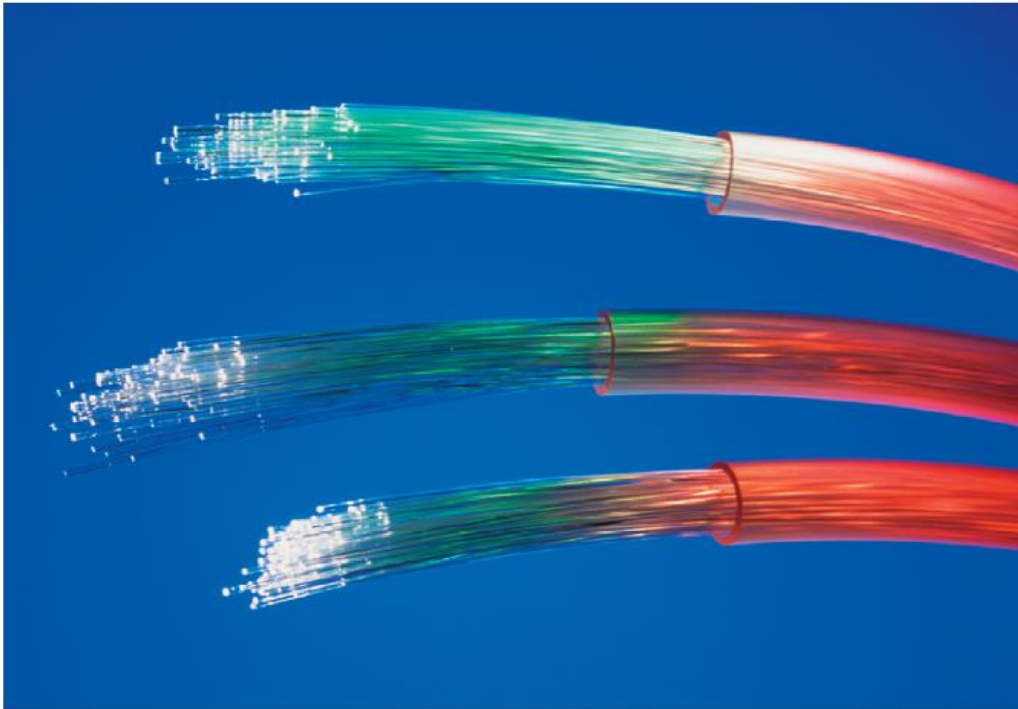


GIPhotoStock/Science Source

Cross-section view
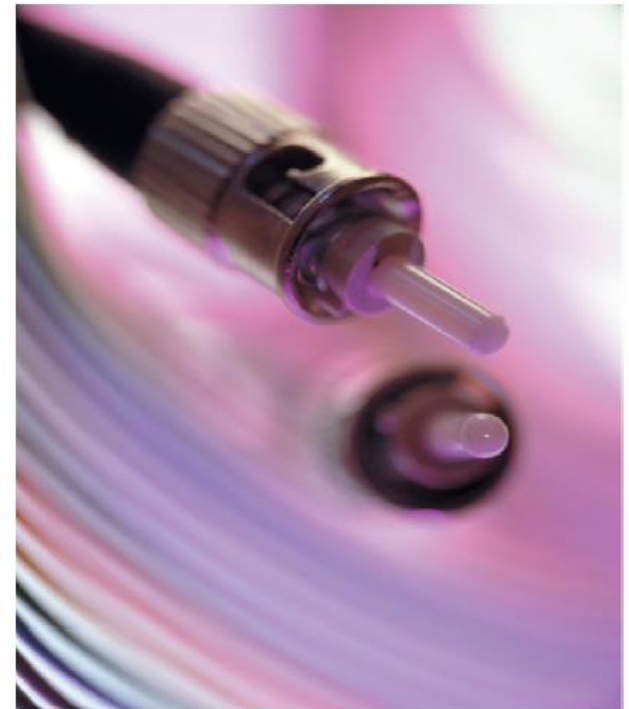


© piotr_malczyk/iStockphoto

How coaxial cable looks to us

# Communications Media: Fiber Optics



Philip Hatson/Science Source

Cross-section view



Chris Knapton/Science Source

How fiber-optic cable looks to us

- Fiber-optic cable consists of thousands of very thin filaments of glass fibers that transmit information via light pulses generated by lasers.

# Network Protocols

- **Protocol:**
  - a common set of rules and procedures that enable nodes on a network to communicate with one another.
  - The two major protocols are the Ethernet and Transmission Control Protocol/Internet Protocol.
- **Ethernet:**
  - A common LAN protocol.
  - Many organizations use 100-gigabit Ethernet, where the network provides data transmission speeds of 100 gigabits (100 billion bits) per second.
- **Transmission Control Protocol/Internet Protocol (TCP/IP):**
  - the protocol of the Internet. TCP/IP uses a suite of protocols, the main ones being the Transmission Control Protocol (TCP) and the Internet Protocol (IP).

# Transmission Control Protocol / Internet Protocol

- **Three Basic Functions of TCP**
  - Manages the movement of data packets between computers by establishing a connection between the computers
  - Sequences the transfer of packets
  - Acknowledges the packets that have been transmitted
- **Internet Protocol (IP):**
  - is responsible for disassembling, delivering, and reassembling the data during transmission.

# Packets & Packet Switching

- **Packets:**
  - Before data are transmitted over the Internet, they are divided into small, fixed bundles called packets.
- **Packet Switching:**
  - the transmission technology that breaks up blocks of data into packets is called packet switching.
  - Each packet carries the information that will help it reach its destination—the sender's IP address, the intended receiver's IP address, the number of packets in the message, and the number of the particular packet within the message.
  - Each packet travels independently across the network and can be routed through different paths in the network.
  - When the packets reach their destination, they are reassembled into the original message.
  - The main reason for using packet switching is to achieve reliable end-to-end message transmission over sometimes unreliable networks that may have short-acting or long-acting problems.

# Four Layers of the TCP/IP Reference Model

**1.Application Layer:**

- enables client application programs to access the other layers, and it defines the protocols that applications use to exchange data.
- One of these application protocols is the [Hypertext Transfer Protocol (HTTP)](), which defines how messages are formulated and how they are interpreted by their receivers.

**2.Transport Layer:**

- provides the application layer with communication and packet services.
- This layer includes TCP and other protocols.

**3.Internet Layer:**

- responsible for addressing, routing, and packaging data packets.
- The IP is one of the protocols in this layer.

**4.Network Interface Layer:**

- places packets on, and receives them from, the network medium, which can be any networking technology.

# Figure 4.6: The Four Layers of the TCP/IP Reference Model

| | | |
|---|---|---|
| Email: Sending a Message via SMPT (Simple Mail Transfer Protocol) | Application | Email: Message received |
| Break Message into packets and determine order | Transport | Packets reordered and replaced (if lost) |
| Assign sending and receiving IP addresses and apply to each packet | Internet | Packets routed through internal network to desired IP address |
| Determine path across network/ Internet to intended destination | Network Interface | Receipt of packets |

# Figure 4.7: Packet Switching
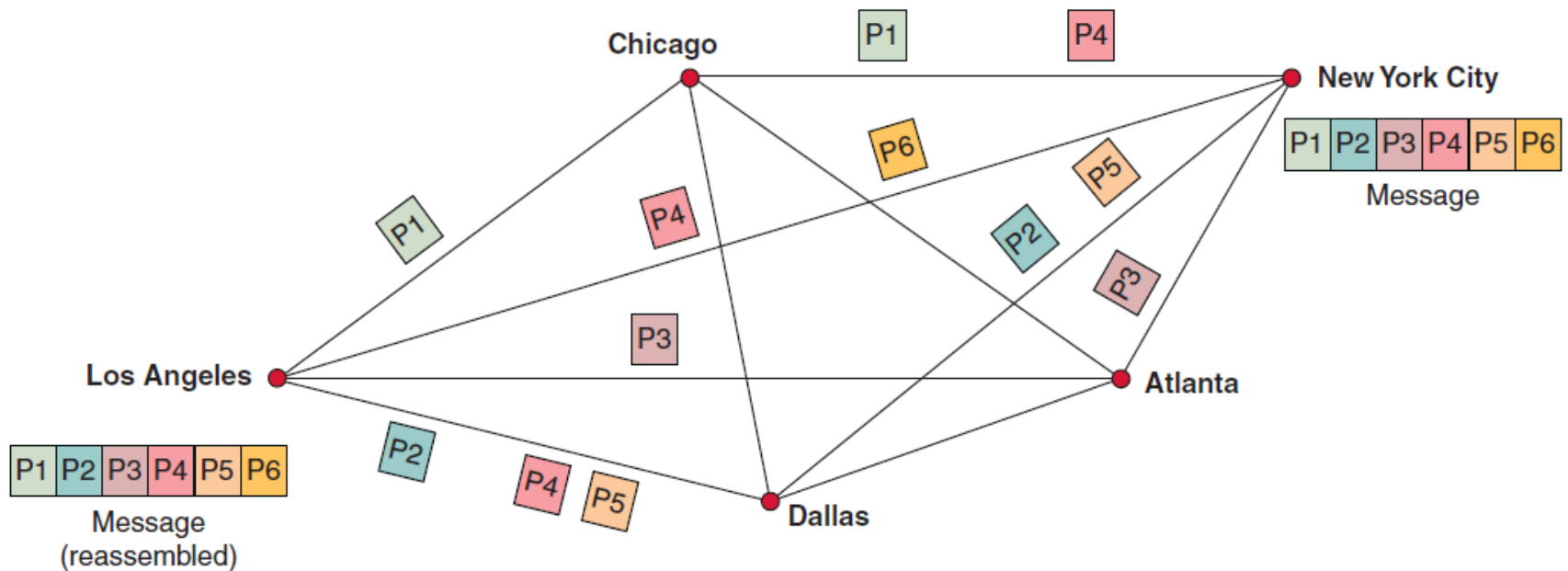
# Types of Network Processing

- **Distributed processing**
  - Organizations typically use multiple computer systems across the firm. Distributed processing divides processing work among two or more computers. This process enables computers in different locations to communicate with one another via telecommunications links.
- **Client/Server Computing**
  - Client/server computing links two or more computers in an arrangement in which some machines, called servers, provide computing services for user PCs, called clients.
  - The client requests applications, data, or processing from the server, which acts on these requests by "serving" the desired commodity.
  - *fat clients* have large storage and processing power and therefore can run local programs if the network goes down.
  - In contrast, *thin clients* may have no local storage and only limited processing power.

# Types of Network Processing

- Peer-to-Peer Processing
  - a type of client/server distributed processing where each computer acts as both a client and a server. Each computer can access (as assigned for security or integrity purposes) all files on all other computers.
  - three basic types of peer-to-peer processing
    - The first type accesses unused CPU power among networked computers. An application of this type is SETI@home (http://setiathome.ssl.berkeley.edu). These applications are from open-source projects, and they can be downloaded at no cost.
    - The second form of peer-to-peer is real-time, person-to-person collaboration, such as Microsoft SharePoint Workspace (http://office.microsoft.com/en-us/sharepoint-workspace). This product provides P2P collaborative applications that use buddy lists to establish a connection and allow real-time collaboration within the application.
    - The third peer-to-peer category is advanced search and file sharing. This category is characterized by natural language searches of millions of peer systems. It enables users to discover other users, not just data and Web pages. One example of this category is BitTorrent. BitTorrent (www.bittorrent.com) is an open-source, free, peer-to-peer file-sharing application that simplifies the problem of sharing large files by dividing them into tiny pieces, or "torrents." BitTorrent eliminates the bottleneck by enabling all users to share little pieces of a file at the same time—a process called *swarming*. Users must upload a file while they download it. Thus, the more popular the content, the more efficiently it travels over a network.

# 4.3 The Internet and the World Wide Web

- Internet ("the Net")
- Accessing the Internet
- The Future of the Internet
- The World Wide Web

# Internet("the Net")

- The Internet ("the Net") is a global WAN that connects approximately one million organizational computer networks in more than 200 countries on all continents, including Antarctica.

- The primary network connections and telecommunications lines that link the nodes are referred to as the Internet backbone. For the Internet, the backbone is a fiber-optic network that is operated primarily by large telecommunications companies.

- The Internet grew out of an experimental project of the Advanced Research Project Agency (ARPA) of the U.S. Department of Defense. The project began in 1969 as the *ARPAnet*.

- An intranet is a network that uses Internet protocols so that users can take advantage of familiar applications and work habits. Intranets support discovery (easy and inexpensive browsing and search), communication, and collaboration inside an organization.

- An extranet connects parts of the intranets of different organizations. In addition, it enables business partners to communicate securely over the Internet using virtual private networks (VPNs)

# Accessing the Internet

- Connecting via an Online Service
  - **Internet service provider (ISP):**
    - a company that provides Internet connections for a fee.
    - ISPs connect to one another through [network access points (NAPs)](#).
  - **Network Access Points (NAPs):**
    - exchange points for Internet traffic. They determine how traffic is routed. NAPs are key components of the Internet backbone.
  - **Internet Protocol (IP) address:**
    - distinguishes your device from all other computers and consists of sets of numbers, in four parts, separated by dots. For example, the IP address of one computer might be 135.62.128.91. You can access a Web site by typing this number in the address bar of your browser.

# Figure 4.9: Internet (backbone in white)

# Table 4.2: Internet Connection Methods

| Service | Description |
|---|---|
| Dial-up | Still used in the United States where broadband is not available |
| DSL | Broadband access via telephone companies |
| Cable modem | Access over your cable TV coaxial cable. Can have degraded performance if many of your neighbors are accessing the Internet at once |
| Satellite | Access where cable and DSL are not available |
| Wireless | Very convenient, and WiMAX will increase the use of broadband wireless |
| Fiber-to-the-home (FTTH) | Expensive and usually placed only in new housing developments |

# Accessing the Internet

- Connecting via Other Means
  - Satellite
    - OneWeb (http://oneweb.world) announced that it would build a micro-satellite network to bring Internet access to all corners of the globe in 2015. OneWeb aims to target rural markets, emerging markets, and in-flight Internet services on airlines. The company plans to create a network of 648 small satellites, each weighing some 285 pounds and orbiting 750 miles above the Earth. OneWeb plans to launch its Internet over satellite service in 2018.
    - Elon Musk (the founder of Tesla Motorcars and SpaceX) announced his plans to launch 4000 satellites into low earth orbit by 2021
  - Google Fiber
    - Google is installing and operating ultrafast fiber-optic cable service, known as Google Fiber (http://fiber.google.com), in U.S. cities. Google Fiber was first deployed to homes in Kansas City (Kansas and Missouri). By May 2016, Google Fiber was operating in nine U.S. cities.

# Accessing the Internet

- Addresses on the Internet
  - Each computer on the Internet has an assigned address
- two IP addressing schemes
  - The first scheme, IPv4, is the most widely used. IP addresses using IPv4 consist of 32 bits, meaning that there are $2^{32}$ possibilities for IP addresses
  - a new IP addressing scheme has been developed, IPv6. IP addresses using IPv6 consist of 128 bits, meaning that there are $2^{128}$ possibilities for distinct IP addresses
- IP addresses must be unique so that computers on the Internet know where to find one another. The Internet Corporation for Assigned Names (ICANN) (www.icann.org) coordinates these unique addresses throughout the world.
- ICANN accredits certain companies called *registrars* to register these names, which are derived from a system called the domain name system (DNS)
- A top-level domain (TLD)
  - the domain at the highest level in the hierarchical Domain Name System of the Internet. Management of most TLDs is delegated to responsible organizations by ICANN
  - Country-code top-level domains (ccTLD): Two letter domains established for countries or territories. For example, *de* stands for Germany, *it* for Italy, and *ru* for Russia.
  - Internationalized country code top-level domains (IDN ccTLD): These are ccTLDs in non-Latin character sets (e.g., Arabic or Chinese).
  - Generic top-level domains (gTLD): Top-level domains with three or more characters. gTLDs initially consisted of .gov, .edu, .com, .mil, .org, and .net. In late 2000, ICANN introduced .aero, .biz, .coop, .info, .museum, .name, and .pro. had

# Future of the Internet

- **High User Demand = Reduced Performance in the Near Future**
  - Researchers assert that if Internet bandwidth is not improved rapidly within a few years the Internet will only function at a much reduced speed.
  - The Internet sometimes is too slow for data-intensive applications such as full-motion video files (movies) and large medical files (X-rays)
- **The Internet is unreliable and not secure.**
- **Internet2**
  - developed by many U.S. universities collaborating with industry and government which develops and deploys advanced network applications such as remote medical diagnosis, digital libraries, distance education, online simulation, and virtual laboratories.
  - It is designed to be fast, always on, everywhere, natural, intelligent, easy, and trusted.
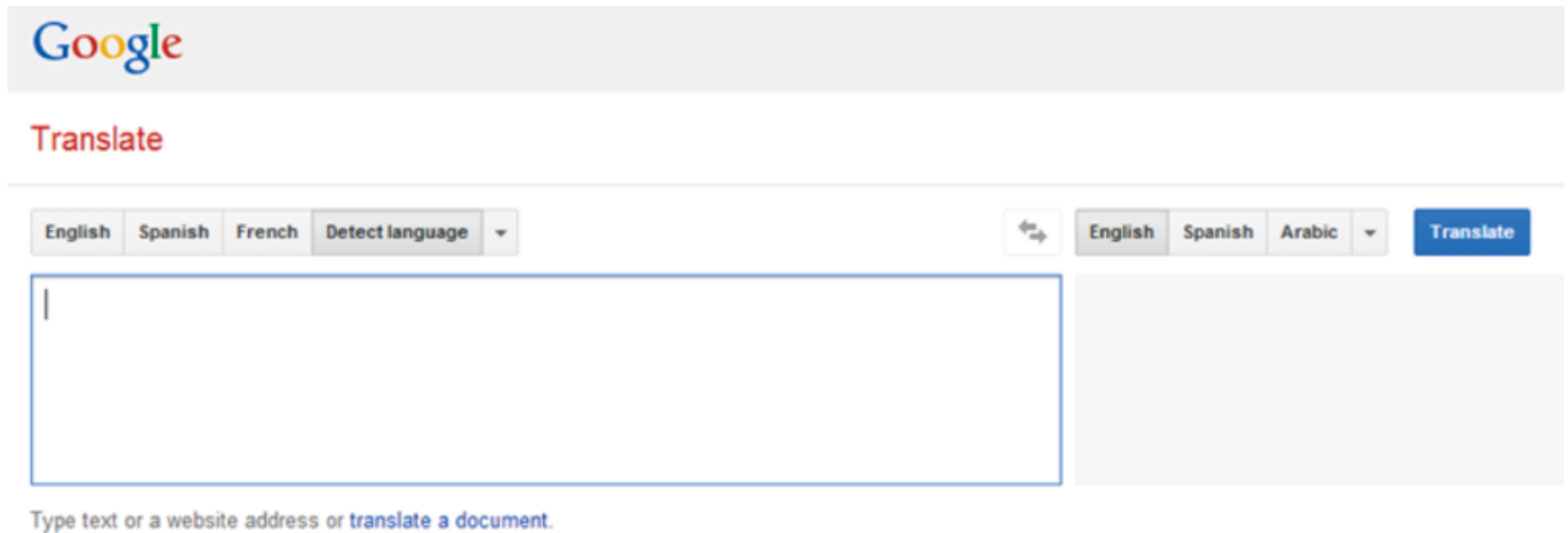  - Note that Internet2 is not a separate physical network from the Internet.

# The World Wide Web (WWW)

- Internet and the World Wide Web are not the same thing
  - The Internet functions as a transport mechanism, whereas the World Wide Web is an application that uses those transport functions. Other applications, such as e-mail, also run on the Internet.
- **World Wide Web:**
  - a system of universally accepted standards for storing, retrieving, formatting, and displaying information via a client/server architecture.
- **Hypertext:**
  - text displayed on a computer display or other electronic device with references, called hyperlinks, to other text that the reader can immediately access, or where text can be revealed progressively at additional levels of details.
- Webmaster
  - The person in charge of an organization's Web site
- **Uniform Resource Locator (URL):**
  - points to the address of a specific resource on the Web. For instance, the URL for Microsoft is http://www.microsoft.com.
- Browser
  - Users access the Web primarily through software applications called browsers. Browsers provide a graphical front end that enables users to point-and-click their way across the Web, a process called *surfing*.
  - Web browsers became a means of universal access because they deliver the same interface on any operating system on which they run.

# 4.4 Network Applications: Discovery

- **Search Engines and Metasearch Engines**
  - **Search Engine:**
    - a computer program that searches for specific information by keywords and then reports the results.
    - A search engine maintains an index of billions of Web pages. Such indexes are created and updated by *webcrawlers*, which are computer programs that browse the Web and create a copy of all visited pages.
    - Search engines then index these pages to provide fast searches.
    - Google ([www.google.com](www.google.com)), Bing ([www.bing.com](www.bing.com)), Yahoo! ([www.yahoo.com](www.yahoo.com)), and Ask ([www.ask.com](www.ask.com)). The leading search engine in China is Baidu ([www.baidu.com](www.baidu.com)).
  - **Metasearch Engines:**
    - search several engines at once and then integrate the findings to answer users' queries.
- **Publication of Material in Foreign Languages**
  - information on the Internet is written in many different languages, and automatic translation of Web pages is essential.
  - Some major translation products are Microsoft's Bing translator ([http://www.microsofttranslator.com](http://www.microsofttranslator.com)) and Google ([www.google.com/language_tools](www.google.com/language_tools)), as well as products and services available at Trados ([www.trados.com](www.trados.com)).
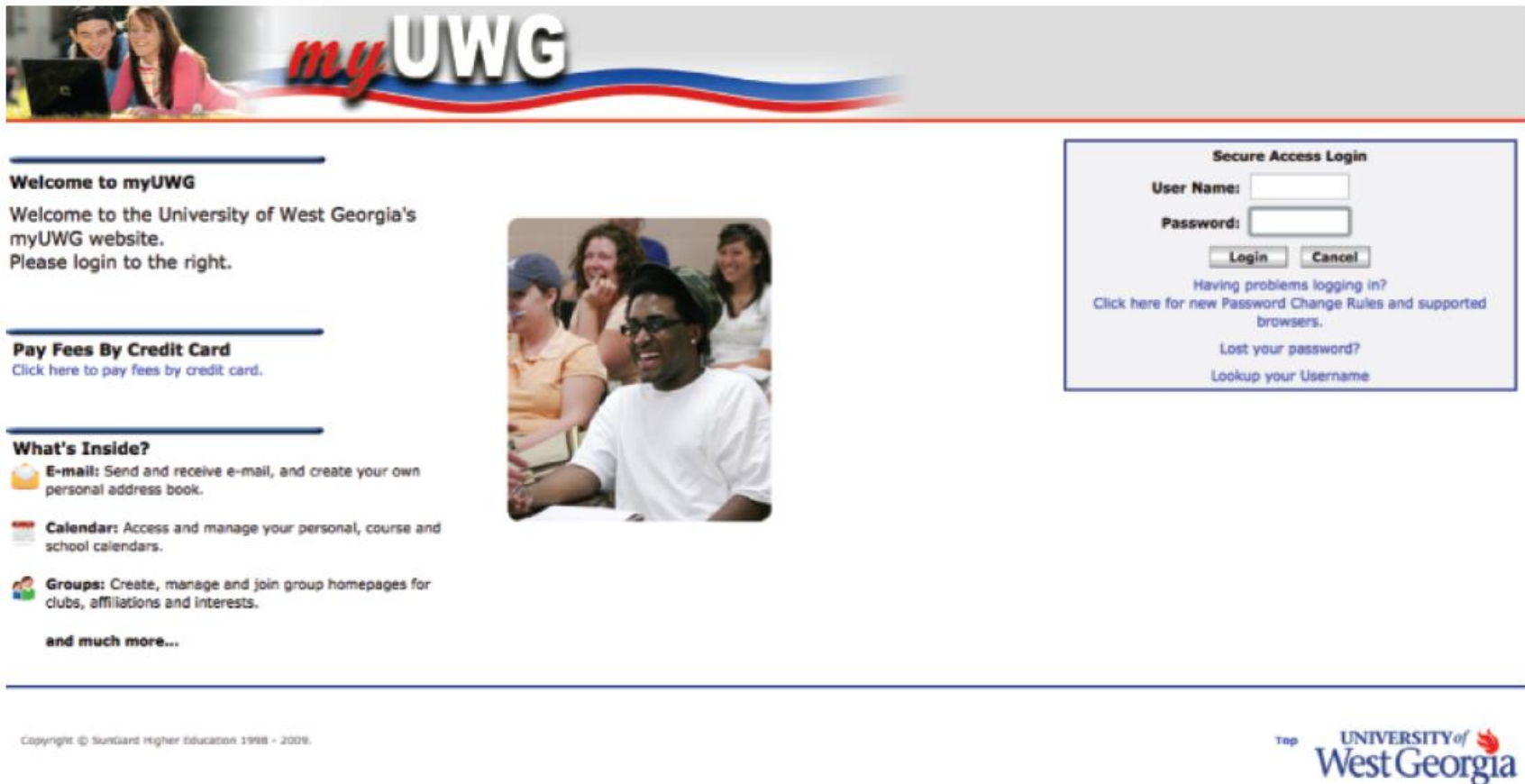
# Publication of Materials in Foreign Languages



Figure 4.10 Google Translate. (Google and the Google logo are registered trademarks of Google Inc., used with permission)

# 4.4 Network Applications: Discovery

- Portals
  - a Web-based, personalized gateway to information and knowledge that provides relevant information from different IT systems and the Internet using advanced search and indexing techniques.
  - **Commercial (public) Portal:**
    - the most popular type of portal on the Internet and is intended for broad and diverse audiences (e.g., a stock ticker).
    - Lycos (www.lycos.com) and Microsoft Network (www.msn.com).
  - **Affinity Portal:**
    - offers a single point of entry to an entire community of affiliated interests, such as a hobby group or a political party.
    - portal for alumni, www.techweb.com and www.zdnet.com.
  - **Corporate Portal:**
    - offers a personalized, single point of access through a Web browser to critical business information located inside and outside an organization.
    - These portals are also known as enterprise portals, information portals, and enterprise information portals.
  - **Industrywide Portal:**
    - a portal that serves an entire industry
    - TruckNet www.truck.net which is a portal for the trucking industry and the trucking community, including professional drivers, owner/operators, and trucking companies..

# Affinity Portals



Figure 4.11  University of West Georgia affinity portal. (Courtesy of the University of West Georgia)

# 4.5 Network Applications: Communication

- **Communication:** a major category of network applications related to communication technologies delivered online (e.g., including e-mail, call centers, chat rooms, and voice).
  - Electronic Mail
  - Web-Based Call Centers
  - Electronic Chat Rooms
  - Voice Communication
    - Voice Over Internet Protocol (VoIP)
- **Unified Communications (UC):**
  - simplifies and integrates all forms of communications (voice, voice mail, fax, chat, e-mail, instant messaging, short message service, presence (location) services, and videoconferencing) on a common hardware and software platform.
  - **Electronic Teleconferencing:** the use of electronic communication technology that enables two or more people at different locations to hold a conference.
- Telecommuting
  - the process in which highly prized "knowledge" workers are now able to work anywhere and anytime.

# 4.6 Network Applications: Collaboration

- **Collaboration:** efforts by two or more entities (that is, individuals, teams, groups, or organizations) who work together to accomplish certain tasks.
- **Workgroup:** two or more individuals who act together to perform some task.
- **Workflow:** the movement of information as it progresses through the sequence of steps that make up an organization's work procedures. Workflow management makes it possible to pass documents, information, and tasks from one participant to another in a way that is governed by the organization's rules or procedures.
- **Virtual Group (Team):** Virtual groups conduct virtual meetings—that is, they "meet" electronically.
- **Virtual collaboration (or e-collaboration):** the use of digital technologies that enable organizations or individuals who are geographically dispersed to collaboratively plan, design, develop, manage, and research products, services, and innovative applications.
- **Synchronous Collaboration:** all team members meet at the same time.
- **Asynchronous Collaboration:** occurs when team members cannot meet at the same time. (e.g. Virtual teams)

# 4.6 Network Applications: Collaboration

- A variety of software products are available to support all types of collaboration. Among the most prominent are Google Drive (http://drive.google.com), Microsoft SharePoint Workspace (www.microsoft.com/Sharepoint/default.mspx), Jive (www.jivesoftware.com), and IBM Lotus Quickr (www.ibm.com/lotus/quickr).
- In general, these products provide online collaboration capabilities, workgroup e-mail, distributed databases, bulletin whiteboards, electronic text editing, document management, workflow capabilities, instant virtual meetings, application sharing, instant messaging, consensus building, voting, ranking, and various application development tools.
- Version Management System
  - Products that provide version management track changes to documents and provide features to accommodate multiple people working on the same document at the same time.
- Version Control System
  - In contrast, version-control systems provide each team member with an account that includes a set of permissions. Document directories are often set up so that users must check out documents before they can edit them. When one team member checks out a document, no other member can access it. Once the document has been checked in, it becomes available to other members.

# 4.6 Network Applications: Collaboration

- **Crowdsourcing:**
  - a process in which an organization outsources a task to an undefined, generally large group of people in the form of an open call.
  - Crowdsourcing help desks:
    - IT help desks are a necessary service on college campuses. Students and professors post their IT problems on an online forum, where other students and amateur IT experts answer them.
  - Recruitment:
    - Champlain College in Vermont developed a Champlain For Reel program, inviting students to share via YouTube videos recounting their experiences at the school and the ways they benefited from their time there.
  - Scitable (www.nature.com/scitable)
    - combines social networking and academic collaboration. Through crowdsourcing, students, professors, and scientists discuss problems, find solutions, and swap resources and journals.
  - Procter & Gamble (P&G)
    - uses InnoCentive (www.innocentive.com), where company researchers post their problems. P&G offers cash rewards to problem solvers.

# 4.6 Network Applications: Collaboration

- **Electronic Teleconferencing and Video Conferencing**
  - Teleconferencing is the use of electronic communication technology that enables two or more people at different locations to hold a conference.
  - a telephone conference call
    - several people talk to one another from multiple locations.
    - The biggest disadvantage of conference calls is that they do not allow the participants to communicate face to face nor can they see graphs, charts, and pictures at other locations.
  - Videoconference
    - participants in one location can view participants, documents, and presentations at other locations
    - The latest version of videoconferencing, called *telepresence*, enables participants to seamlessly share data, voice, pictures, graphics, and animation by electronic means.
    - Google Hangout, Skype, etc.

# Figure 4.11: Telepresence System



HO Marketwire Photos/NewsCom

# 4.7 Network Applications: Educational

- E-Learning
  - learning supported by the Web. It can take place inside classrooms as a support to conventional teaching, such as when students work on the Web during class. It also can take place in virtual classrooms, in which all coursework is completed.
- Distance Education
  - refers to any learning situation in which teachers and students do not meet face-to-face
  - MOOC's **(Massive Open Online Courses):**
    - A new form of distance learning which are a tool for democratizing higher education. Several factors have contributed to the growth of MOOCs, including improved technology and the rapidly increasing costs of traditional universities. MOOCs are highly automated, complete with computer-graded assignments and exams. MOOCs have not yet proved that they can effectively teach the thousands of students who enroll in them. In addition, they do not provide revenues for universities.
- Virtual Universities
  - online universities in which students take classes via the Internet either at home or in an off-site location.