Data Communications and Networking

11th Edition

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Chapter 1

Introduction to Data Communications

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Chapter 1 Outline

1.1 – Introduction

- Brief history of Data Communications, Communications, Information Systems and the Internet

1.2 - Data Communications Networks

- Network components, network types

1.3 - Network Models

- OSI model, Internet model, transmission via “layers”

1.4 - Network Standards

- Standards making, common standards

1.5 - Future Trends

- Pervasive networking, integration of voice, video, and data, new information services

1.6 – Implications for Management

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1.1 Introduction

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Information Age

- **First Industrial Revolution**
  - **Introduction of machinery**
  - **New organizational methods**
  - **Changed the way people worked**
- **Second Industrial Revolution – Information Age**
  - **Introduction of computers**
  - **Introduction of networking and data communication**
  - **Changed the way people worked again**
    - **Faster communication → Collapsing Information lag**
    - **Brought people together → Globalization**

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DISRUPTIVE TECHNOLOGIES AND WEB 1.0

- **Digital Darwinism – Implies that organizations which cannot adapt to the new demands placed on them for surviving in the information age are doomed to extinction**
- **How can a company like Polaroid go bankrupt?**





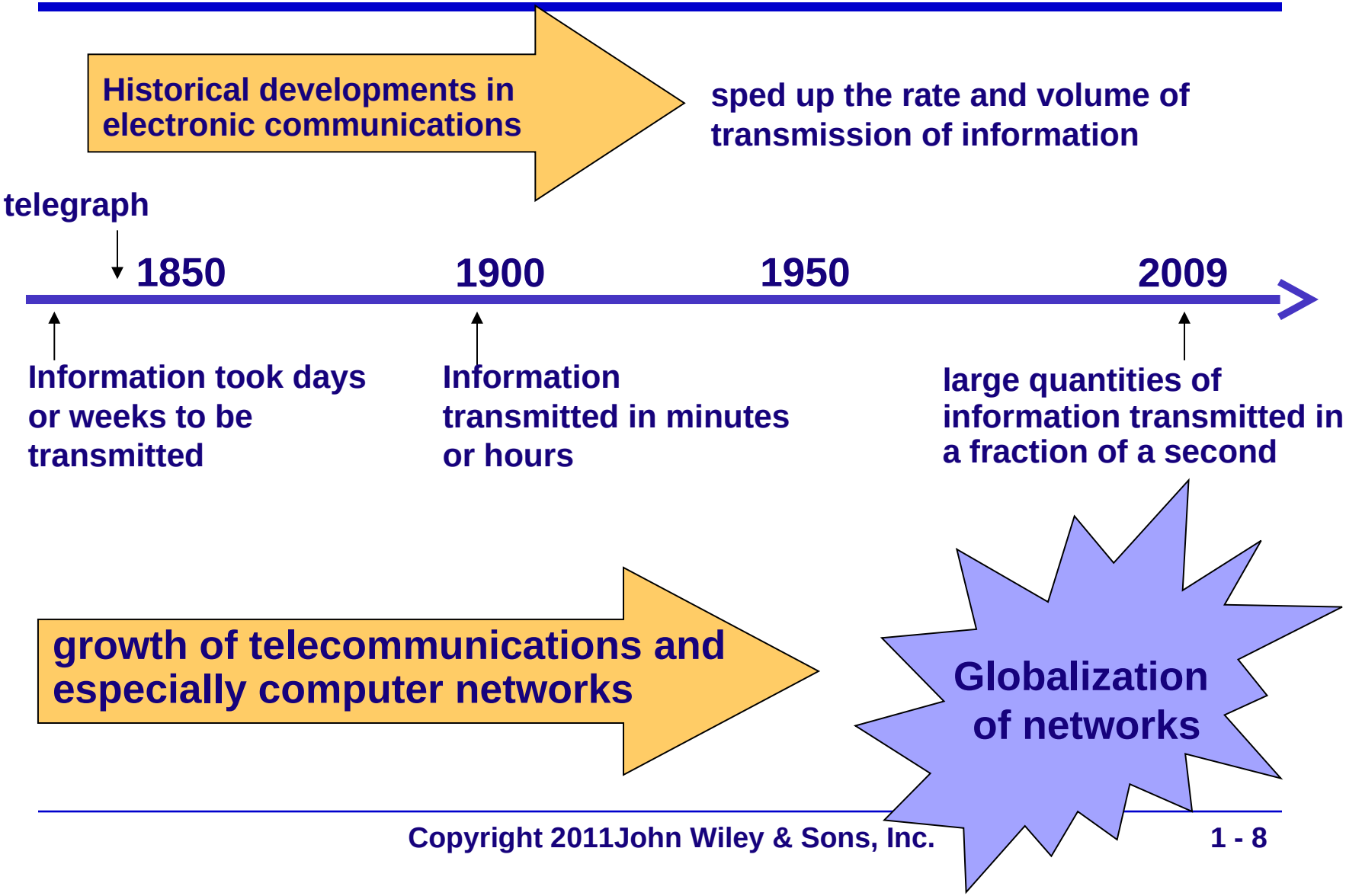
Edwin Land 1943

DISRUPTIVE VERSUS SUSTAINING TECHNOLOGY

- **What do steamboats, transistor radios, and Intel's 8088 processor all have in common?**
  - **Disruptive technology – A new way of doing things that initially does not meet the needs of existing customers**
  - **Sustaining technology – Produces an improved product customers are eager to buy**



The Collapsing Information Lag



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Three Parts to Understanding Networking

1. ***Concepts*** of networking
   - **How data moves from one computer to another over a network**
   - **Theories of how networks operate**
2. ***Technologies*** in use today
   - **How theories are implemented, specific products**
   - **How do they work, their use, applications**
3. ***Management*** of networking technologies
   - **Security**
   - **Network Design**
   - **Managing the network**

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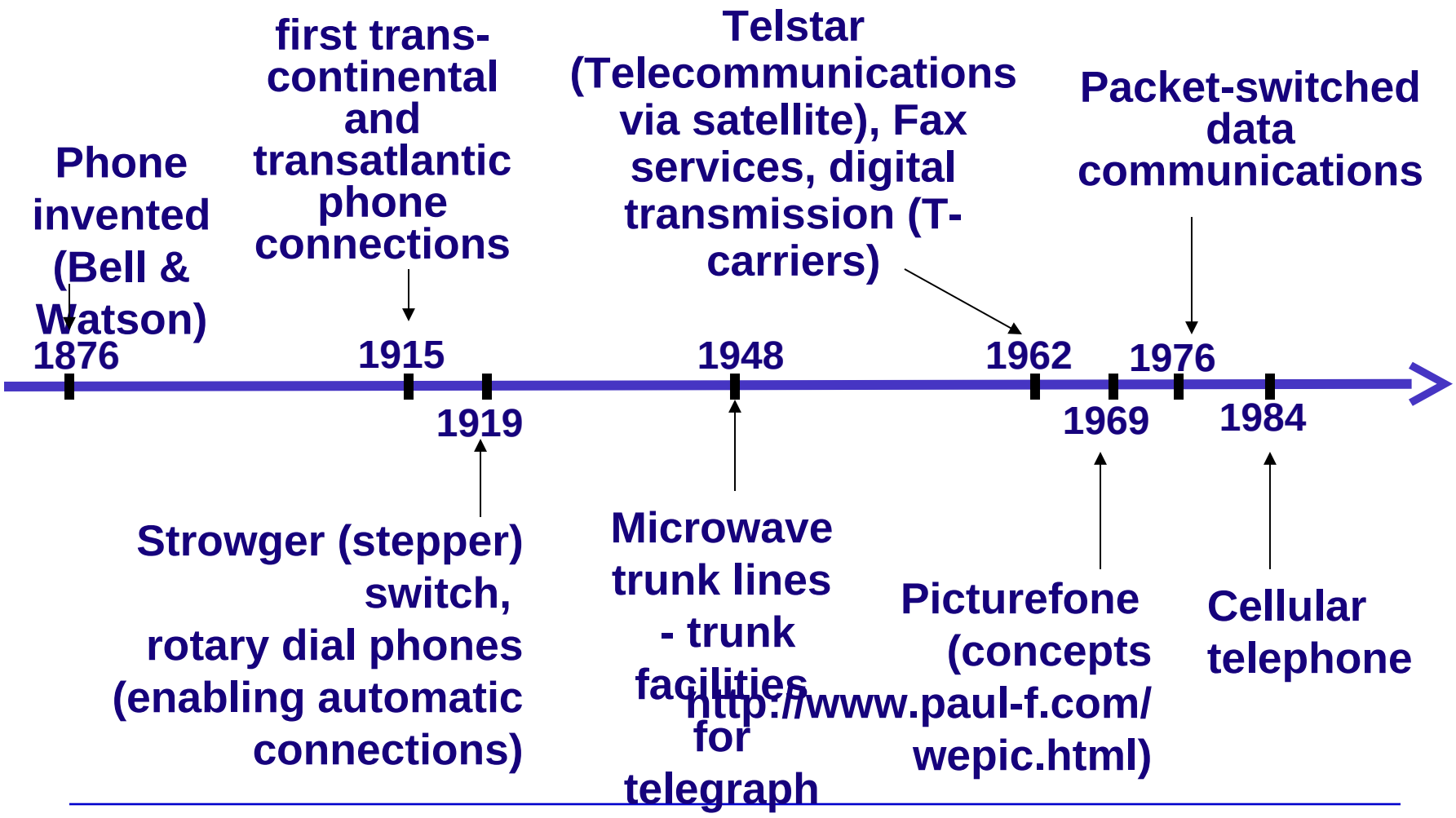
Advances in Phone Technology



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Advances in Phone Technology – cont.

On June 27, 1914, ATT's last pole was erected at Wendover, Utah, on the Nevada/Utah state line, and was topped with the American flag. Commercial service was started on Jan. 25, 1915. Inset: Stamp from the U.S. Post Office's "Celebrate the Century" series commemorates AT&T's achievement.



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Advances in Phone Technology – cont.

A 1969 AT&T videophone, the result of decades long R&D at a cost of over US$500M.



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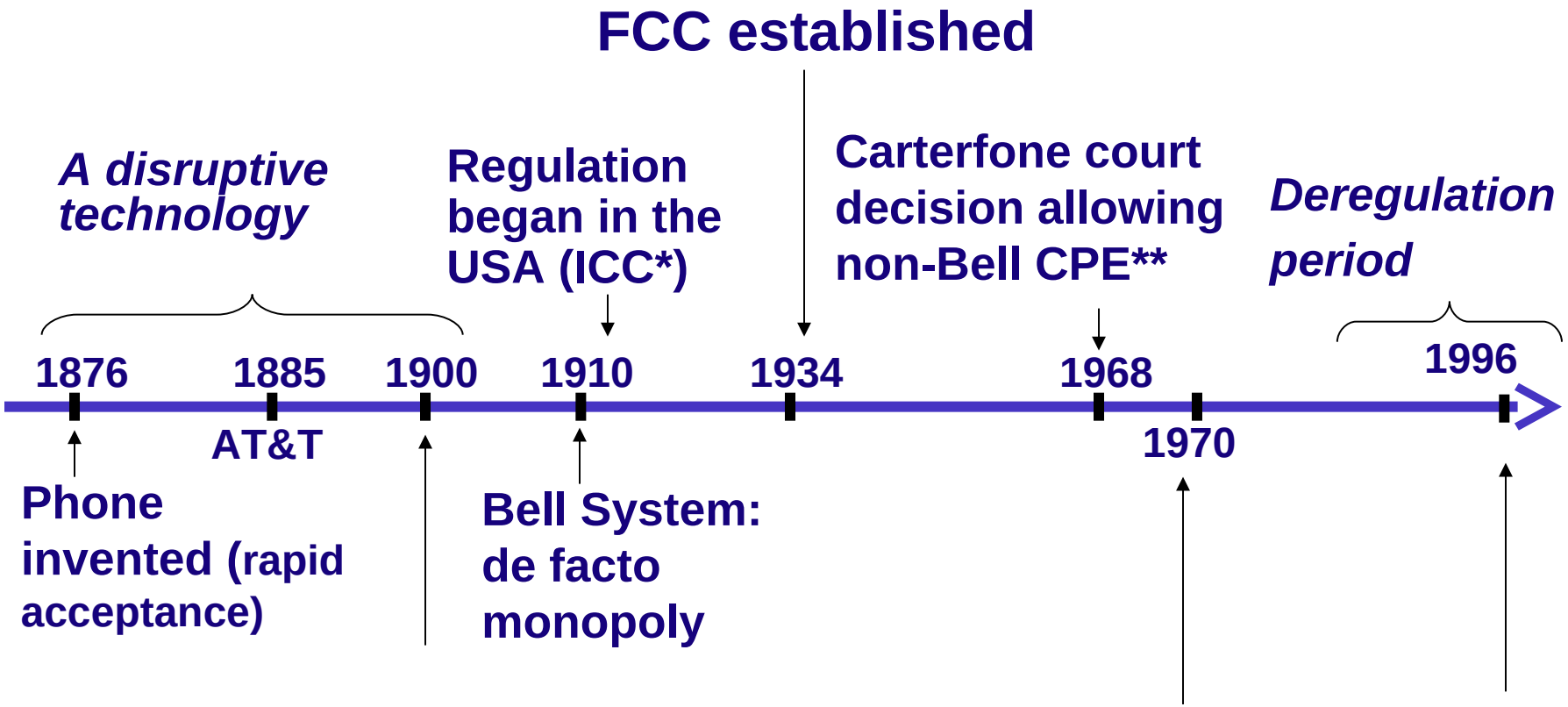
Regulation of Inventions



*ICC : The Interstate Commerce Commission (ICC) ** CPE : Customer Premises Equipment such as routers, phone devices

Regulation Invention

- **1996 US telecom act: The Telecommunications Act of 1996 is the first major overhaul of telecommunications law in almost 62 years. The goal of this new law is to let anyone enter any communications business -- to let any communications business compete in any market against any other.**
- **The Telecommunications Act of 1996 provided the potential to change the way we work, live and learn. It will affect telephone service -- local and long distance, cable programming and other video services, broadcast services and services provided to schools.**
- **The Federal Communications Commission has a tremendous role to play in creating fair rules for this new era of competition.**

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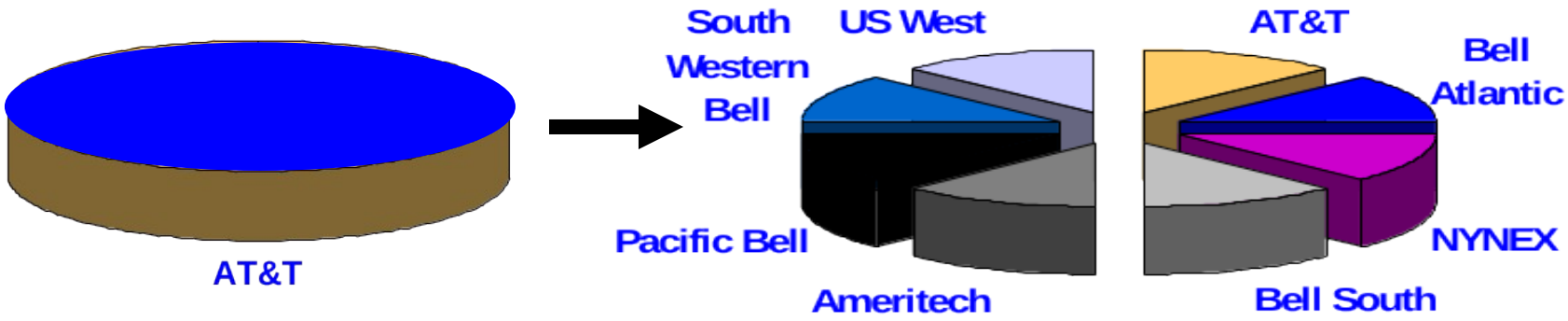
1984 Consent Decree

Divestiture of 1/1/1984: RBOC's

- AT&T broken up into one long distance company (AT&T) and 7 Regional Bell Operating Companies (RBOC's)



Deregulation: IXC's and LEC's

- Competitive long distance (IXC) market; MCI & Sprint enter long distance telephone market (among others)
- Local Exchange Carrier (LEC) service markets remained under RBOC monopoly

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US Telecom Act of 1996

- Replaced all current laws, FCC regulations, 1984 consent decree, and overrules state laws
- Main goal: open local markets to competition
- To date, though, local and long distance competition slow to take hold
  - Large IXCs expected to move into the local markets, happening only recently
  - Likewise, RBOCs expected to move into long distance markets, happening only recently

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THE INTERNET AND WORLD WIDE WEB – THE ULTIMATE BUSINESS DISRUPTORS

- One of the biggest forces changing business is the Internet – A massive network that connects computers all over the world and allows them to communicate with one another
- Organizations must be able to transform as markets, economic environments, and technologies change
- Focusing on the unexpected allows an organization to capitalize on the opportunity for new business growth from a disruptive

THE INTERNET AND WORLD WIDE WEB – THE ULTIMATE BUSINESS DISRUPTORS

- The Internet began as an emergency military communications system operated by the Department of Defense
- Gradually the Internet moved from a military pipeline to a communication tool for scientists to businesses



THE INTERNET AND WORLD WIDE WEB – THE ULTIMATE BUSINESS DISRUPTORS

- **World Wide Web (WWW) – Provides access to Internet information through documents including text, graphics, audio, and video files that use a special formatting language called HTML – hypertext markup language**
- **Web browser – Allows users to access the WWW**
- **Hypertext Transport Protocol – The Internet protocol Web browsers use to request and display Web pages using URL – universal resource locator**



THE INTERNET AND WORLD WIDE WEB – THE ULTIMATE BUSINESS DISRUPTORS



- Reasons for growth of the WWW
  - Microcomputer revolution
  - Advancements in networking
  - Easy browser software
  - Speed, convenience, and low cost of email
  - Web pages easy to create and flexible

WEB 1.0 – THE CATALYST FOR EBUSINESS

- The Internet has had an impact on almost every industry including
  - Travel
  - Entertainment
  - Electronics
  - Financial services
  - Retail
  - Automobiles
  - Education and training



WEB 1.0 – THE CATALYST FOR EBUSINESS

- **Web 1.0 – A term to refer to the WWW during its first few years of operation between 1991 and 2003**
- **Ecommerce – Buying and selling of goods and services over the Internet**
- **Ebusiness – Includes ecommerce along with all activities related to internal and external business operations**



–PARADIGM SHIFT

WEB 2.0: ADVANTAGES OF BUSINESS 2.0

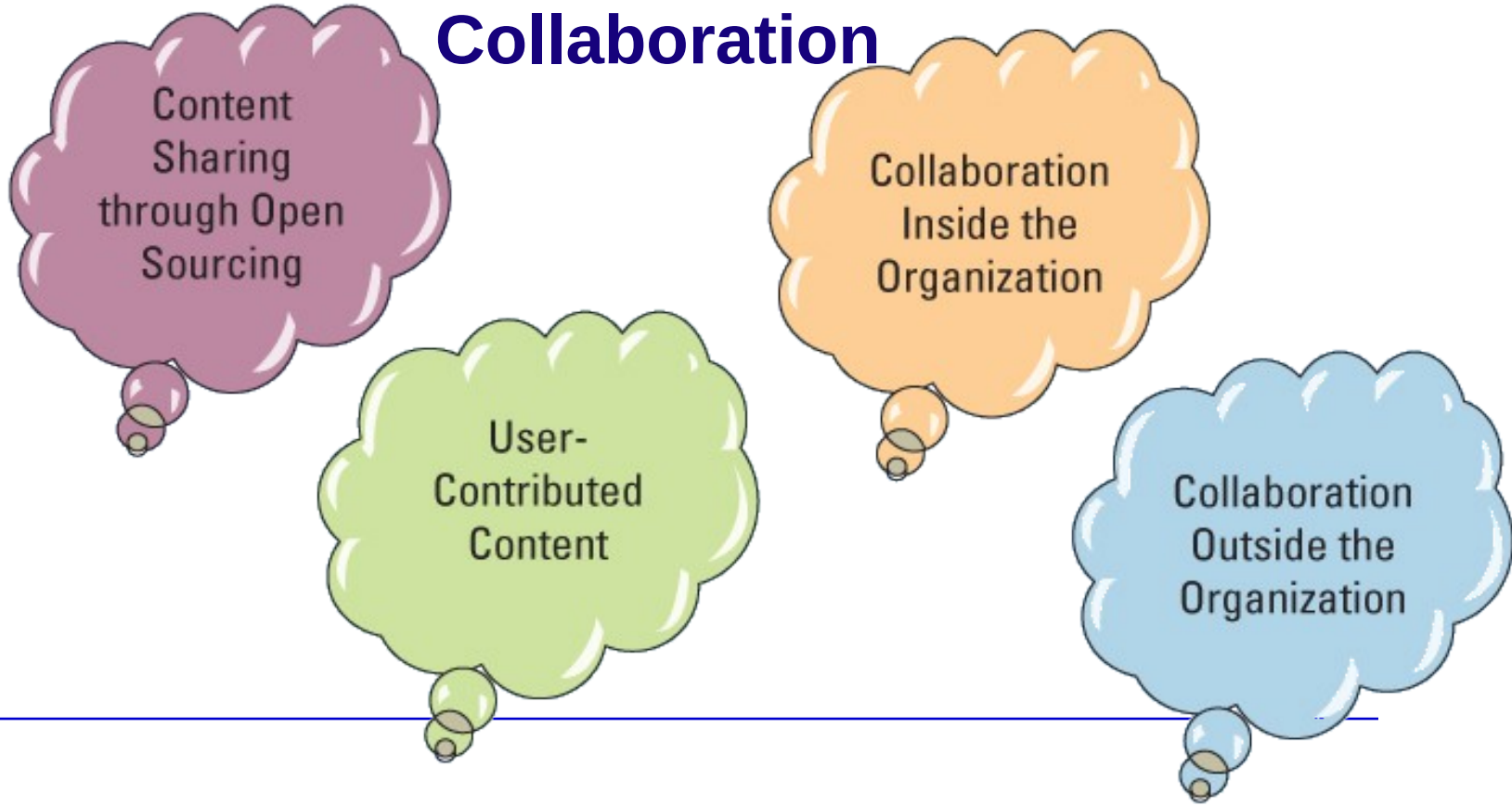
- **Web 2.0 – The next generation of Internet use – a more mature, distinctive communications platform characterized by three qualities**
  - **Collaboration**
  - **Sharing**
  - **Free**



WEB 2.0: ADVANTAGES OF BUSINESS 2.0

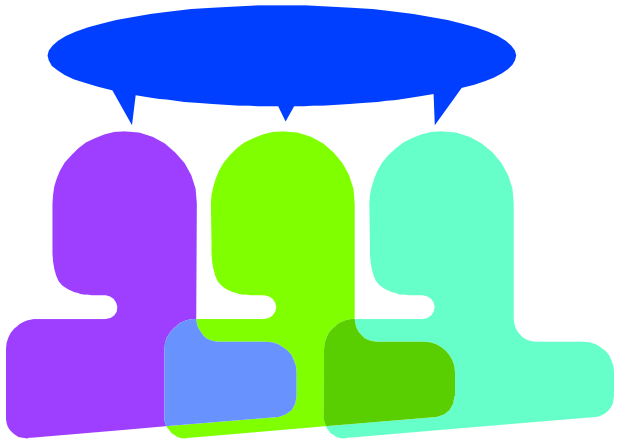
Characteristics of Business 2.0

Collaboration



CONTENT SHARING THROUGH OPEN SOURCING

- **Open system – Nonproprietary hardware and software based on publicly known standards that allows third parties to create add-on products to plug into or interoperate with the system**
  - **Source code**
  - **Open source**



USER-CONTRIBUTED CONTENT

- **User-contributed content – Created and updated by many users for many users**
  - **Reputation system – Where buyers post feedback on sellers**



WEB 3.0

- **Web 3.0 – Based on “intelligent” Web applications using natural language processing, machine-based learning and reasoning, and intelligence applications**
- **Semantic Web – A component of Web 2.0 that describes things in a way that computers can understand**



Clip: example of web3D
http://www.youtube.com/watch?v=mUdDhWfpqxg

Worldwide Competitive Markets

- **Internet market**
  - **Extremely competitive with more than 5000 Internet Service Providers (ISPs) in the US alone.**
  - **Heavy competition in this area may lead to a shake out in the near future.**
- **World Trade Organization (WTO) agreement (1997)**
  - **commitments by 68 countries to open, deregulate or lessen regulation in their telecom markets**
- **Multi-national telecom companies**
  - **US companies offering services in Europe, South America**
  - **European companies offering services in USA**

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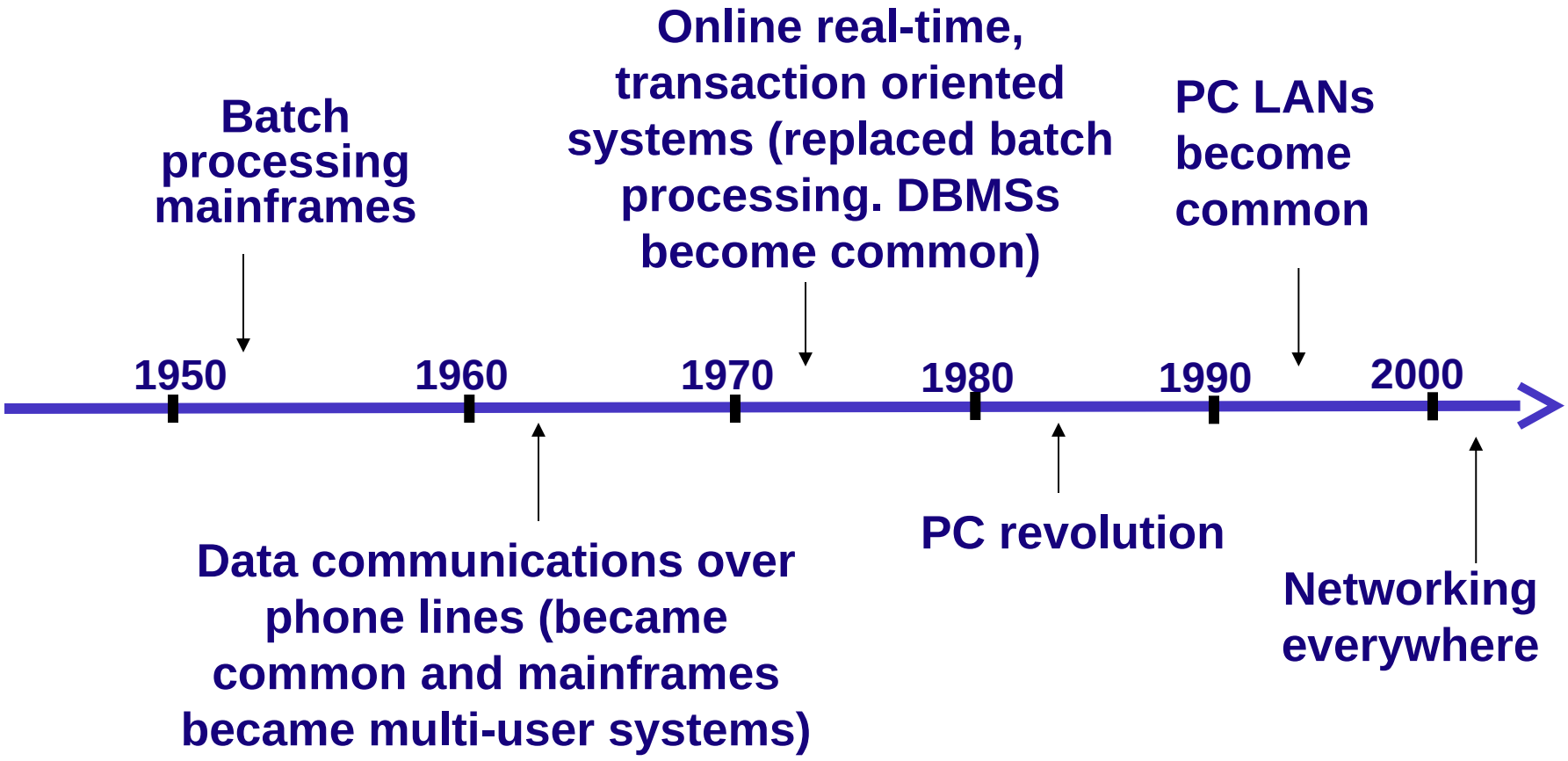
History of Information Systems



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The Internet and the World Wide Web

- **Computer network**
  - **Technology allowing people to connect computers**
  - **Internet**
    - **Interconnected global computer networks (capital “I”)**
    - **internet (small “i”): group of interconnected computer networks**
- **Basic technology structure**
  - **Supports networks, the Internet, and e-commerce**

30

Origins of the Internet

- **Early 1960s**
  - **Defense Department nuclear attack concerns**
  - **Used powerful computers (large mainframes)**
  - **Used leased telephone company lines**
    - **Single connection**
  - **Single connection risk solution**
    - **Communicate using multiple channels (packets)**
- **1969 Advanced Research Projects Agency (ARPA)**
  - **Packet network connected four computers (UCLA, UCSB, UU, Stanford Research Institute)**
    - **ARPANET: earliest network (became the Internet)**
    - **Academic research use (1970s and 1980s)**

New Uses for the Internet

- **Defense Department network use was original goal**
  - **Control weapons systems, transfer research files**
- **1970s: other uses**
  - **E-mail (1972)**
  - **Networking technology**
    - **Remote file transfer and computer access**
  - **Mailing lists**
    - **E-mail address forwards message to subscribed users**
- **1979: Usenet (User's News Network)**
  - **Read and post articles**
  - **Newsgroups (topic areas)**

New Uses for the Internet (cont'd.)

- **Limited Internet use**
  - **Research and academic communities**
- **1979 – 1989**
  - **Network applications improved and tested**
  - **Defense Department's networking software**
    - **Gained wider academic and research institution use**
    - **Common communications network benefit recognized**
  - **Security problems recognized**
- **1980s: personal computer use explosion**
  - **Academic and research networks merged**

Commercial Use of the Internet

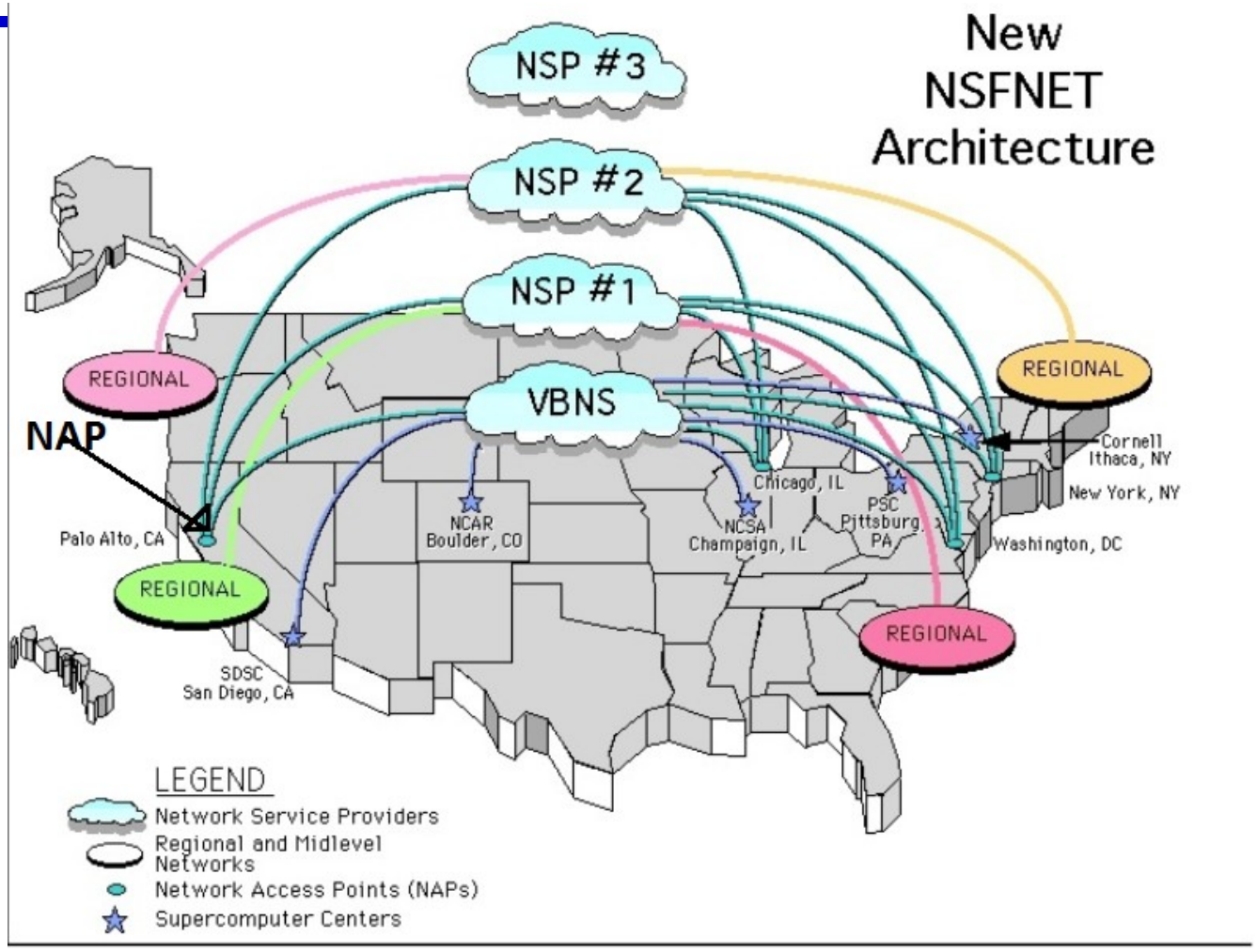
- **National Science Foundation (NSF)**
  - **Provided funding**
- **Businesses turned to commercial e-mail providers**
- **Larger firms built networks (leased telephone lines)**
- **1989: NSF permitted two commercial e-mail services**
  - **MCI Mail and CompuServe**
    - **Commercial enterprises could send e-mail**
    - **Research, education communities sent e-mail directly to MCI Mail and CompuServe**

Growth of the Internet

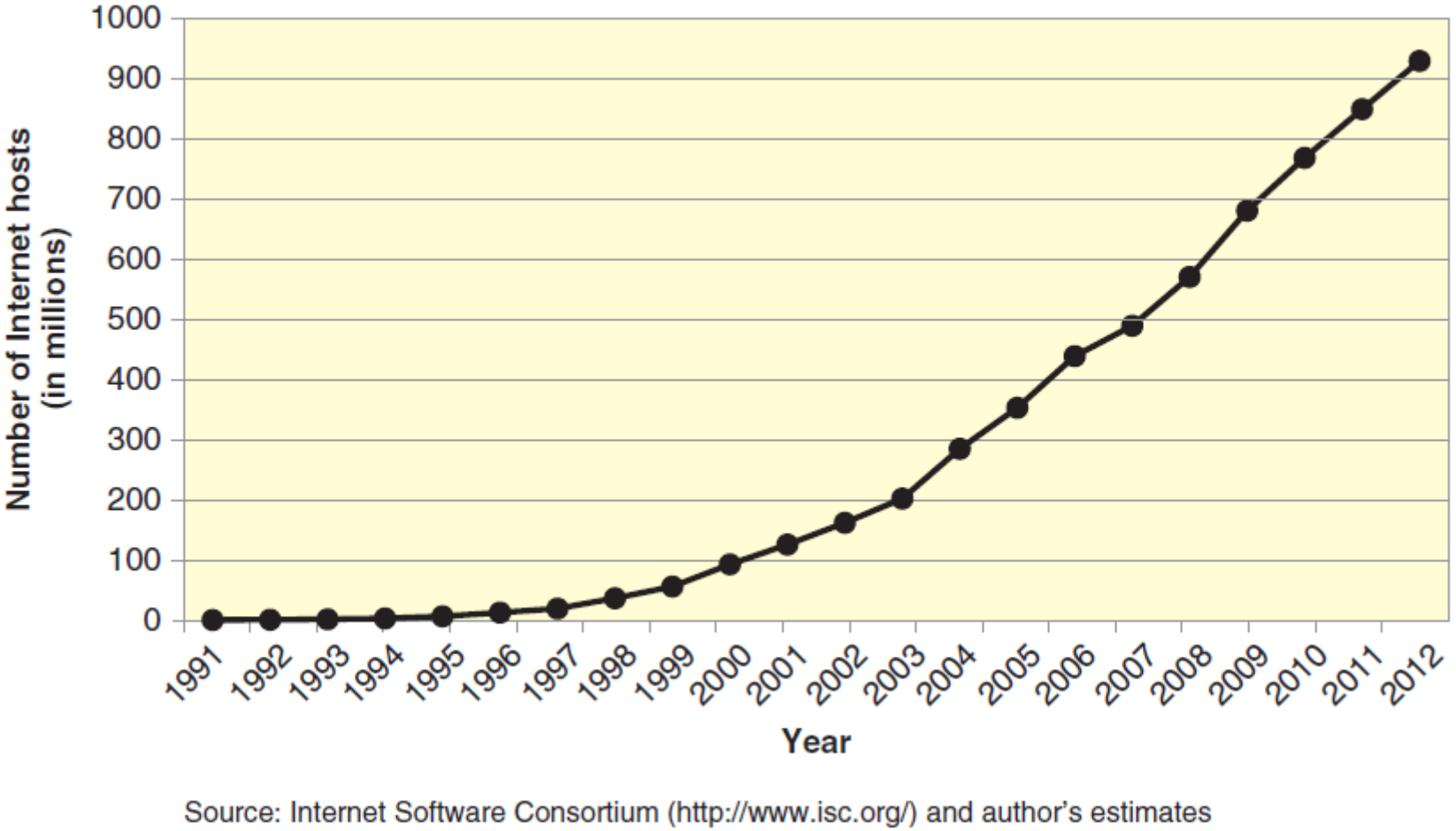
- **1991**
  - **Further easing of commercial Internet activity restrictions**
- **1995: privatization of the Internet**
  - **Operations turned over to privately owned companies**
    - **Internet based on a number of network access points (NAPs)**
- **Network access providers**
  - **Sell Internet access rights directly to larger customers**
  - **Use Internet service providers (ISPs)**
    - **Sell to smaller firms and individuals**

NETWORK PROVIDERS

- National service providers (NSPs) - Private companies that own/maintain the worldwide backbone that supports the Internet (Sprint, MCI) (aka backbone providers) they also sell bandwidth
- Network access points (NAPs) - Traffic exchange points in the routing hierarchy of the Internet that connects NSPs
- Regional service providers (RSPs) - Offer Internet service by connecting to NSPs, but they also can connect directly to each other



A Visitor-based network (VBN) is a computer network intended for mobile users in need of temporary Internet access



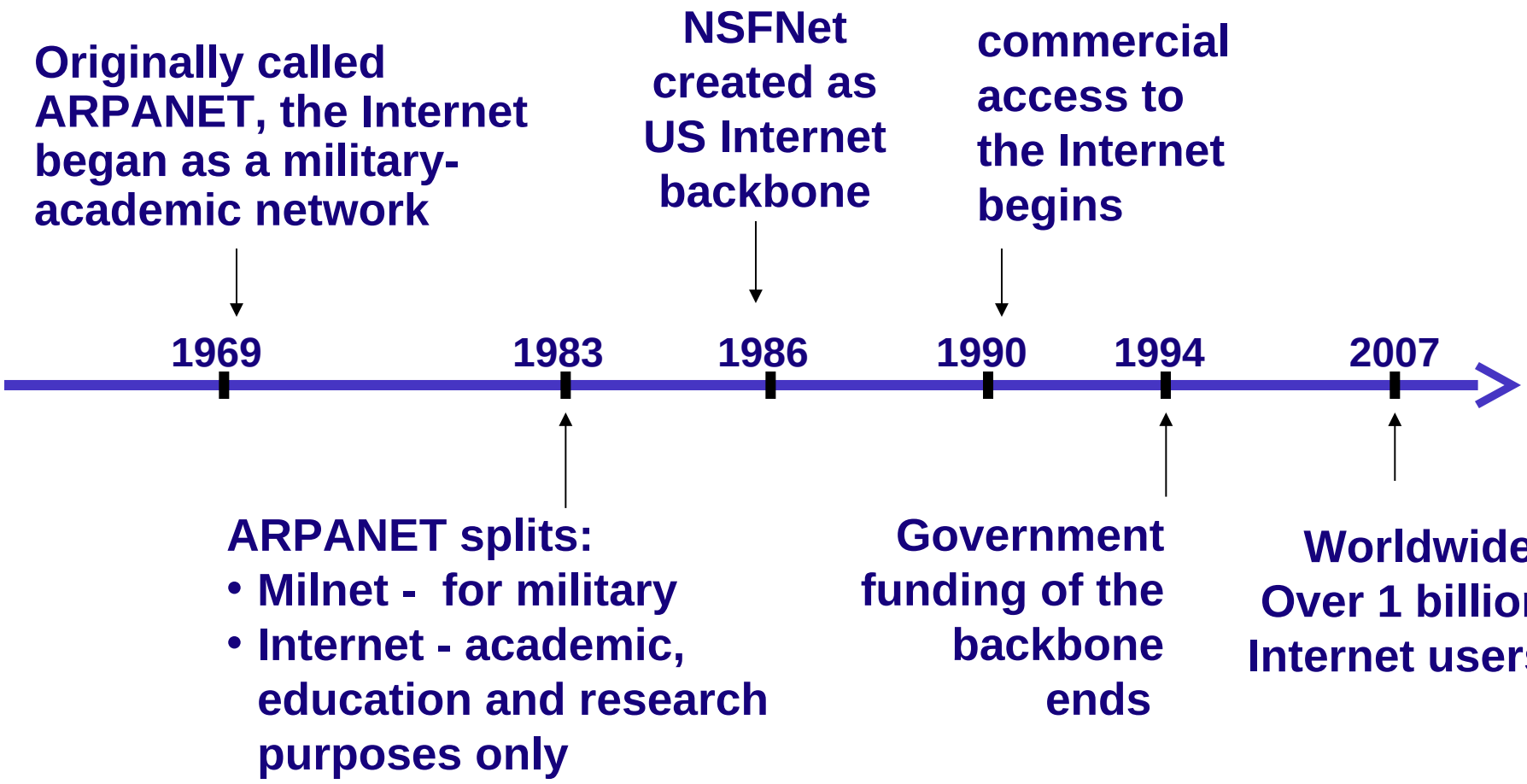
Source: Internet Software Consortium (http://www.isc.org/) and author's estimates

FIGURE 2-1 Growth of the Internet

Growth of the Internet (cont'd.)

- **Internet hosts: directly connected computers**
- **Internet growth**
  - **One of the most significant technological and social accomplishments of last millennium**
  - **Nearly every country involved**
  - **Used by millions of people**
  - **Billions of dollars change hands yearly**

Internet Milestones



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Net Neutrality

Net neutrality means that for a given type of content (i.e. email, web, video, etc), all content providers are treated the same.

Net neutrality prevents ISPs from giving priority to some content providers, while slowing down others

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1.2 Data Comm Networks

Telecommunications =

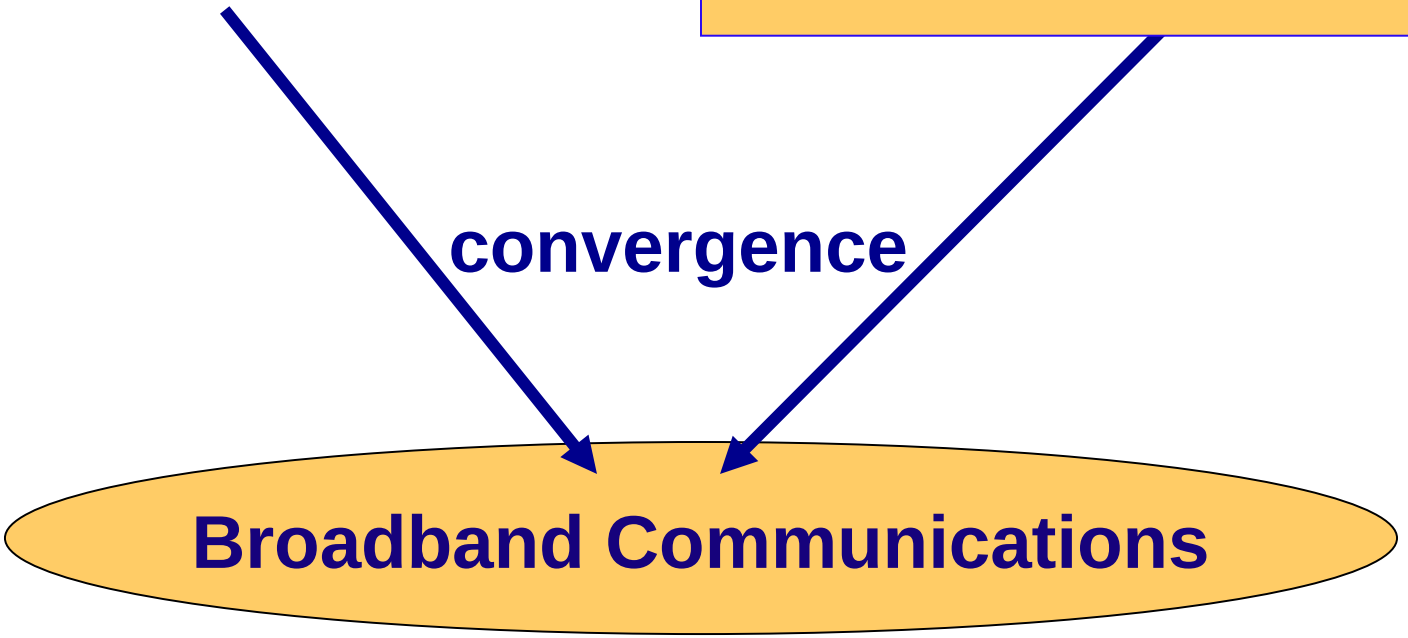
Transmission of voice, video, and/or data

- Implies longer distances

- Broad term

Data Communications =

Movement of computer information by means of electrical or optical transmission systems



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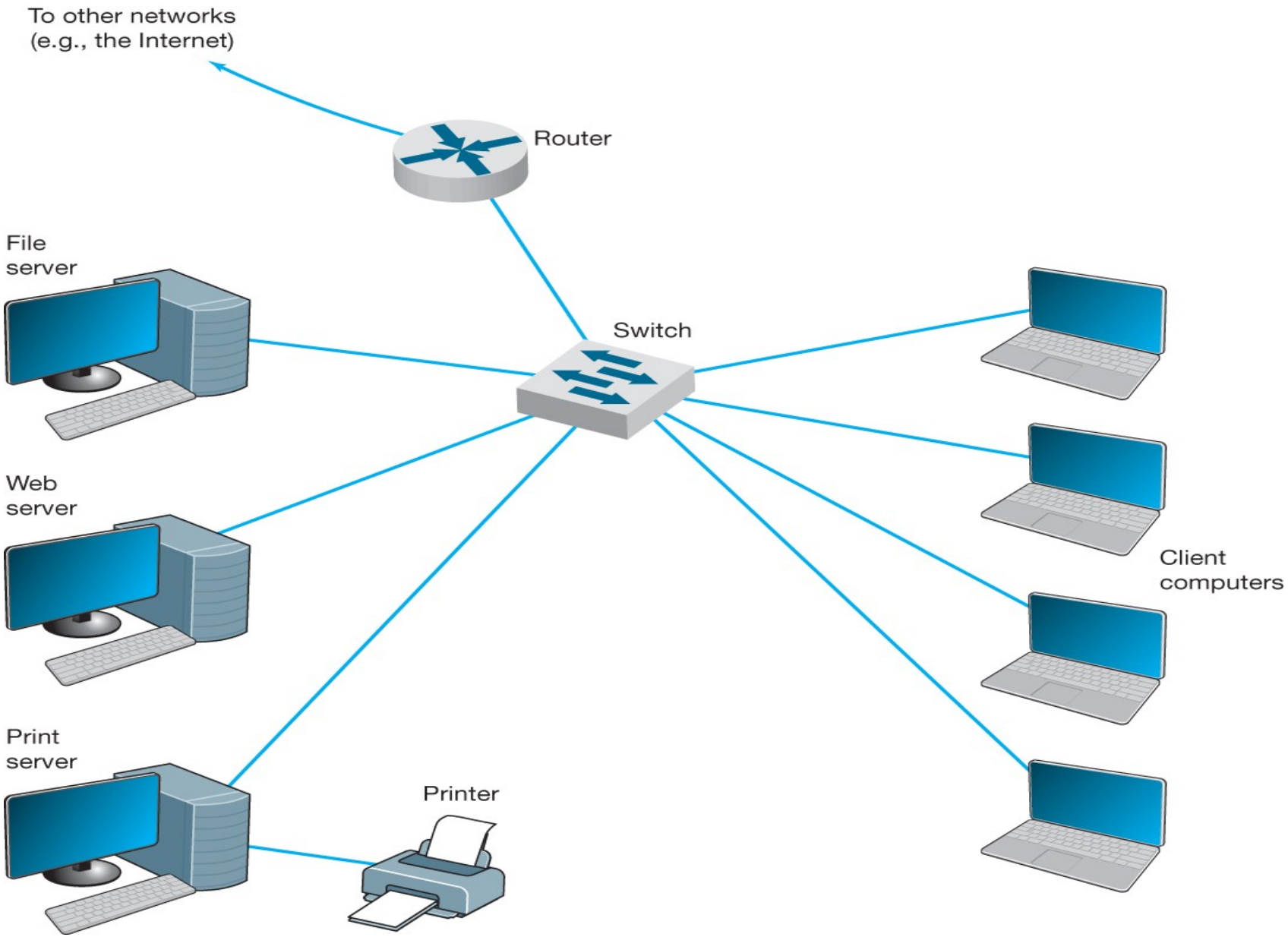
Components of a Local Area Network



Network Types (based on Scale)

- **Local Area Networks (LAN) - room, building**
  - **a group of PCs that share a circuit.**
- **Backbone Networks (BN) - less than few kms**
  - **a high speed backbone linking together organizational LANs at various locations.**
- **Metropolitan Area Networks (MAN) - (more than a few kms)**
  - **connects LANs and BNs across different locations**
  - **Often uses leased lines**
- **Wide Area Networks (WANs) - (far greater than 10 kms)**
  - **Same as MAN except wider scale**

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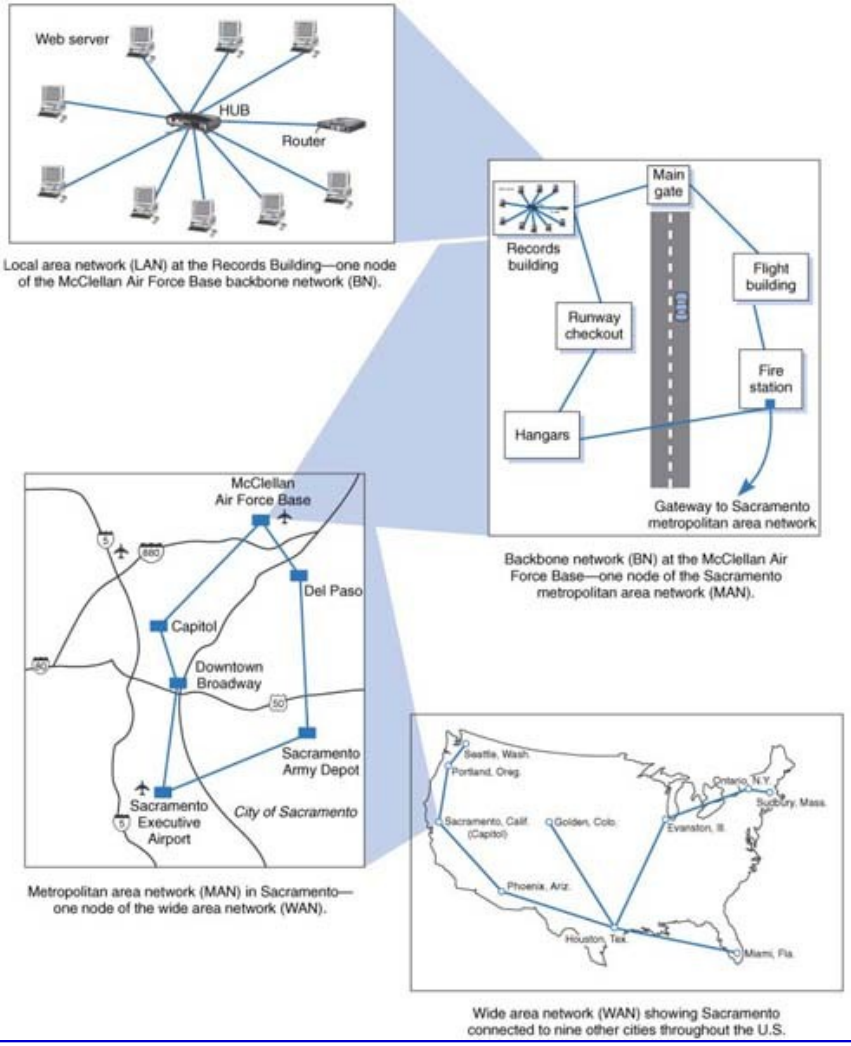
LANs and Backbones, Wide Area and Metropolitan Area Networks



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Intranet vs. Extranet

- **Intranet**
  - **A LAN that uses the Internet technologies *within* an organization**
  - **Open only those inside the organization**
  - **Example: insurance related information provided to employees over an intranet**
- **Extranet**
  - **A LAN that uses the Internet technologies *across* an organization including some external constituents**
  - **Open only those invited users outside the organization**
  - **Accessible through the Internet**
  - **Example: Suppliers and customers accessing inventory information in a company over an extranet**

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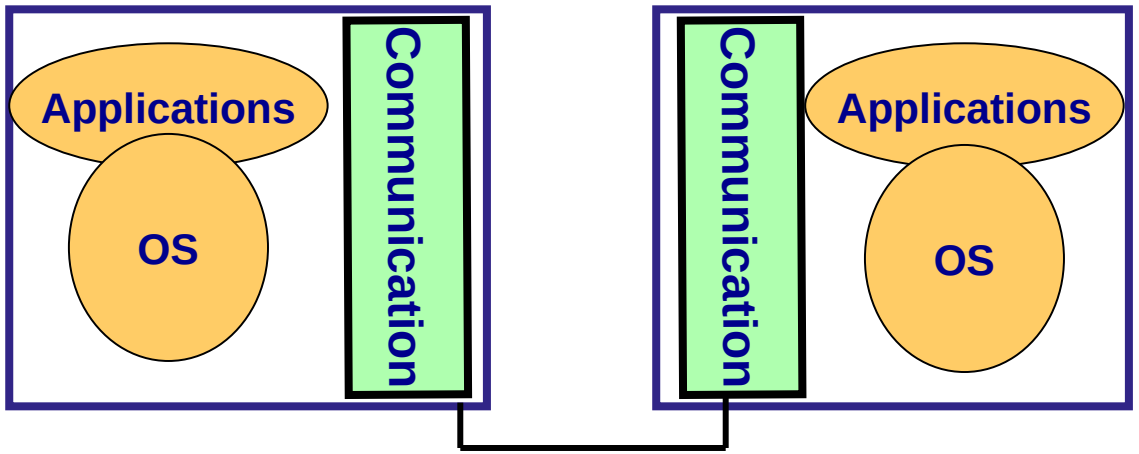
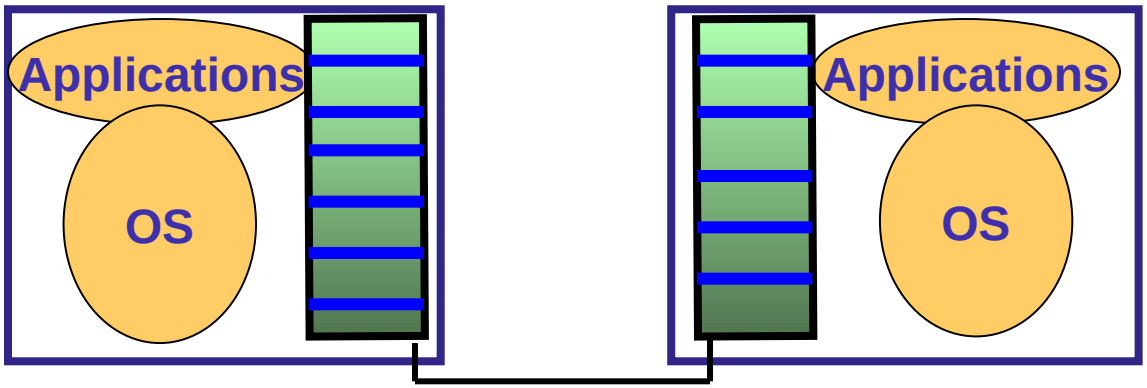
Layered Implementation of Communications Functions



Single layer implementation

-Networking with large components is complex to understand and implement



Multi layer implementation

-Breaking down into smaller components

-Easier to implement

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1.3 Multi-layer Network Models

- **The two most important such network models: OSI and Internet**
- **Open Systems Interconnection Model**
  - **Created by International Standards Organization (ISO) as a framework for computer network standards in 1984**
  - **Based on 7 layers**
- **Internet Model**
  - **Created by DARPA (Defense Advanced Research Projects Agency) originally in early 1970's**
  - **Developed to solve to the problem of internetworking**
  - **Based on 5 layers**
  - **Based on Transmission Control Protocol/ Internet Protocol (TCP/IP) suite**

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7-Layer Model of OSI

"Please Do Not Touch Steve's Pet Alligators"

Physical	DataLink	Network	Transport	Session	Presentation	Application

- **Application Layer**
  - **set of utilities used by application programs**
  - **(**Two example Application layer protocols are Post Office Protocol (POP) and **Simple Mail Transfer Protocol** (SMTP)
- **Presentation Layer**
  - **formats data for presentation to the user**
  - **provides data interfaces, data compression and translation between different data formats**
  - Example: Conversion of .wav to .mp3
- **Session Layer**
  - **initiates, maintains and terminates each logical session between sender and receiver**
  - **Examples of session layer** protocols include DLC (data link control), PAP (printer access control), SMB (server message block), ASP (AppleTalk **session** protocol

7-Layer Model of OSI

- **Transport Layer**
  - **deals with end-to-end issues such as segmenting the message for network transport, and maintaining the logical connections between sender and receiver**
  - Transmission Control Protocol ; User Datagram Protocol
- **Network Layer**
  - **responsible for making routing decisions**
  - Examples: (IP)Internet Protocol; Internet Control Message Protocol (ICMP or "ping"); Internet Gateway Management Protocol (IGMP)

7-Layer Model of OSI

Data Link Layer

•This layer deals with getting data across a specific medium and individual links by providing one or more data link connections between two network entities. End points are specifically identified, if required by the Network layer Sequencing. The frames are maintained in the correct sequence and there are facilities for Flow control and Quality of Service parameters such as Throughput, Service Availability and Transit Delay.

•Examples include:

•IEEE 802.2, IEEE 802.3, 802.5 - Token Ring, HDLC, Frame Relay, FDDI, ATM, PPP

•The Data link layer performs the error check using the Frame Check Sequence (FCS) in the trailer and discards the frame if an error is detected. It then looks at the addresses to see if it needs to process the rest of the frame itself or whether to pass it on to another host. The data between the header and the trailer is passed to layer

•The MAC layer concerns itself with the access control method and determines how use of the physical transmission is controlled and provides the token ring protocols that define how a token ring operates

7-Layer Model of OSI

Physical Layer

•defines how individual bits are formatted to be transmitted through the network

This layer deals with the physical aspects of the media being used to transmit the data.

The electrical, mechanical, procedural and functional means

This defines things like modulation and encoding of data bits on carrier signals. It ensures bit synchronization and places the binary pattern that it receives into a receive buffer.

Once it decodes the bit stream, the physical layer notifies the data link layer that a frame has been received and passes it up. Examples of specifications include:

V.24, V.35, EIA/TIA-232, EIA/TIA-449, FDDI, 802.3, 802.5, Ethernet

RJ45

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Internet's 5-Layer Model



"Please Do Not Touch Alligators"

- **Application Layer**
  - **used by application program**
- **Transport Layer**
  - **responsible for establishing end-to-end connections, translates domain names into numeric addresses and segments messages**
- **Network Layer -** same as in OSI model
- **Data Link Layer -** same as in OSI model
- **Physical Layer -** same as in OSI model

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Comparison of Network Models

OSI Model	Internet Model	Groups of Layers	Examples
7. Application Layer	5. Application Layer	***Application Layer***	Internet Explorer and Web pages
6. Presentation Layer			
5. Session Layer			
4. Transport Layer	4. Transport Layer	***Internetwork Layer***	TCP/IP Software
3. Network Layer	3. Network Layer		
2. Data Link Layer	2. Data Link Layer	***Hardware Layer***	Ethernet port, Ethernet cables, and Ethernet software drivers
1. Physical Layer	1. Physical Layer		

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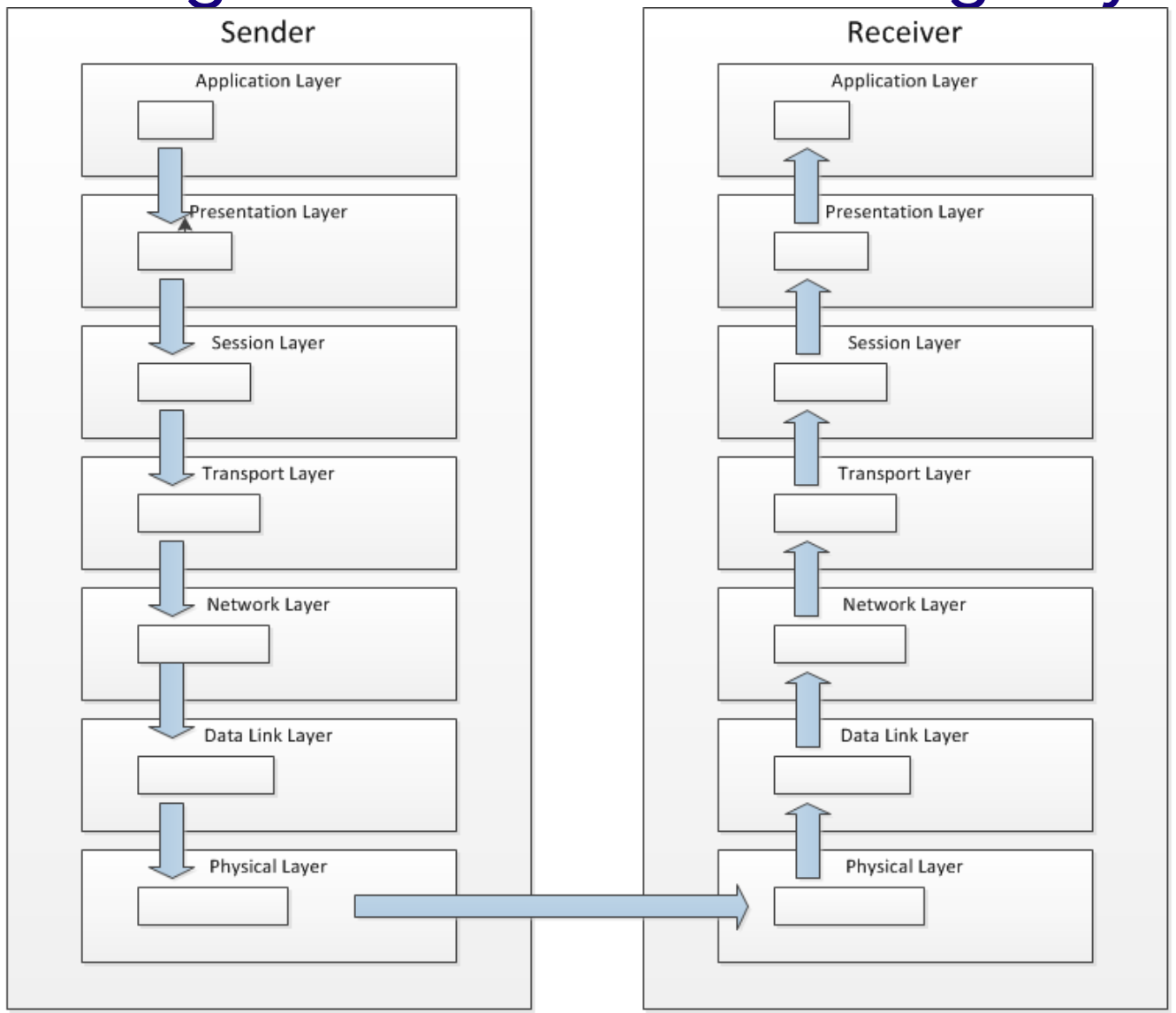
Message Transmission Using Layers

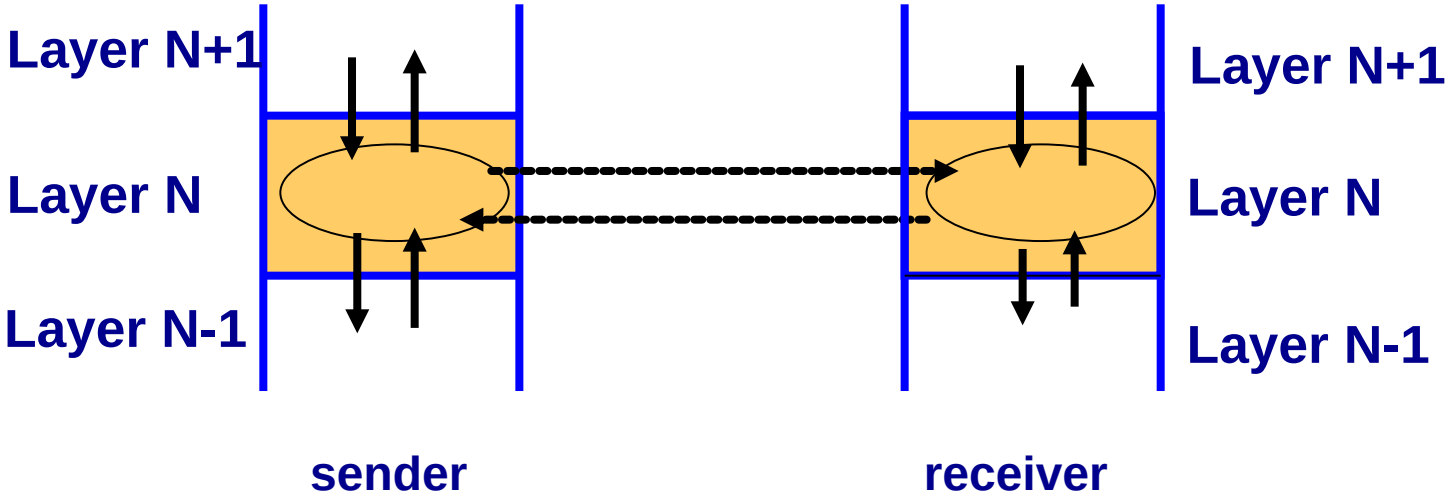


A sending layer wraps the incoming message with an envelope. It adds layer-related addressing information

A receiving layer removes the layer-related envelope and forwards the message up.

Protocols

- **Used by network model layers**
- **Sets of standardized rules to define how to communicate at each layer and how to interface with adjacent layers**



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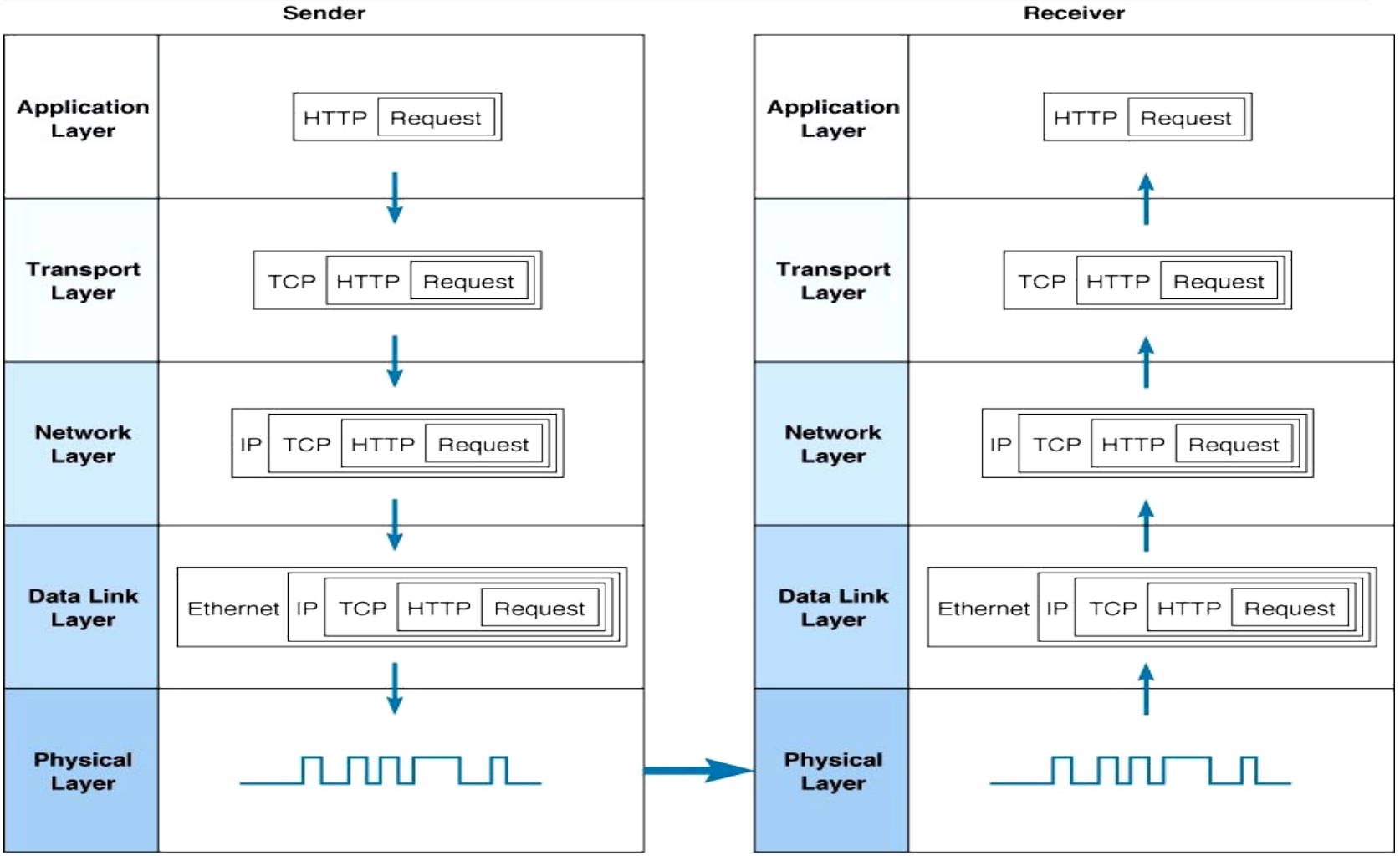
Message Transmission Example



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Points about Network Layer View

- **Layers allow simplicity of networking in some ways**
  - **Easy to develop new software that fits each layer**
  - **Relatively simple to change the software at any level**
- **Matching layers communicate between different computers and computer platforms**
  - **Accomplished by standards that we all agree on**
  - **e.g., Physical layer at the sending computer must match up with the same layer in the receiving computer**
- **Somewhat inefficient**
  - **Involves many software packages and packets**
  - **Packet overhead (slower transmission, processing time)**
  - **Interoperability achieved at the expense of perfectly streamlined communication**

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1.4 Network Standards

- **Importance**
  - **Provide a “fixed” way for hardware and/or software systems (different companies) to communicate**
  - **Help promote competition and decrease the price**
- **Types of Standards**
  - **Formal standards (proprietary or open ie ISO)**
    - **Developed by an industry or government standards-making body**
  - **De-facto standards – aka Informal (a proprietary that is used widely)**
    - **Emerge in the marketplace and widely used**
    - **Lack official backing by a standards-making body**

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Standardization Processes

- **Specification**
  - **Developing the nomenclature and identifying the problems to be addressed**
- **Identification of choices**
  - **Identifying solutions to the problems and choose the "optimum" solution**
- **Acceptance**
  - **Defining the solution, getting it recognized by industry so that a uniform solution is accepted**

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Major Standards Bodies

- **ITU-T (International Telecommunications Union – Telecom Group; part of ITU, creates telecom std)**
  - **Technical recommendations about telephone, telegraph and data communications interfaces**
  - **Composed of representatives from each country in UN**
  - **Based in Geneva, Switzerland (www.itu.int)**
- **ISO (International Organization for Standardization)**
  - **Technical recommendations for data communication interfaces**
  - **Composed of each country's national standards orgs.**
  - **Based in Geneva, Switzerland (www.iso.ch)**

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Major Standards Bodies (Cont.)

- **ANSI (American National Standards Institute)**
  - **Coordinating organization for US (not a standards-making body)**
  - **www.ansi.org**
- **IEEE (Institute of Electrical and Electronic Engineers)**
  - **Professional society**
  - **also develops mostly LAN standards**
  - **standards.ieee.org**
- **IETF (Internet Engineering Task Force)**
  - **Develops Internet standards**
  - **www.ietf.org**

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Some Data Comm. Standards

Layer	Common Standards
5. Application layer	HTTP, HTML (Web) MPEG, H.323 (audio/video) IMAP, POP (e-mail)
4. Transport layer	TCP (Internet) SPX (Novell LANs)
3. Network layer	IP (Internet) IPX (Novell LANs)
2. Data link layer	Ethernet (LAN) Frame Relay (WAN) T1 (MAN and WAN)
1. Physical layer	RS-232c cable (LAN) Category 5 twisted pair (LAN) V.92 (56 kbps modem)

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1.5 Newer and Future Trends

- **Pervasive Networking**
- **Integration of Voice, Video and Data**
- **New Information Services**

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Pervasive Networking

- **Means “Networks will be everywhere”**
- **Exponential growth of Network use**
- **Many new types of devices will have network capability**
- **Exponential growth of data rates for all kinds of networking**
- **Broadband communications**
  - **Use circuits with 1 Mbps or higher (e.g., DSL)**

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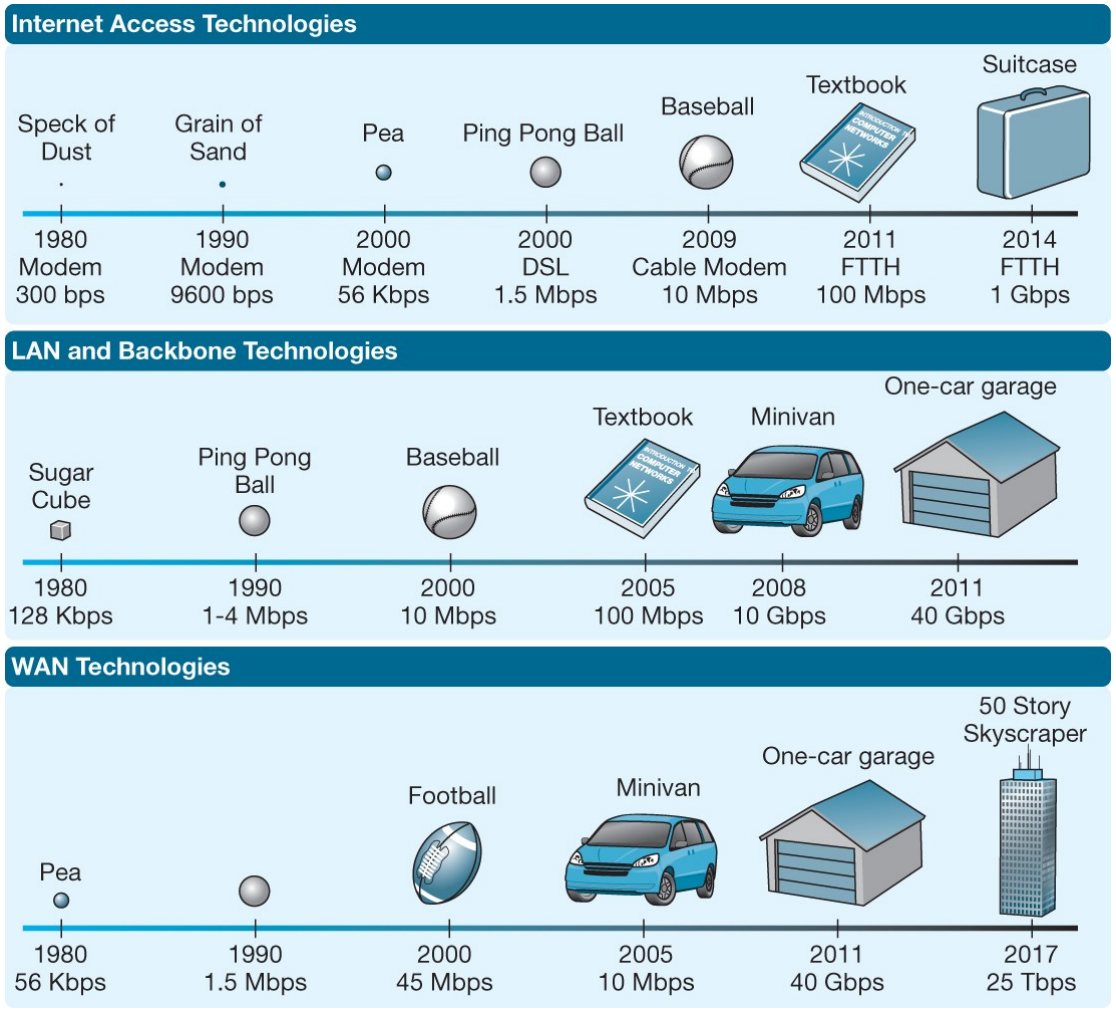
Relative Capacities of Telephone, LAN, BN, WAN, and Internet Circuits.



Integration of Voice, Video & Data

- **Also called "Convergence"**
  - **Networks that were previously transmitted using separate networks have merged or are in process of merging into a single, high speed, multimedia network in the near future**
- **First step largely complete**
  - **Integration of voice and data**
- **Next step**
  - **Video merging with voice and data**
  - **Will take longer partly due to the high data rates required for video**

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New Information Services

- **World Wide Web based**
  - **Many new types of information services becoming available**
    - **Services that help ensure quality of information received over www**
- **Application Service Providers (ASPs)**
  - **Develop specific systems for companies such as providing and operating a payroll system for a company that does not have one of its own**
- **Information Utilities (Future of ASPs)**
  - **Providing a wide range of info services (email, web, payroll, etc.) (similar to electric or water utilities)**

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1.6 Implications for Management

- **Embrace change and actively seek to use new aspects of networks toward improving your organization**
  - **Information moved quickly and easily anywhere and anytime**
  - **Information accessed by customers and competitors globally**
- **Use a set of industry standard technologies**
  - **Can easily mix and match equipment from different vendors**
  - **Easier to migrate from older technologies to newer technologies**
  - **Smaller cost by using a few well known standards**

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