Managing Telecommunications

Chapter 6

Outline

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  - The Optical Era will Provide Bandwidth Abundance
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- The Role of the IS Department

Telecom and IS Organization

- IS departments have been responsible for designing, building, and maintaining the information
  - Just as governments are responsible for building and maintaining streets, roads, and freeways
- Telecom provides infrastructure for moving information and messages
  - Internet opened up a new view of telecom of providing a **Cyberspace**

The Evolving Telecommunications Scene

- The oldest part of the telecommunications infrastructure is the telephone network
  - This global network was built on twisted-pair copper wires and was intended for voice communications
  - It uses analog technology, which although appropriate for delivering high-quality voice, is inefficient for data transmission
    - Dedicated circuit (switching)
  - The basic traffic-handling mechanism had to change for data

A New Telecommunications Infrastructure is being Built

- Today, the new telecommunications infrastructure is being built around the world aimed at transmitting data, and consists of:
  - Wired – Fiber optic links
  - Wireless – Radio signals
- Both use packet switching, where messages are divided into packets, each with an address header, and each packet is sent separately
  - No circuit is created; each packet may take a different path through the network
- Packets from any number of senders and of any type, whether email, music downloads, voice conversations, or video clips, can be intermixed on a network segment –
  - Making these next generation networks able to handle much more traffic and a great variety of traffic

A New Telecommunications Infrastructure is being Built

- The Internet can handle all kinds of intelligent user devices, including:
  - Voice-over-IP (VoIP) phones
  - Personal digital assistants (PDA)
  - Gaming consoles
  - All manner of wireless devices
- The global telecom infrastructure is changing from a focus on voice to a focus on data

This architecture allows new kinds of services to be deployed much more rapidly

Transformation of Telecom Industry

- The telecom structure of old was originally provided by (often Government owned) monopolies (e.g. AT&T)
- Gradually, the telecom industry has been deregulated
- Telecom industry is even more competitive than computer industry
  - Bandwidth on fiber is now doubling capacity every four months

Last Mile Problems

- Who ‘owns’ the ‘last mile’
  - In the 1990s, the ‘monopolies’ began encountering competition for “the last mile”
- Bottleneck issues (hose to straw)
  - Visualize the world’s networks as huge fire hoses because they use fiber optic cables that can transmit at a whopping speed of a terabit (10^{12} bits per second)
- Then visualize the twisted pair phone line coming into your home or business as a straw, only operating at speeds of 56 kbps (10^4)

Telecom Technologies and their Speeds

Bits Per Second	Notation	Abbreviation	Amount	Term	Technologies
1,000,000,000,000	10^{12}	1 tbps	Trillion	Terabits	Optical fiber potential (and higher)
100,000,000,000	10^{11}	100 gbps			
10,000,000,000	10^{10}	10 gbps			Optical wireless local loop (20G), OC-768 (40G), WMAN (100G)
1,000,000,000	10^{9}	1 gbps	Billion	Gigabits	Microwave LANs (1.5G–2.0G), OC-48 (2.5G), ATM (2.5G), Gigabit Ethernet (1G), WMAN (24G)
100,000,000	10^{8}	100 mbps			OC-12 (622M), ATM (155M to 622M), T4 (274.176M), OC-3 (155.52M), Faster Ethernet (100M), infrared (100M), WMB (100–400M)
10,000,000	10^{7}	10 mbps			T3 (44.736M), E3 (34.318M), frame relay (10M), Ethernet (10M), WLANs (10M), cable modem (10M), Wi-Fi (11–54M)
1,000,000	10^{6}	1 mbps	Million	Megabits	T2 (6.132M), infrared LAN (4M), stationary 3G wireless (2M), E1 (2.048M), DSL (1.544M to 7M), T1 (1.544M), Wi Max (1.5–10M)
100,000	10^{5}	100 kbps			Wireless local loop (428K), mobile 3G wireless (384K), ISDN (128K), 2G wireless (128K)
10,000	10^{4}	10 kbps			Modems (56K), 2.5G wireless (57K)
1,000	10^{3}	1 kbps	Thousand	Kilobits	2G wireless (9.6K to 14.4), infrared LAN (9.6K)
100	10^{2}	100 bps			
10	10^{1}	10 bps			

Read Case Example P.231-232

History of the Internet

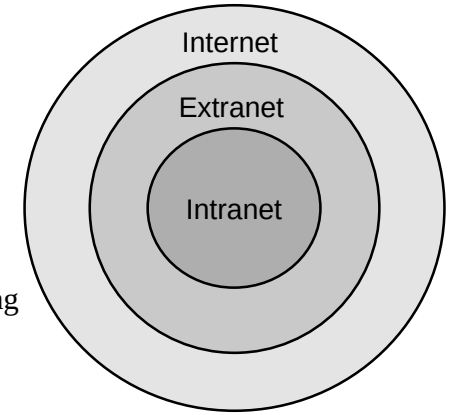
- In 1960s, APARNET developed by DOD for transferring scientific files
  - Mainly used for email
- Until 1993, still an all-text world-wide network for scientists and academics
  - Email, FTP, Telnet, Gopher…
- In 1994, Tim Berners Lee invented World Wide Web (WWW)
  - URL, HTML, Browser

The Internet is the Network of Choice

- Internet and telecom surprised us by its fast rise and fall in the past one decade
- The Internet has done for telecom what the IBM PC did for computing:
  - Brought it "to the masses"
- 3 important attributes of the Internet
  - Ubiquity
    - Global reach
  - Reliability
    - Alternate routing, scale-free network
  - Scalability
    - Easy extension of its reach, increasing performance of websites

The Internet is the Network of Choice

- Intranet
  - Internet technology used inside an enterprise
- Extranet
  - Internet technology used to connect trading partners, customers, suppliers etc.



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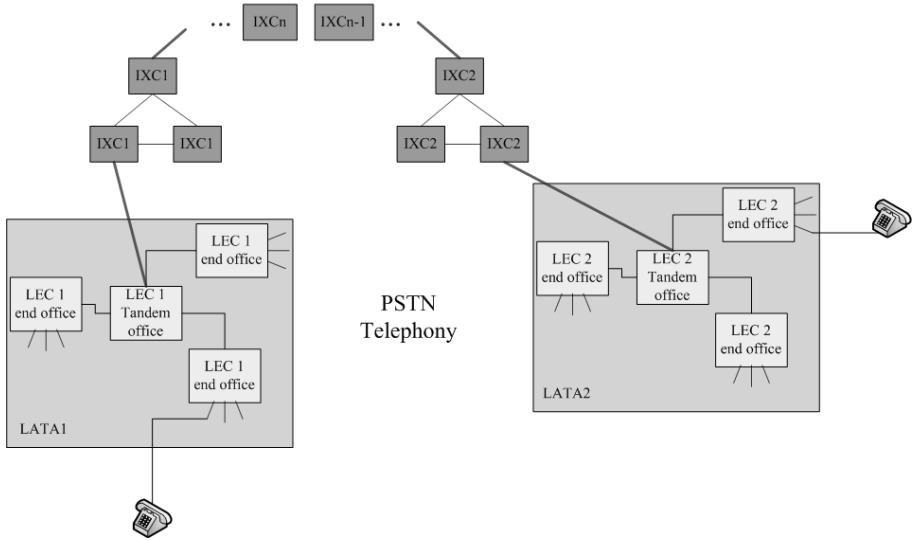
Digital Convergence has Become a Reality

- Digital convergence is the intertwining of various forms of media – voice, data and video
- Convergence is now occurring because IP has become the network protocol of choice
  - When all forms of media can be digitized, put into packets and sent over an IP network, they can be managed and manipulated digitally and integrated in highly imaginative ways
- IP telephony and video telephony have been the 'last frontiers' of convergence – and now they are a reality

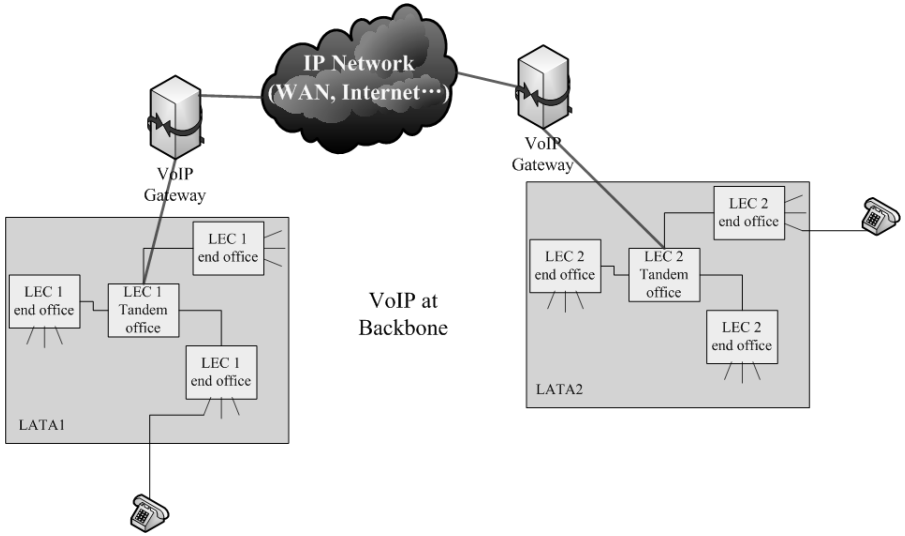
IP Telephony

- The use of Internet to transmit voice to replace their telephone system
  - A phone with an IP address, voice delivered in digital packets
- Previously conceived application of IP telephony
  - To another IP phone on the LAN
  - Through the company's WAN to a distant IP phone on another of the company's LAN
  - Through an IP voice gateway to the PSTN to a standard telephone

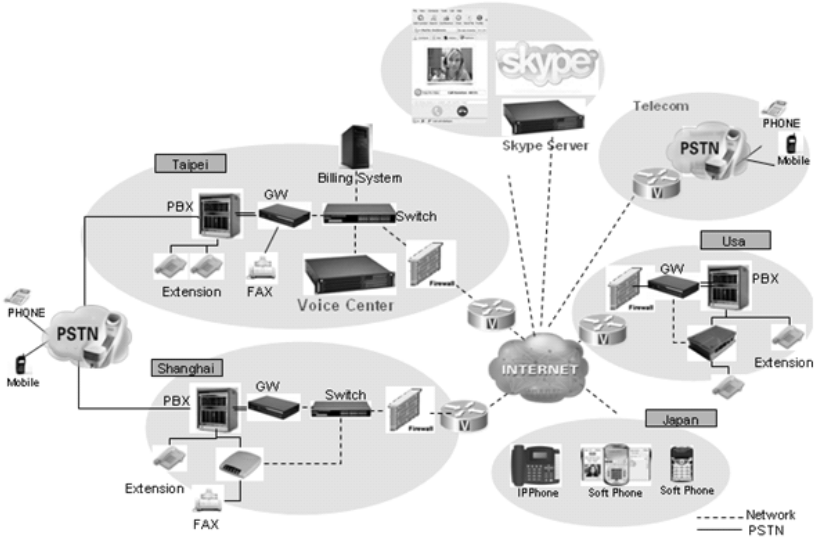
IP Telephony



IP Telephony



IP Telephony



Video Telephony

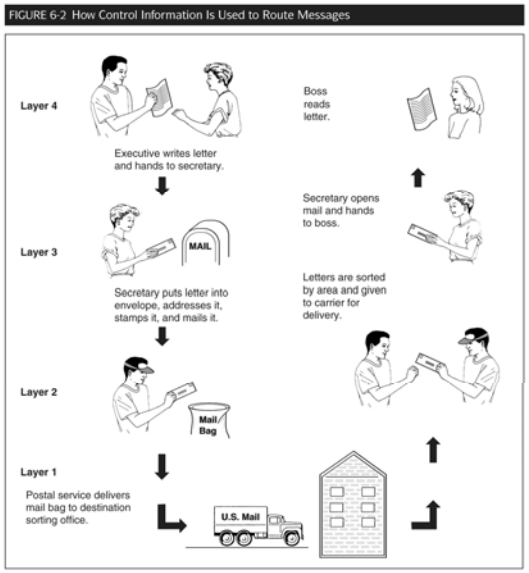
- Similar story to IP Telephony
- Not video conferencing via a PBX, but rather video over IP
  - With the appropriate IP infrastructure, video telephony can be, say, launched from an instant-messaging conversation
    - IP phones with cameras also facilitate it, phone to phone

Read Case Example P.239

The OSI Reference Model Underlies Today's Networks

- Closed versus Open Networks
  - **Closed Network**: using proprietary networking technology
  - **Open Network**: based on national or international standards
- What is a reference model?
  - A division of functionality together with data flow between the pieces
  - No detailed standards specified for each layer

Analogy of Mailing a Letter



Analogy of Mailing a Letter

- Control information (address and type of delivery) on the envelope - determines the services provided by the next lower layer and addressing information for next lower layer
- When a layer receives a “message” from the next higher layer, it performs the requested services and “wraps” the message in its own layer of control information
- It passes the “bundle” to the layer directly below it. On the receiving end, a layer receiving a bundle from a lower layer unwraps the outermost layer of control information, interprets the information, and acts on it

The Model’s Seven Layers

- The OSI Reference Model describes the type of control data produced by each layer

FIGURE 6-3 The OSI Reference Model

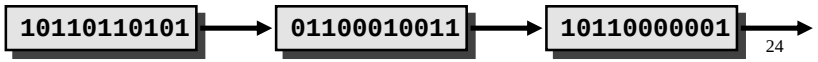
Layer	*Name*	*Job*	*Protocol Examples*
7	Application Layer	Interface to application	HTTP, X.500, X.400, ODA, Internet key exchange (IKE), Postscript
6	Presentation Layer	Translates data to and from language in Layer 7	NetBIOS
5	Session Layer	Controls dialog, acts as moderator for a session	Secure Sockets Layer (SSL)
4	Transport Layer	Controls flow, ensures reliable packet delivery	TCP
3	Network Layer	Addresses and routes packets	IP, X.25, Packet-level Protocol
2	Logical Link Layer	Makes sure no data are lost or garbled	Ethernet, Token Ring, FDDI, ISDN, ATM, Frame relay
1	Physical Layer	Defines physical connection to network	Ethernet 50 ohm coaxial cable, 10BaseT, twisted pair, fiber-optic cable

Layer 1: Physical Layer

- This layer conveys the bit stream - electrical impulse, light or radio signal - through the network at the electrical and mechanical level.
- It provides the hardware means of sending and receiving data on a carrier, including defining cables, cards and physical aspects.
- Fast Ethernet, RS232, and ATM are protocols with physical layer components.

Layer 2: Data Layer

- At this layer, data packets are encoded and decoded into bits.
- It furnishes transmission protocol knowledge and management and handles errors in the physical layer, flow control and frame synchronization.
- The data link layer is divided into two sub layers:
  - The Media Access Control (MAC) layer - Controls how a computer on the network gains access to the data and permission to transmit it.
  - The Logical Link Control (LLC) layer - Controls frame synchronization, flow control and error checking.



Layer 3: Network Layer

- This layer provides switching and routing technologies, creating logical paths, known as virtual circuits, for transmitting data from node to node.
- Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

Layer 4: Transport Later

- This layer provides transparent transfer of data between end systems, or hosts, and is responsible for end-to-end error recovery and flow control.
- It ensures complete data transfer.

Layer 5: Session Layer

- This layer establishes, manages and terminates connections between applications.
- The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications at each end.
- It deals with session and connection coordination.

Layer 6: Presentation Layer

- This layer provides independence from differences in data representation (e.g., encryption) by translating from application to network format, and vice versa.
- The presentation layer works to transform data into the form that the application layer can accept.
- This layer formats and encrypts data to be sent across a network, providing freedom from compatibility problems.
- It is sometimes called the Syntax Layer.

Layer 7: Application Layer

- This layer supports application and end-user processes.
- Communication partners are identified, quality of service is identified, user authentication and privacy are considered, and any constraints on data syntax are identified.
- Everything at this layer is application-specific. This layer provides application services for file transfers, e-mail, and other network software services.
- Telnet and FTP are applications that exist entirely in the application level.
- Tiered application architectures are part of this layer.

The Rate of Change is Accelerating

- Although no one seems to know for sure, many people speculate that data traffic surpassed voice traffic either in 1999 or 2000
- In 1995, exactly 32 doublings of computer power had occurred since the invention of the digital computer after World War II
- E-mail outnumbered postal mail for the first time in 1995
  - Unfortunately many are Spam or junk
- The number of PC sales overtook the number of TV sales in late 1995
- Such changes will only accelerate
  - Everyone in business must become comfortable with technology to cope with this brand new world of ever-increasing technological change

The Optical Era will Provide Bandwidth Abundance

- Decline in cost of key factors
  - During the industrial era: Horsepower
  - Since the 1960s: Semiconductors
  - Now: Bandwidth
- 40 million miles of fiber optic cable have been laid around the world, in the USA at a rate of 4,000 miles per day
  - Half of the cable is dark, that is, it is not used. And the other half is used to just one-millionth of its potential
  - Over the next decade, bandwidth will expand ten times as fast as computer power and completely transform the economy

The Wireless Century Begins

- The goal of wireless is to do everything we can do on wired networks, but without the wire
- Wireless communications have been with us for some time
  - Mobile phones, pagers, VSAT, infrared networks, wireless LANs etc.
  - Radio waves are none-deterministic
- The 20th century was the Wire-line Century, the 21st will be the Wireless Century

Licensed vs. Unlicensed Frequencies

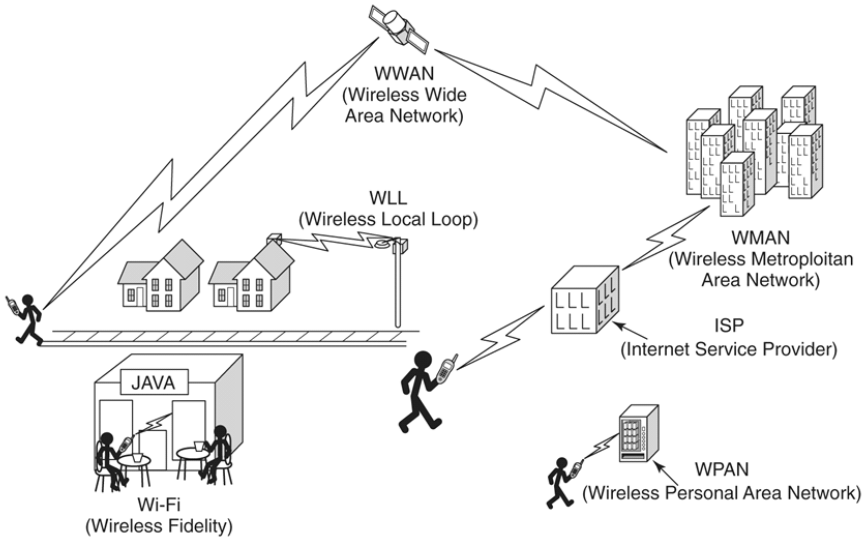
- Some frequencies of the radio spectrum are licensed by governments for specific purposes; others are not
- Devices that tap unlicensed frequencies are cheaper
  - No big licensing fees
  - Greater competition, more innovation and faster changes
  - Possibility of collision between signals

Wireless Technologies for Networks that Cover Different Distances

- Wireless Personal Area Networks (WPAN)
  - Provide high-speed connections between devices that are up to 30 feet apart
- Wireless Local Area Networks (WLAN)
  - Provide access to corporate computers in office buildings, retail stores, or hospitals or access to Internet "hot spots" where people congregate
- Wireless Metropolitan Area Networks (WMAN)
  - Provide connections in cities and campuses at distances up to 30 miles
- Wireless Wide Area Networks (WWAN)
  - Provide broadband wireless connections over thousands of miles

Read Case Example P.248

The Span of Wireless



Wireless Long Distance

- The only two wireless technologies are infrared light and radio airwaves
  - Cell (mobile) phones use radio transmitters and receivers
    - Call is passed from one cell to another – fades out of one and into another
  - Much of the bandwidths and radio waves are regulated by governments
- In the main, GSM has become the mobile telephony standard for all but the Americas
  - Unlike the computing industry, a number of leading global telecom manufacturers are outside the United States. NTT is in Japan, Ericsson and Nokia are in Scandinavia

The Electromagnetic Spectrum and Broadcast Frequencies

Frequency	Frequency Name	Technologies	Spectrum Uses
3,000 EHz 300 EHz 30 EHz 3 EHz 300 PHz 30 PHz 3 PHz		Gamma rays	
		X-rays	
		Ultraviolet radiation	
		Visible light	
300 THz 30 THz 3 THz		Infrared radiation	
300 GHz 30 GHz	Extra high frequency	Microwave	Wireless Local Loop (71–95 GHz) Terrestrial microwave
3 GHz	Super high frequency		Satellites (0.5–51.4GHz)
	Ultra high frequency	Radio waves	Wireless LANs (2.4–5.0 GHz) 3G wireless (1,800–2,200 Mhz) 1G cellular (800–900 MHz) UHF TV (500–800 Mhz)
300 MHz	Very high frequency		VHF TV (175–216 MHz) FM radio (88–108 MHz)
30 MHz	High frequency		
3 MHz	Medium frequency		Wireless local loop (1.25 MHz) AM radio (540–1800 KHz)
300 KHz	Low frequency		GSM 2G wireless (200 KHz)
30 KHz 3 KHz 300 HZ	Very low frequency		
30 HZ 7.5 HZ	Earth		

Wireless Long Distance – 1G Cellular

- Using analog technology and circuit switching
- Main targeted at voice service
- In the main, GSM has become the mobile telephony standard

Wireless Long Distance – 2G Cellular

- Predominant today, uses digital technology, but still circuit switched
- 2G can carry SMS service
- It aims at digital telephony, but with certain ability to carry data
- 2.5G (e.g. GPRS) → 2.75G (e.g. CDMA)
  - Adds data capacity to a 2G network
  - The problem with adoption has been pricing

Read Case Example P.251

Wireless Long Distance – 3G

- Services include wide-area wireless voice telephony and broadband wireless data, all in a mobile environment.
  - 802.11 networks are short range
- 384k-2M
- Costs to deploy not seen as tenable in many circumstances
- It faces the same pricing issues at 2.5G – perhaps worse
- Killer apps still not clear
- Battery and input

Read Case Example P.253-255

Wireless Long Distance – 4G

- A comprehensive IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis
- Features
  - higher data rates than previous generations: 100M-1G (any two points in the world)
  - premium quality and high security
  - Fully IP-based
  - Supporting a greater number of wireless devices that are directly addressable and routable (IPv6)
  - Spectrally efficient and high network capacity
- Pre-4G technologies
  - WiMax, LTE, UMB...

Is Wireless Secure?

- Security is a major issue today
- Eavesdroppers need special equipment
- Radio scrambling and spread-spectrum technologies add security, encryption protects data, and eventually , 802.11i will provide a framework for security
- Requires eternal vigilance
  - Note: the network is often not the main problem

Is Wireless Safe?

- Although a lot of attention is focused on all the new wireless services, a troubling question has not yet been answered: Are these transmissions safe for humans?
- It is quite possible that there could soon be a backlash against wireless devices, similar to protests against genetically modified organisms
  - Already heaps of debate (informed and otherwise) in this area

Messaging is a Killer App

- The key attribute of Instant Messaging (IM) is that it provides presence, which means that a person on your buddy list can see when you are using a computer or phone and therefore knows you are “present” and available to receive an IM
- Newer technologies will allow messaging to become even more personal
  - Photo messaging
  - Video messaging
  - Video phones

Read Case Example P.257-258

Coming: An Internet of Things

- Wireless communications not just for people
  - A machine-to-machine Internet is coming
    - Likely to use Wi-Fi as one wireless communication protocol
- RFID (Radio Frequency Identification)
  - Like the barcode which involves small tags affixed to objects that provide information about the object
- Communication systems, a mix of wired and wireless, one of the many challenges for CIO

The Role of the IS Department

- Create the telecom architecture
  - Connectivity – Allowing users to communicate up, down, across, and out of an organization
  - Interoperability – This interoperability is the goal of architecture and is the main job of the IS department
- Operate the network
  - Many companies are outsourcing (part of) this work
- Stay current with the technology