Information Technology
Inside and Outside
- David Cyganski & John A. Orr

V. Bandwidth and Information Theory

13. The Telephone System: Wired and Wireless

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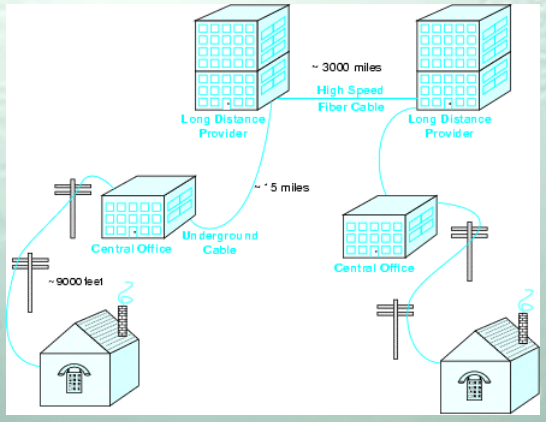
13. The Telephone System: Wired and Wireless

- Objectives:
  - the five fundamental components of the original analog telephone system: the microphone, transmission system, receiver, switching system, and signaling system (some of these will be discussed in more detail in Chapter 18);
  - the present telephone system, which is a hybrid of analog and digital technologies;
  - the principles of the cellular telephone system and the ways in which it differs from the wired system;
  - the many different ``flavors'' of cellular systems, and the technical and marketing reasons for the many variations; and
  - satellite telephone systems, and their advantages and disadvantages.

13.1 Introduction

- **Figure 1.3:** Pictorial description of the major components that make up the telephone transmission system.



13.2 The Original (Analog) Telephone System

- Five major components (telephone system)
  - The **microphone**, which responds to input sounds and converts it to electrical energy,
  - The **transmission system**, which conveys information representing the sound from the microphone to the receiver;
  - The **receiver**, which converts the received information (which may be in many forms as described below) into sound waves;
  - The **switching system**, which makes appropriate connections among pieces of the transmission system to create an unbroken (real or virtual) path from transmitter to receiver (and also in the reverse direction for two-way communication); and
  - The **signaling system**, which indicates to the switches the connections that they should make.

13.2 The Original (Analog) Telephone System(2)

- Working telephone system
  - ***1) Microphone***: a small amount of carbon granules, a container for the granules, a diaphragm making up one side of the container, and two metal contacts. The action of sound waves on the diaphragm alternately compresses and relaxes pressure on the granules, varying their electrical resistance in synchronism with the sound waves. Hence, a mechanical quantity (sound or air pressure variations) is converted into an electrical quantity (resistance).
  - ***2) Receiver***: a permanent magnet and a coil of wire attached to a paper diaphragm. When an electrical current passes through the coil, a magnetic field results, which interacts with the permanent magnet field to cause the diaphragm to move. If the electric current varies at the same speed as the sound pressure waves for voice, the diaphragm moves at that same speed, and produces new air pressure variations also at the same speed, and hence with the same sound. This describes the operation of all loudspeakers.

13.2 The Original (Analog) Telephone System(3)

- Working telephone system (2)
  - ***3) Transmission System***: two lengths of wire and a flashlight battery. The wires, the battery, the microphone, and the receiver are connected into an *electrical circuit* so that the current caused by the battery varies due to the variation in resistance of the microphone in response to sound waves. The receiver (loudspeaker) moves in synchronism with the electrical current and hence produces new sound waves that match the original sound waves.
  - ***4) Switching System***: the system described above is a working telephone (actually one direction of a telephone, but adding the second direction is easy to understand) but it does not permit the transmitter and receiver to change. The switching system breaks the electrical wires from one end and connects them to the desired telephone at the other end. In fact, this connection generally happens with many intervening switches as various point-point transmission systems are connected together to reach between the two desired telephones.

13.3 The Digital Telephone System

- For voice, the signal is **sampled at 8,000 Hz (for a 4 kHz bandwidth)** and quantized to 256 levels at each sample. Eight bits are required to represent 256 levels.
  - Hence the bit rate for the digital telephone call (in each direction) is **8,000 times 8, or 64,000 bits per second**.
- The smallest unit of channel combination(in the U.S.) is **24 channels**, which corresponds to a data rate of **1.544 Mbits/second**.
- This is the so-called **T1 rate**, which has become well known. Actually, some bits are ``stolen" from the voice data so that **synchronization bits** may be included in the 1.544 Mbits/sec rate.
- This is also referred to as the **DS1 rate in the hierarchy** of digital transmission.

Advantages of Digital Communications

- Reduction of noise, distortion, and other impairments
- Regeneration of the signal is easier
- Encryption and compression is easier
- Easier to handle diverse channel types
- VLSI

Digital Carrier Systems

- Hierarchy of TDM
- USA/Canada/Japan use one system
- ITU-T use a similar (but different) system
- US system based on DS-1 format
- Multiplexes 24 channels
- Each frame has 8 bits per channel plus one framing bit
- 193 bits per frame

Digital Carrier Systems (2)

- For voice each channel contains one word of digitized data (PCM, 8000 samples per sec)
  - Data rate 8000x193 = 1.544Mbps
  - Five out of six frames have 8 bit PCM samples
  - Sixth frame is 7 bit PCM word plus signaling bit
  - Signaling bits form stream for each channel containing control and routing info
- Same format for digital data
  - 23 channels of data
    - 7 bits per frame plus indicator bit for data or systems control
  - 24th channel is sync

Digital Hierarchies

Level	N. America	Europe	Japan
0	64 Kb/s, 1	64 Kb/s, 1	64 Kb/s, 1
1	1.544 Mb/s, 24	2.048 Mb/s, 30	1.544 Mb/s, 24
2	6.312 Mb/s, 96	8.448 Mb/s, 120	6.312 Mb/s, 96
3	44.736 Mb/s, 672	34.368 Mb/s, 480	32.064 Mb/s, 384
4	274.176 Mb/s, 4032	139.264 Mb/s, 1920	97.728 Mb/s, 1536
5		565.148Mb/s, 7680	397.20Mb/s, 6144

Mixed Data

- DS -1 can carry mixed voice and data signals
- 24 channels used
- No sync byte
- Can also interleave DS -1 channels
  - Ds -2 is four DS -1 giving 6.312Mbps

Introduction to SONET

- **Synchronous Optical NETwork**
- **Provides a rich built-in capacity for advanced network management and maintenance**
- **Supports new types of customer service signals (ATM, TCP/IP, SNA, X.25, frame relay, etc.)**

Sonet/SDH

- Synchronous Optical Network (ANSI)
- Synchronous Digital Hierarchy (ITU-T)
- Compatible
- Signal Hierarchy
  - Synchronous Transport Signal level 1 (STS-1) or Optical Carrier level 1 (OC-1)
  - 51.84Mbps
  - Carry DS-3 or group of lower rate signals (DS1 DS1C DS2) plus ITU-T rates (e.g. 2.048Mbps)
  - Multiple STS-1 combined into STS-N signal
  - ITU-T lowest rate is 155.52Mbps (STM-1)

SONET Advantages

- Reliability
  - electronics/optics redundancy
  - path diversity
  - performance monitoring
  - circuit provisioning online
- Vendor-neutral standard
  - leads to less expensive hardware
- Ease of engineering

SONET Hierarchy

Optical Carrier	Electrical Signal	Line Rate Mbps
OC-1	STS-1	51.84
OC-3	STS-3	155.52
OC-12	STS-12	622.48
OC-48	STS-48	2488.32
OC-192	STS-192	9953.28

13.4 Cellular Telephone Systems

- **Conventional telephone systems** and **conventional radio systems** could not be more different:
  - Telephone systems connect **two users for a private conversation**; radio by its nature is **broadcast for many people to hear**.
  - Telephones are **connected via wires**; radio is **a wireless** medium.
  - Radio systems are **limited in range**; telephones **can connect everyone** on earth.
  - Telephones are **private** (at least reasonably private); radio is **open to eavesdropping**.
  - Telephones **limit access** because a physical connection is required; the radio waves are **open to anyone** with a transmitter.

13.4 Cellular Telephone Systems(2)

- **Cellular radio system**
  - **The radio spectrum is limited in size (frequency range)**, and hence **in the number of telephone signals** that can be active at any given time.
  - **The *ultimate* upper limit of the spectrum**, and hence the number of telephone channels, is determined by physical laws. For example, as the frequency becomes very high, the signals can no longer pass through heavy rain.
  - **The *practical* upper limit of the spectrum** is affected by current technology. Until recently, the electronic equipment for very high frequencies was quite expensive.
- Federal Communications Commission (FCC): Early model
  - This might have represented **100 channels, each 20 kHz** in width. The base station transmitted with enough **power to cover the entire city**.

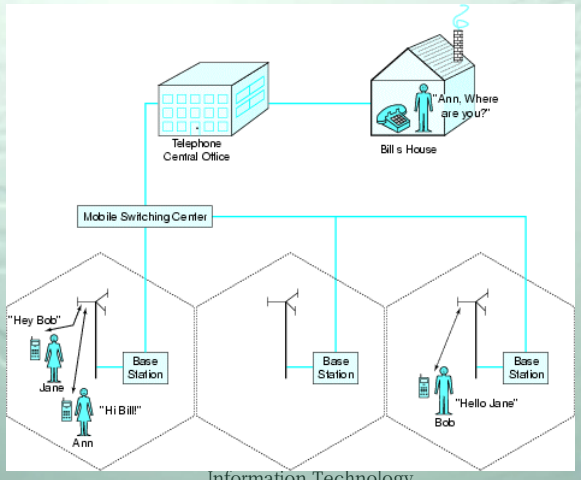
13.4 Cellular Telephone Systems(3)

Figure 13.1: Two cellular telephone antenna towers erected by competing cellular phone service providers at the top of a solitary hill.

Figure 13.2: The cellular telephone has made it possible for people to stay in contact over most highly populated regions of the world.

13.4 Cellular Telephone Systems(4)

Figure 13.3: Basic components of the Cellular Telephone system: cell phone, cell site transmitter/receiver, conventional telephone links connecting cell sites, switching and control system.



13.4 Cellular Telephone Systems(5)

- While **the cell system** is straightforward in concept, it was a completely new system and hence **required substantial time and money for design and construction**. Also, until there are many users, the overall costs must be shared by few customers, raising the average cost, and hence **slowing market penetration**.
- The cell system makes use of much **higher technology** than the conventional telephone system (all of whose major pieces would be quite recognizable to Alexander Graham Bell) and initially all of **the components (base stations and cell phones) were very expensive**. As in almost everything else electronic, costs have fallen rapidly, so that equipment costs are **now quite reasonable**.

13.4 Cellular Telephone Systems(6)

13.4.1 The Cellular Telephone System: How It Works

1. The user **turns on** his or her **phone**.
2. The phone generally **indicates** that it is **in service**.
   - If **no cell site** is within range, the phone indicates ``**no service**."
3. The phone has automatically communicated with at least **one cell site base station** to confirm that **communication is possible**, and (very importantly) to let the telephone system know **where the cell phone is now located**.
   - If **more than one cell site** is within range, **the one with the strongest signal is selected**, and **the control system directs the other cell site(s) to ignore the call**.
4. When the user **enters a number** on the cell phone and **presses ``send**," a channel is dedicated to that user, and then umber is processed at the cell site and sent into the regular telephone network (called the Public Switched Telephone Network, or **PSTN**).
   - Assuming the called number is **a wired telephone**, the call is completed in the normal manner. If it is **another cell phone**, the cellular system control center is queried to determine whether the called cell phone is in service, and if so, what cell site (nearby or around the world) it is currently accessing. If the cell phone is **not located**, the calling party is notified via a tone or recorded message.

13.4 Cellular Telephone Systems(7)

13.4.1 The Cellular Telephone System: How It Works(2)

- What happens if either (or both) cell phones in a conversation move from one cell site to another?
  - The call must be``**handed off**" from one site to another without losing the connection.
  - The connection first **becomes noisy, and then becomes clear again** when the transfer is made. This hand-off is possible because each cell site continuously monitors all the cell phone signals it hears, even if that site is not handling the call.
- What about ``roaming?"
  - This mode reflects **a combination of non ideal technical design of the cell system**, and the competitive nature of telecommunications!
  - When your cell phone indicates that it is **in ``roam" mode**, it means that **you are not within range of the cell system** to which you subscribe (to which you pay your monthly bill) **but you are within range of another system**.

13.4 Cellular Telephone Systems(8)

13.4.2 The Alphabet Soup of Competing Cellular Systems: AMPS, GSM, TDMA, CDMA, and PCS(1)

- **AMPS** (Advanced Mobile Phone System)
  - The only system in the United States until about 1997, and as of 2000 is still **in common use in the U.S.**
  - **The voice transmission part** of the AMPS system is completely conventional, essentially **the same as** could be used in any ``**walkie talkie.**"
  - AMPS uses the **800 MHz frequency band**.
  - It was the cellular system design and the overall control functions that were technically novel.
  - The analog format made cell phone conversation almost completely **non private**. Anyone with **a simple scanning receiver** could listen to the conversations.

13.4 Cellular Telephone Systems(9)

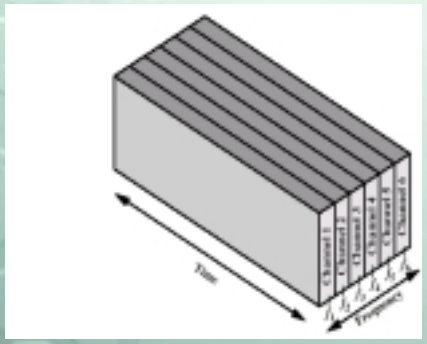
13.4.2 The Alphabet Soup of Competing Cellular Systems: AMPS, GSM, TDMA, CDMA, and PCS(2)

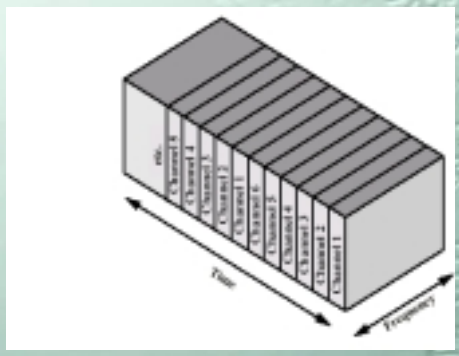
- **GSM**(*Groupe Special Mobile → Global System for Mobile Communications)*
  - A **European standard → worldwide (including the U.S.)**
  - A **digital system**, meaning that the voices are digitized and processed to minimize the bit rate (using some of the techniques described in this book) before transmission.
  - The digital signals are transmitted over similar RF channels as in the analog case, **in the 900 and 1800 MHz bands**. (The frequencies for AMPS and GSM are different so that both systems may **operate simultaneously in a given area**.)
  - **Digital coding of a voice signal (for speech, not music)** requires a sampling rate of about 8,000 Hz and on the order of 8 bits (256 levels) per sample = **64kbps→** sophisticated **voice coders** have been designed that produce good speech quality with much lower bit rates, on the order of **13kbps.**

13.4 Cellular Telephone Systems(10)

13.4.2 The Alphabet Soup of Competing Cellular Systems: AMPS, GSM, TDMA, CDMA, and PCS(2)

- **AMPS vs. GSM**
  - AMPS → FDMA (Frequency Division Multiple Access)
  - GSM → TDMA (Time Division Multiple Access)





- FDMA

TDMA

13.4 Cellular Telephone Systems(11)

13.4.2 The Alphabet Soup of Competing Cellular Systems: AMPS, GSM, TDMA, CDMA, and PCS(3)

- **CDMA**(*Code Division Multiple Access*)
  - Each user is assigned a **unique digital code (the ``Code" in CDMA)** which is used to encode the data from the voice digitized before transmission.
  - At the receiver the same code is used to decode the incoming signal, and the result contains two terms: the original voice coder data bits, and a (hopefully) small amount of interference from the other users with different codes.
  - **FDMA → the number of available radio channels**
  - **TDMA → the number of available time slots**
  - **CDMA → the maximum number of users** is determined by **the amount of interference ➔ somewhat greater than would be the case with FDMA or TDMA on a given piece of radio spectrum.**

13.4 Cellular Telephone Systems(12)

13.4.2 The Alphabet Soup of Competing Cellular Systems: AMPS, GSM, TDMA, CDMA, and PCS(4)

- **PCS**(Personal Communications Services)
  - A person might have **a small handset** which he or she always carried, and **a telephone number** associated with the person rather than with a conventional telephone.
  - The telephone system **always keeps track of the person's location for call delivery**.
  - In the home or office, the handset operates as a ***cordless phone*** working inside buildings, and **not taking up expensive cellular bandwidth**. Outside it operates as **cell phone**.
  - At all times it also incorporates paging functions. It may also work **in planes and trains** in a ***microcellular* mode**.
  - This range of functions requires digital capability, and the various digital standards have become somewhat synonymous with PCS.

13.4 Cellular Telephone Systems(13)

13.4.3 The Three Generations of Cellular Systems

- **First generation: AMPS** analog phone **still in widespread use**, and will remain so for some years.
- ***Second generation*** of cellular service: The various digital cellular systems → **GSM, TDMA, CDMA, and PCS**
  - From the users' point of view, along with **better audio quality**, the second generation systems add some features such as **Caller ID and integrated paging.**
- **Dual-mode cell phones**, which can operate on two systems, such as **analog AMPS and digital-GSM**
- **Third generation cellular** : IMT-2000
  - **higher (much higher) data rates** for video, Internet access, Web browsing, **complete worldwide operability**, and **usability inside aircraft and buildings**.
  - Widespread introduction of third-generation systems is expected to begin **by 2005**.

13.4 Cellular Telephone Systems(14)

13.4.4 Cellular System FAQs

- Why are base station cellular antennas so ugly?
  - The antenna on a hand held cell phone is a simple rod, **about 6 inches long**. Base station antennas could be as simple and unobtrusive as this, but technically they work better if they are arranged in **groups of three** so that each antenna transmits to **one third (120 degrees) of the complete cell**.
- Why are some antennas on high towers, while some are fairly low to the ground?
  - This relates to the **desired size of the cell**. As you drive along the Interstate highways in the midwest of the United States, you will see occasional high towers with cellular antennas on top. These serve **large (long and narrow) cells** along the highway, that may be **20 miles or more in size**.
  - Conversely, in cities the cells must be **small to handle the large number of users**, and it is desired to keep the radio energy from propagating outside those cells. Because the energy travels only in straight lines, keeping the antennas low accomplishes this goal.

13.4 Cellular Telephone Systems(15)

13.4.4 Cellular System FAQs(2)

- Why aren't all telephones wireless?
  - Until recently, a simple answer to this question is that it would have been **too expensive**. Cost is becoming less of a factor, and in some circumstances cell phones can **be cheaper** to install and use than wired phones.
  - However, it appears that **the fundamental limit of frequency spectrum capacity may not permit all communication to be wireless.**
- What is the difference between a cell phone and a cordless phone?
  - A **cordless phone** is more properly called a ``**cordless handset**'' because it must be connected to regular telephone service. The cordless handset must stay **within range of its base station**, which in turn is connected to the wired network. The cordless phone has **no capability to travel from one base station to another.**

13.4 Cellular Telephone Systems(16)

13.4.4 Cellular System FAQs(3)

- Why is it illegal to use a cell phone in an airplane?
  - During critical phases of flight, the use of any devices that can emit radio energy is not permitted because of possible (highly unlikely) **disturbances to the aircraft control and navigation systems**. Specifically for cell phones, the problem is that from a high altitude the signal would be received by many cell sites, potentially causing confusion, and certainly tying up channels on unneeded sites.
- Are cell phones safe to use?
  - There is a potential concern whenever radio frequency energy is absorbed by humans. The concern increases as frequency increases. As we reach **X-ray (so-called ionizing) frequencies the danger is quite serious**. However, cell phone frequencies are **well below the ionizing range**, and the limits are stated in terms of how much heating of tissue the energy creates.
  - It should be noted that **distance from the antenna is the most significant factor**, with any risk falling off rapidly with distance. Hence, any possible concern relates to the users of hand-held cell phones (**because the antenna is within inches of the brain**), *not* to cellular base stations in the neighborhood!

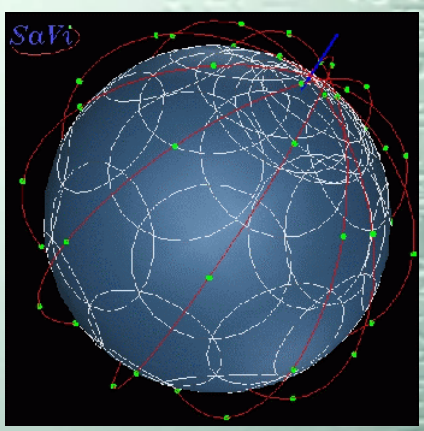
13.5 Satellite Telephones

- **INMARSAT** (for International Marine Satellite)
  - **satellite radio communications for ships at sea**, and somewhat as a sideline has made their facilities available to other users,typically those in very remote areas.
  - This system has **two disadvantages**: the ground terminals are **rather bulky** (by today's standards) and **service is expensive**. The smallest available terminal is the size of a briefcase, and it requires that an antenna be set upband aimed at the satellite.
- ***Iridium* system (Motorola Corporation)**
  - A constellation of **66 satellites** in low earth orbit, **780 km high**
  - Frequencies of about **1.6 GHz** are used **between the cellular telephone and the satellites**, and
  - Frequencies of **20 to 30 GHz** are used **between satellites, and between satellites and ground stations**.
  - **Bankruptcy** and ceased operations early in 2000.(With the service's high cost and inability to handle data transmission)

13.5 Satellite Telephones(2)

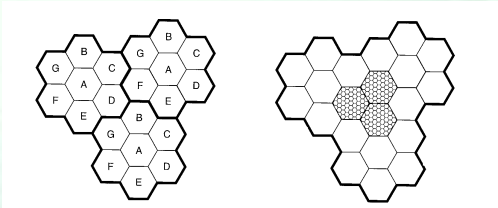
- ***Iridium* system (Motorola Corporation) (2)**

Figure 13.4: This picture depicts the orbits of the 66 satellites that made up the space borne portion of the Iridium satellite telephone system. (Courtesy of Patrick Worfolk (http:www.ee.surrey.ac.ukPersonalL. Woodconstellations), based upon Lloyd's satellite constellations, rendered using SaVi, by the geometry Center at the University of Minnesota(http:www.geom.umn.edulocateSaVi).



Analog Cellular Telephones

- History
  - 1946 Car-based telephones : single large transmitter on top of hill, single channel for both sending and receiving
  - 1950s push-to-talk system : CB-radio, taxis, and police cars
  - 1960s IMTS (Improved Mobile Telephone System) :
    - a high powered (200-watt) transmitter on top of hill
    - two frequencies ; sending and receiving
    - only 23 channels from 150 MHz to 450 MHz
  - 1982 AMPS (Advanced Mobile Phone System) :
    - a geographic region is divided up into cells typically 10 to 20 km across
    - reusing band of frequencies (not neighbor)
    - base station located in the center of the cell



MTSO (Mobile Telephone Switching Office) controls handoff(ownership)

- AMPS Channels
  - 832 full-duplex channels, each consisting of a pair of simplex channels
  - 832 sending channels from 824 ~ 849 MHz
  - 832 receiving channels from 869 ~ 894 MHz
  - FDM (each simplex channels is 30 kHz wide)
  - divided into 4 categories : 1) Control to manage the system, 2) Paging to alert mobile users to calls for them, 3) Access (bidirectional) for call setup and channel assignment, 4) Data (bidirectional) for voice, fax, or data

Digital Cellular Telephones

- Second generation cellular system from AMPS
- System IS -54
  - dual mode (analog and digital)
  - uses the same 30 kHz channels as AMPS
  - digital signaling and digital voice encoding
- GSM (Global Systems for Mobile communications)
  - common digital system developed for Europe
  - new frequency band (1.8 GHz)
  - uses both FDM, TDM
- PCS (Personal Communication Services)
  - under development
  - cellular technology with microcells
  - low power (1/4 watt) : small light phones
  - problem with frequency reallocation : too many users

Wireless Transmission

- Unguided media
- Transmission and reception via antenna
- Directional
  - Focused beam
  - Careful alignment required
- Omnidirectional
  - Signal spreads in all directions
  - Can be received by many antennae

Frequencies

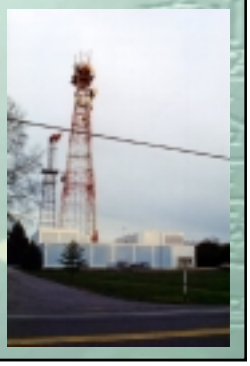
- 2GHz to 40GHz
  - Microwave
  - Highly directional
  - Point to point
  - Satellite
- 30MHz to 1GHz
  - Omnidirectional
  - Broadcast radio
- 3×10^{11} to 2×10^{14}
  - Infrared
  - Local

Terrestrial Microwave

- Parabolic dish
- Focused beam
- Line of sight
- Long haul telecommunications
- Higher frequencies give higher data rates
- 2 -40 GHz

Terrestrial Microwave

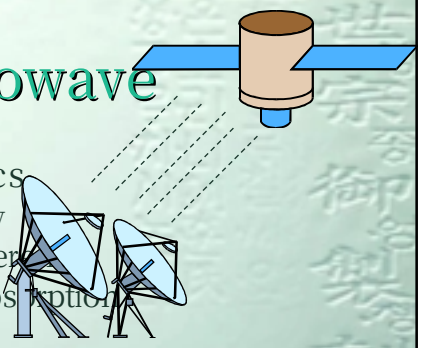
- Attenuation
  - loss varies as square of distance instead of logarithmic, therefore repeaters/amps 10 -100km apart
  - increased attenuation with rain fall
- Interference is a worry
- Pressure on spectrum allocations



Satellite Microwave

- transmission to orbiting satellite(s)
- uplink/downlink different frequencies (usually specified pairs)
- Uses
  - television
  - long distance telecommunication
  - private business networking
- 2 -40 GHz; > 40GHz sat -sat

Satellite Microwave

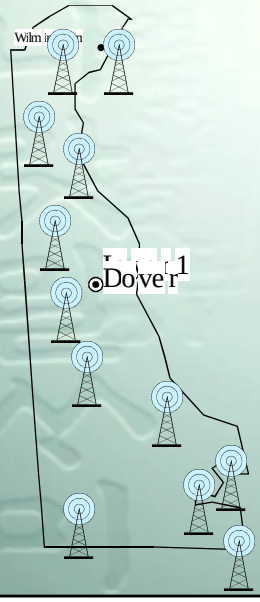


- Transmission Characteristics
  - typically 2 -30 GHz frequency
    - < 2 GHz too much interfer
    - >10 GHz atmospheric abs rptions
  - common pairs
    - (5.925 -6.425 uplink, 3.7 -4.2 downlink) 4/6 band
    - (14 -14.5 uplink, 11.7 -12.2 downlink) 12/14 band
  - at higher frequencies need stronger signals to beat attenuation
  - delay 240 -300ms, noticeable in telecommunication
- Terrestrial interference!

Radio

- Radio
  - omni -directional 30MHz – 2 GHz
  - not disk shaped antennas, not rigidly mount
- Uses
  - VHF -> UHF, radio/television
  - packet radio, uses ground based antennas to link many sites
- Transmission Characteristics
  - ionosphere transparent > 30MHz
  - less rain attenuation but lower data rates (Kbps NOT Mbps)
  - as line of site attenuation same as microwave
  - Big problem/ multipath => reflection

Cellular Radio



Coverage Area determined by power and antenna patterns

Re-use of frequencies

Usable for data rates up to 19.2 kbps

Mobile Data Systems Environment

- Low bit rate
- Variable latency
- Fading
- Interference
- Multipathing

APRS – An Interesting Mobile Data Network Application

- **A**utomatic **P**osition **R**eporting **S**ystem
- Designed by Bob Bruninga at USNA
- Utilizes relatively low-powered VHF radios
- Low-speed (1200 bps)
- Variable topology
- Used to disseminate position reports, weather data, short messages

APRS – We're talking portable!

Global Positioning Satellite Receiver

VHF Transceiver with 1200/9600 bps TNC

How do you increase the range?

Digipeaters

TNC

Serial Data

Antenna

VHF Radio

Wireless Trends

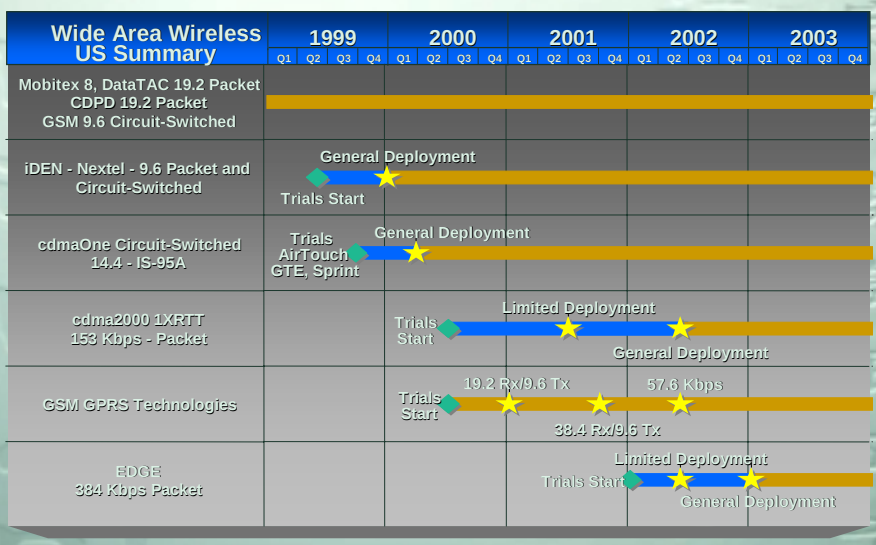
- IP networks
- Always connected
- Increased bandwidth
- Convenience
- Moving from vertical market to horizontal markets
- Moving from proprietary to standards based
- Proliferation of smart devices
- New scenarios enabled
- Outsourcing
- Adhoc networks

Data Speeds Today

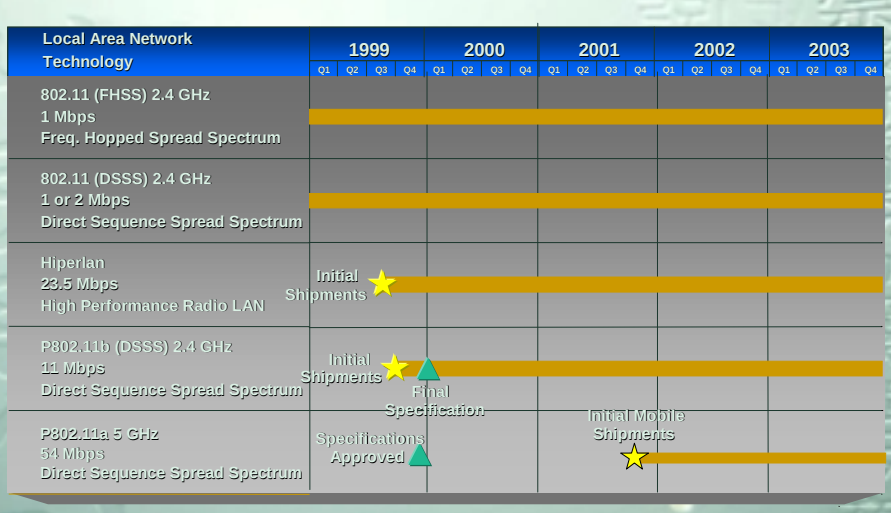
Network	Speed*	Type of Data
American Mobile ARDIS	19.2/4.8 Kbps	Packet
BellSouth Wireless Data	8 Kbps	Packet
Cellular (Analog)	9.6/4.8 Kbps	Circuit-Switched
CDPD	19.2 Kbps	Packet
CDMA	14.4 Kbps	Circuit-Switched
Nextel	9.6 Kbps	Circuit-switched
GSM	9.6 Kbps	Circuit-Switched
Metricom	28.8 Kbps	Packet as Dial-up
TDMA**	One-Way SMS Only	None

*Typical data throughput speed is usually 50% of gross speed
**TDMA systems do not support data in the U.S. at this time

Wide-Area Wireless

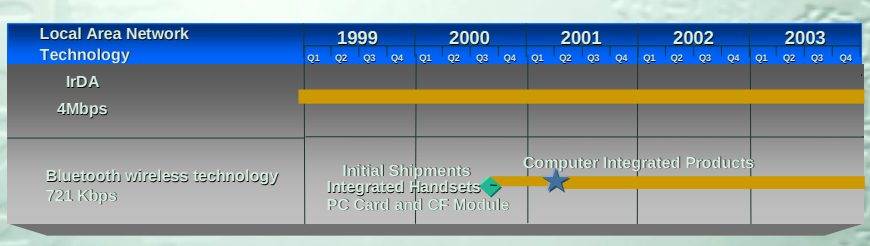


Local -Area Wireless



Materials from Andrew Seybold-Microsoft Exchange Conference 1999

Personal Area Wireless



Materials from Andrew Seybold-Microsoft Exchange Conference 1999

*I*nfra*r*ed *D*ata *A*dapter (*IrDA*)

- Modulate non-coherent infrared light
- Line of sight (or reflection)
- Blocked by walls
- e.g. TV remote control, IRD port

Personal Area Wireless

- IrDA
  - Around since 1994
  - Available on every PC and lots of devices
    - >20 million existing IrDA devices
    - Camera, PDAs, cellphones, printers, keyboards
- Exploding market fueled by Bluetooth momentum
  - Bluetooth wireless technology is a defacto standard
  - Proliferation of smart devices, convenience of cable replacement, and new usage scenarios