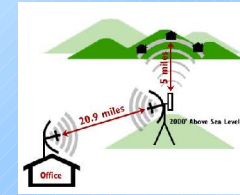
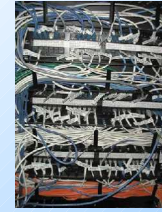


Wireless Communication: Multiple Access Techniques

Kameswari Chebrolu
Department of EE, IIT Kanpur

Wired versus Wireless

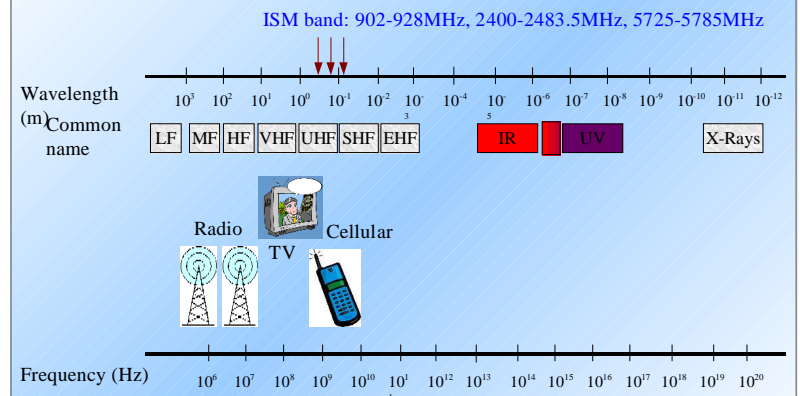


- **Attenuation is low**
- **Interference is nil: each wire is a separate medium**
- **Clumsy, costly, no mobility**
- **Attenuation is high**
- **Interference is high: single medium**
- **No knots, no digging to lay cables, tether-free**

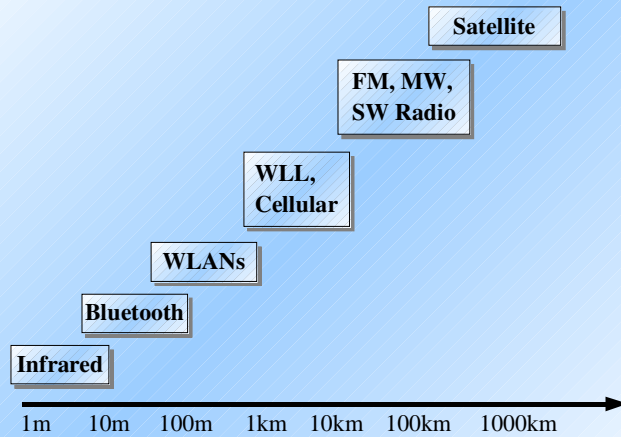
Limitations

- **Bandwidth**
 - Scarce spectrum -> low data rates
- **Reliability**
 - High loss rates
- **Power**
 - Mobility brings about battery operation
- **Security**
 - Medium is broadcast

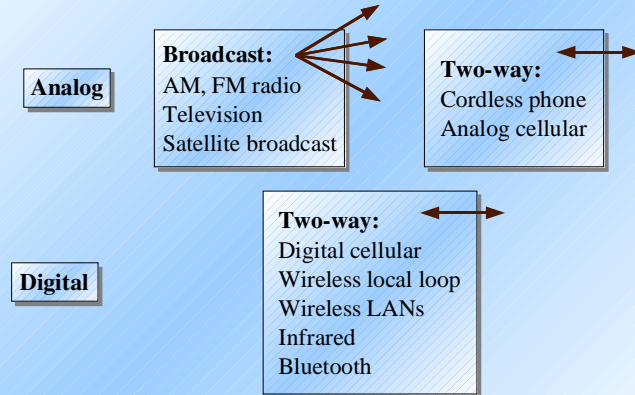
Electro-Magnetic Spectrum



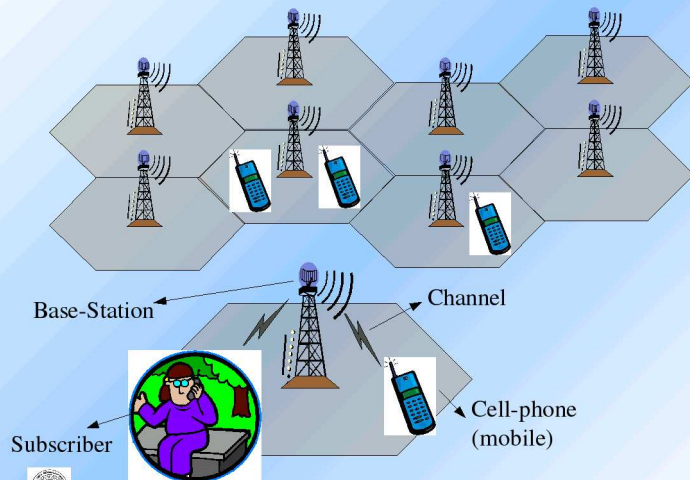
Range of Wireless Systems



Examples of Wireless Communication



Cellular Network Terminology



History

- 1897: Marconi demonstrated radio ability to keep in contact with ships sailing English Channel
- 1946: First public mobile system
 - Push to talk; 50 km range; Analog FM, 120kHz RF bandwidth, operated assisted dialing
- 1950s: Bell Labs proposed "cell concept"
- 1976s: AT&T introduced IMTS (Improved Mobile Telephone System)
 - 30kHz RF bandwidth, full duplex, auto-dialed

Cellular Network Generations

- **First Generation: Analog**
 - 1983: AT&T launched Advance Mobile Phone System (AMPS) in US
 - 1985-1990: Six incompatible standards in Europe
 - E.g., ETACS, NMT-450, NMT-900
- **Second Generation: Digital**
 - 1990: GSM was launched in Europe
 - 1993: IS-95 (Interim Standard) launched in US
 - 1993: PDC (Personal Digital Cellular) launched in Japan



Cellular Network Generations

- **2.5 Generation: Packet Switching**
 - HSCSD (57.6kbps), GPRS(171.2kbps), EDGE (547.2kbps), IS-95B(115.2kbps)
- **Third Generation: Unparalleled wireless access**
 - cdma2000(307kbps), W-CDMA(2Mbps), EDGE (547.2Kbps)

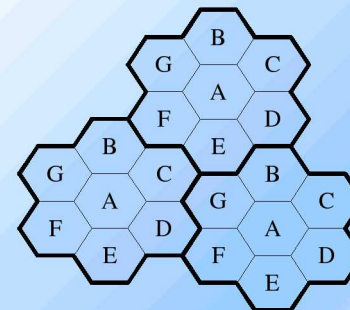


Cellular Concept

- **1970s: A maximum of 12 channels could be supported thousand square miles**
- **Efficiently uses spectrum**
- **Basic Idea:**
 - Replace a single high-power transmitter (large cell) with many low power transmitters (small cells)
 - Allocate channels such that neighboring cells have different frequency sets



Frequency Reuse



Total duplex channels: S
 Cluster size: N
 Allocation per cell: k
 $S = k * N$

Capacity of system: C
 Cluster replication: M
 $C = M * k * N = M * S$

$N = i^2 + i*j + j^2$
 i, j are non-negative integers
 N = 1,3,4,7,9,12 etc



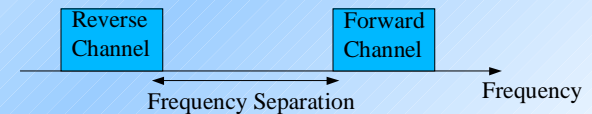
Multiple Access techniques

- Duplexing:
 - Simplex: Communication possible in only one direction
 - Half duplex: At any given time, user can either transmit or receive
 - Full duplex: Allow simultaneous transmission and reception
- Two Types of full duplex
 - Frequency Division Duplexing (FDD)
 - Time Division Duplexing (TDD)



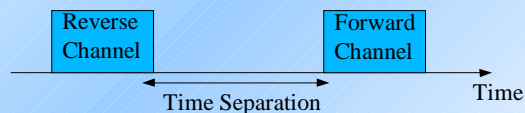
FDD

- Provides two distant bands (simplex) of frequency for each user
 - *Forward band* provides traffic from the base station to the mobile
 - *Reverse band* provides traffic from the mobile to the base station
 - Frequency separation between the forward and reverse band is constant



TDD

- Each user is assigned a single frequency (channel)
- Channel has
 - a forward time slot for communication from base-station to mobile
 - a reverse time slot for communication from mobile to base-station



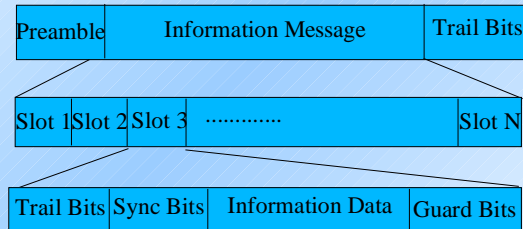
Frequency Division Multiple Access (FDMA)

- Each user is allocated a unique frequency band (channel)
- Channels assigned based on demand
- Dedicated channel:
 - During the period of call, no other user can share the channel
 - If the channel is not in use, it wastes resources
 - Typically FDMA channels are narrow band (30kHz)



Time Division Multiple Access (TDMA)

- Divides the radio spectrum into time slots
- Only a single user can transmit/receive in each slot
- A channel can be thought of as a particular time slot that reoccurs every frame



Code Division Multiple Access (CDMA)

- All users use the same carrier frequency
- All may transmit simultaneously
- Users use code words that are orthogonal to each other
- Receiver performs a time correlation operation to detect specified code word
- Interference limited system
- Walsh codes: 11110000; 11001100; 10101010



Cellular System	Access
AMPS	FDMA/FDD
GSM	TDMA/FDD
PDC	TDMA/FDD
Cordless Phone	FDMA/TDD
IS-95	CDMA/FDD



Summary

- Wireless offers cost and mobility benefits
- Variety of wireless technologies available with different ranges
- Frequency Reuse permits efficient use of scarce spectrum
- Variety of multiple access techniques available to access shared media
 - FDMA, TDMA and CDMA

