Mobile Computing
Lecture 1
Introduction

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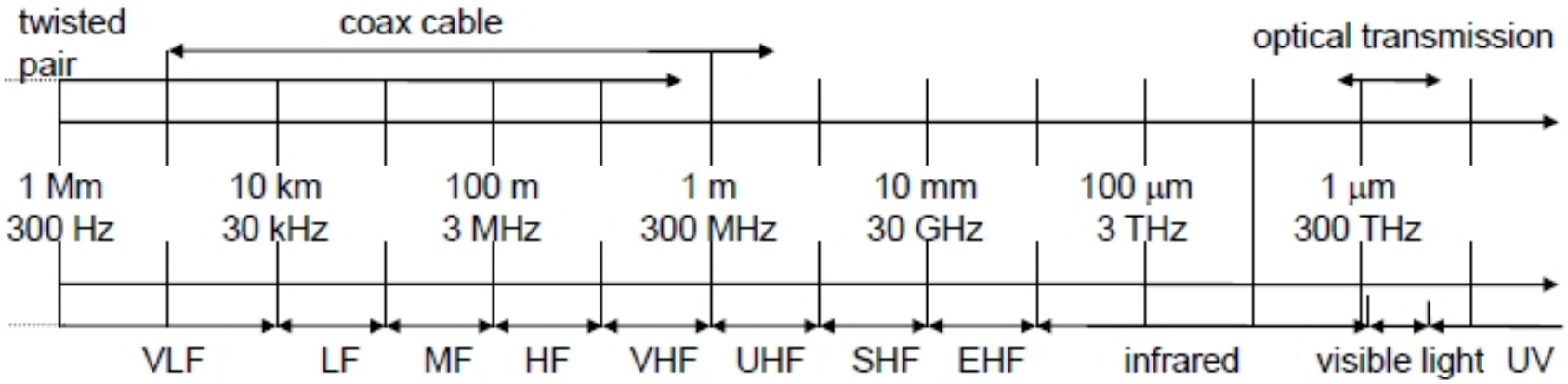
Wireless communication

- Communication is an essential need of human being, e.g., conversation, letter
- "Wireless" used to be the only (limited and unreliable) way to communicate in ancient times: 烽火狼烟、摔杯为号、铜镜反光、鸣金收兵…
- Modern wireless communications are based on the electromagnetic field theory (Maxwell's equations, Marconi's invention)

Wireless data technologies

- Radio communication system
- Broadcasting
- Amateur radio
- Land Mobile Radio or Professional Mobile Radio: TETRA, P25, OpenSky, EDACS, DMR, dPMR
- Cordless telephony:DECT (Digital Enhanced Cordless Telecommunications)
- Cellular networks: 0G, 1G, 2G, 3G, Beyond 3G (4G), Future wireless
- List of emerging technologies
- Short-range point-to-point communication : Wireless microphones, Remote controls, IrDA, RFID (Radio Frequency Identification), TransferJet, Wireless USB, DSRC (Dedicated Short Range Communications), EnOcean, Near Field Communication
- Wireless sensor networks: ZigBee, EnOcean; Personal area networks, Bluetooth, TransferJet, Ultra-wideband (UWB from WiMedia Alliance).
- Wireless networks: Wireless LAN (WLAN), (IEEE 802.11 branded as Wi-Fi and HiperLAN), Wireless Metropolitan Area Networks (WMAN) and (LMDS, WiMAX, and HiperMAN)

Frequencies for communication



- VLF = Very Low Frequency
- UHF = Ultra High Frequency
- LF = Low Frequency
- SHF = Super High Frequency
- MF = Medium Frequency
- EHF = Extra High Frequency
- HF = High Frequency UV = Ultraviolet Light
- VHF = Very High Frequency
- Frequency and wave length:
  - $\lambda = c/f$
- wave length λ, speed of light $c \cong 3 \times 10^8 m/s$, frequency f

Cont..

- VHF-/UHF-ranges for mobile radio
  - simple, small antenna for cars
  - deterministic propagation characteristics, reliable connections
- SHF and higher for directed radio links, satellite communication
  - small antenna, beam forming
  - large bandwidth available
- Wireless LANs use frequencies in UHF to SHF range
  - some systems planned up to EHF
  - limitations due to absorption by water and oxygen molecules (resonance frequencies)
    - weather dependent fading, signal loss caused by heavy rainfall etc.

Frequencies & Regulation

- ITU-R holds auctions for new frequencies, manages frequency bands worldwide (WRC, World Radio Conferences)

	Europe	USA	Japan
Cellular Phones	GSM 450-457, 479-486/460-467,489-496, 890-915/935-960, 1710-1785/1805-1880 UMTS (FDD) 1920-1980, 2110-2190 UMTS (TDD) 1900-1920, 2020-2025	AMPS, TDMA, CDMA 824-849, 869-894 TDMA, CDMA, GSM 1850-1910, 1930-1990	PDC 810-826, 940-956, 1429-1465, 1477-1513
Cordless Phones	CT1+ 885-887, 930-932 CT2 864-868 DECT 1880-1900	PACS 1850-1910, 1930-1990 PACS-UB 1910-1930	PHS 1895-1918 JCT 254-380
Wireless LANs	IEEE 802.11 2400-2483 HIPERLAN 2 5150-5350, 5470-5725	902-928 IEEE 802.11 2400-2483 5150-5350, 5725-5825	IEEE 802.11 2471-2497 5150-5250
Others	RF-Control 27, 128, 418, 433, 868	RF-Control 315, 915	RF-Control 426, 868

Signals

- physical representation of data
- function of time and location
- signal parameters: parameters representing the value of data
- Classification
  - continuous time/discrete time
  - continuous values/discrete values
  - analog signal = continuous time and continuous values
  - digital signal = discrete time and discrete values
- signal parameters of periodic signals:
- period T, frequency f=1/T, amplitude A, phase shift ϕ
  - sine wave as special periodic signal for a carrier:

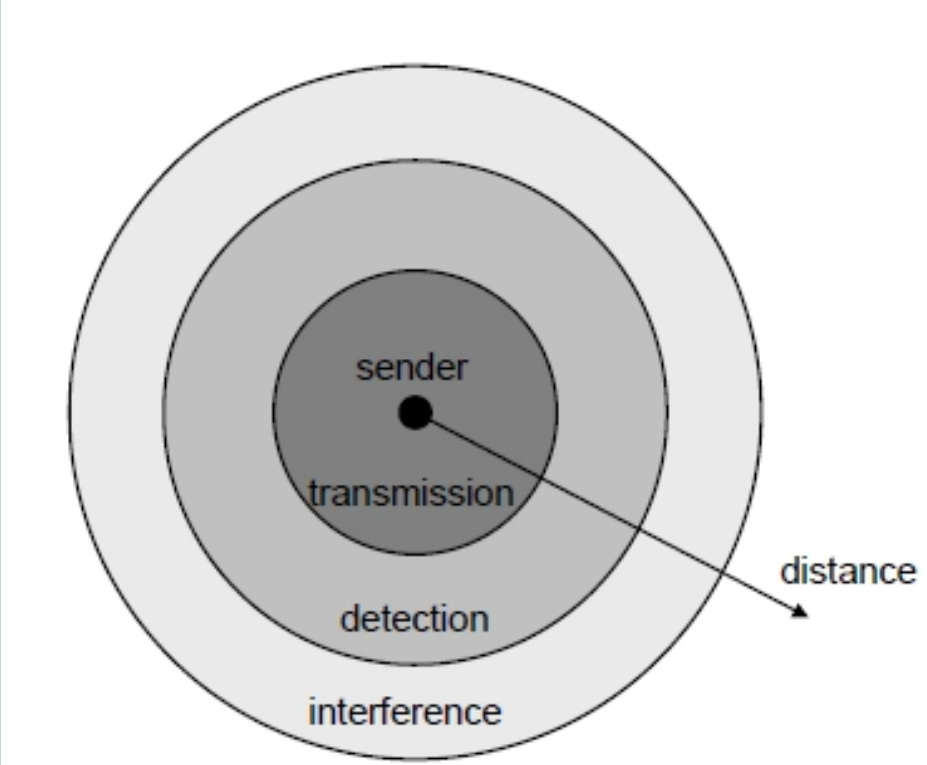
$$s(t) = At \sin(2 \pi ft t + \phi t)$$

Antennas

- Getting rid of wires
- Transmitting signals through space without guidance
- Antennas couple electromagnetic energy to and from space to and from a wire or coaxial cable
- Types
  - Isotropic radiator
  - Marconi antenna
  - Directional antenna
  - Sectorized antenna

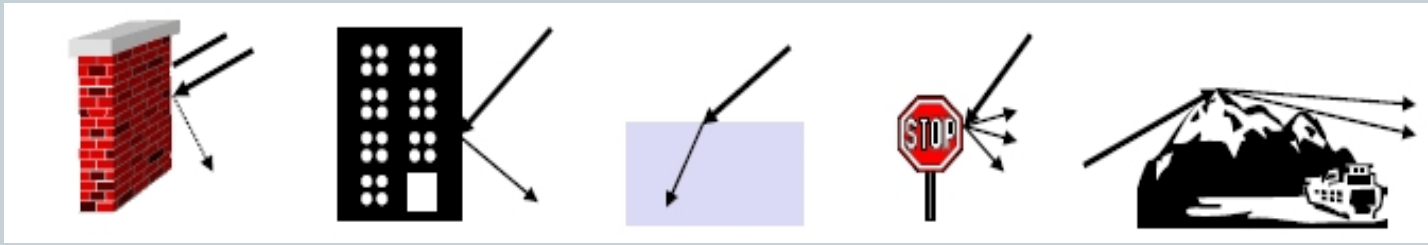
Signal propagation ranges

- Transmission range
  - communication possible
  - low error rate
- Detection range
  - detection of the signal possible
  - no communication possible
- Interference range
  - signal may not be detected
  - signal adds to the background noise



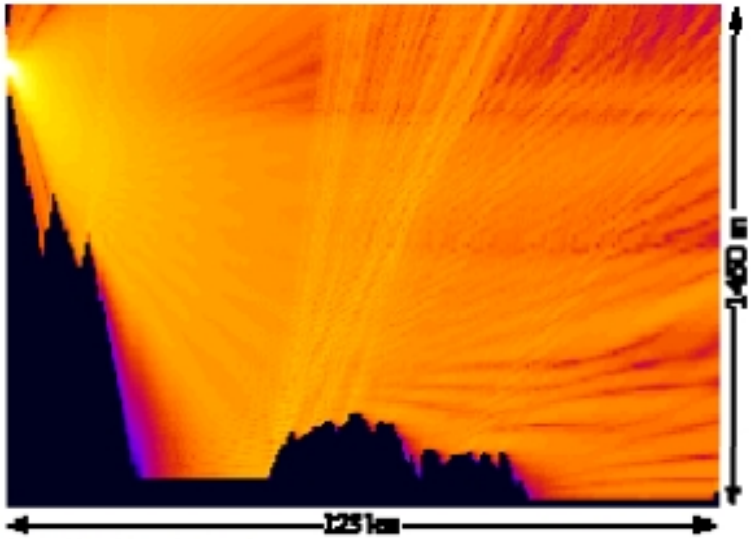
Signal propagation

- Propagation in free space always like light (straight line)
- Receiving power proportional to $1/d^2$ in vacuum – much more in real environments
- (d = distance between sender and receiver)
- Receiving power additionally influenced by
  - fading (frequency dependent)
  - Shadowing
  - reflection at large obstacles
  - refraction depending on the density of a medium
  - scattering at small obstacles
  - diffraction at edges



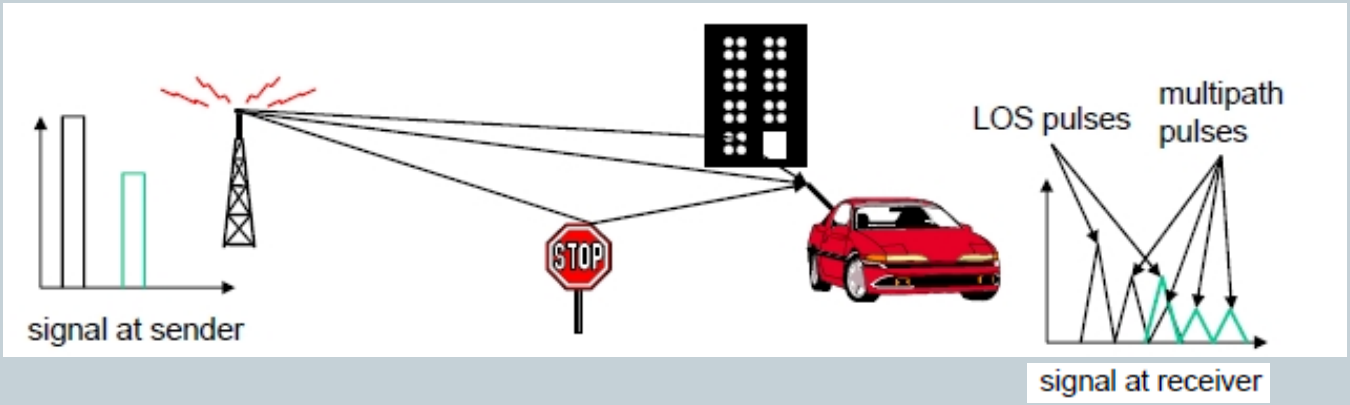
shadowing reflection refraction scattering diffraction

Real World Example



Multipath propagation

- Signal can take many different paths between sender and receiver due to reflection, scattering, diffraction
- Time dispersion: signal is dispersed over time
  - interference with “neighbor” symbols, Inter Symbol Interference (ISI)
- The signal reaches a receiver directly and phase shifted
  - distorted signal depending on the phases of the different parts



Effects of mobility

- Channel characteristics change over time and location
  - signal paths change
  - different delay variations of different signal parts
  - different phases of signal parts
- quick changes in the power received (short term fading)
- Additional changes in
  - distance to sender
  - obstacles further away
- slow changes in the average power received (long term fading)