Digital Communication I

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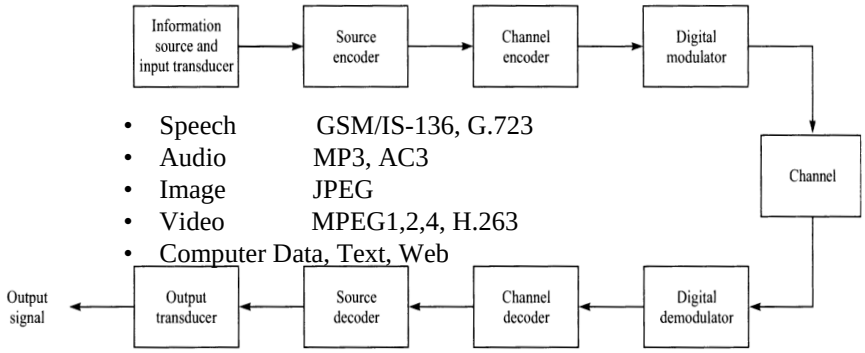
Syllabus

- Introduction
- Review of probability and stochastic process
- Signal characteristics
- Receiver performance
- Band-limited channel
- Equalization
- Adaptive equalization
- Allocation(??)
  - HW: 25%
  - Midterm: 35%
  - Final: 40%
- Midterm: Middle of November
- Report: (Optional)
  - English, 1st page as self-introduction

Digital Communication Systems



- Speech GSM/IS-136, G.723
- Audio MP3, AC3
- Image JPEG
- Video MPEG1,2,4, H.263
- Computer Data, Text, Web

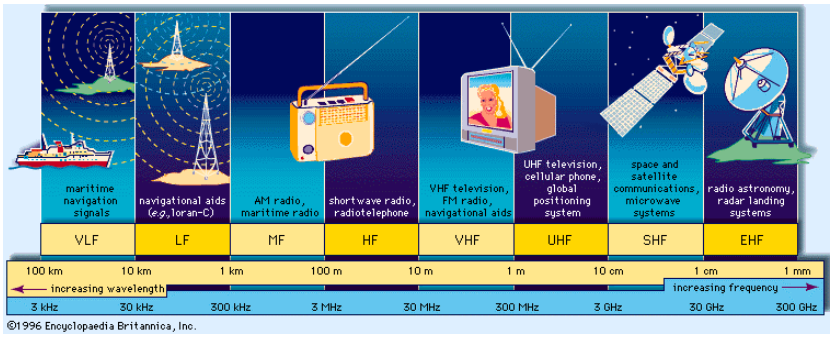
Channel Coder

- Introduce redundancy into the data to detect/correct error at the receiver.
- Mapping *k* to *n* bits sequence
- Examples
  - Block code: Reed-Solomon code
  - Convolution code: Rate-compatible punctured convolutional codes (RCPC codes)
  - Turbo codes

Digital Modulator/Channel

- Mapping digital data to analog waveform for transmission
- Channel
  - The medium for transmission
  - Limited by power and bandwidth
  - Contaminated by noise
  - Affected by channel distortion

Channel
RF, Air: Spectrum Allocations



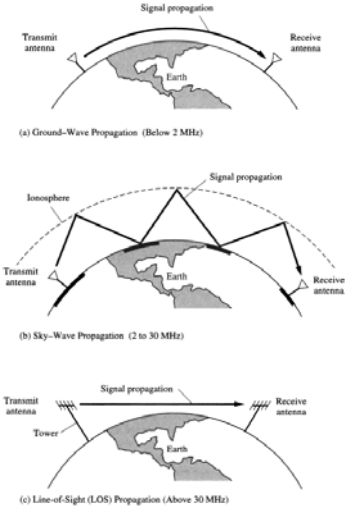
GSM: ~900 MHz, PCS: ~1900 MHz

FM: ~100 MHz, TV: ~50 MHz, 300 MHz up, Wireless LAN: ~2.4 GHz

RF, EM wave in Air Propagation Effects

- EM Wave Propagation
  - Ground wave (< 2 MHz)
  - Sky wave (2~30 MHz)
  - Light-of-sight (>30 MHz)

- Light-of-sight (LOS)
  - Optical LOS
    $\sqrt{13h}$ km
  - Effective Earth radius
    4/3 x 6400 km
  - Effective LOS
    $\sqrt{17h}$ km

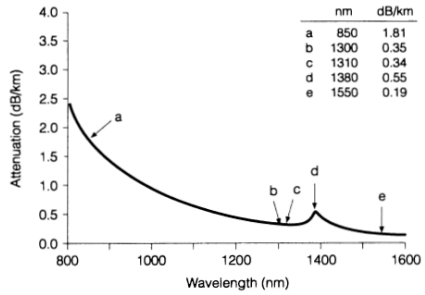


Electrical: Copper Wire

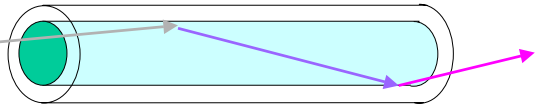
- Telephone Line
  - Voice-band modem (300 ~ 3600 Hz)
    - 56 Kbit/s
  - Digital subscriber lines (50 kHz ~ 1 MHz)
    - 3 km (1.5 Mb/s), 2 km (6 Mb/s), 1 km (30 Mb/s)
- Coaxial Cable (up to 1 GHz bandwidth)
  - CATV: 36 Mb/s per 6 MHz bandwidth
- IC Interconnect
  - Up to 10 Gb/s for short distance

Optical Fiber

- Single-Mode Fiber
  - ~100 nm bandwidth in 1550 low-loss window
  - About 12 THz
  - More than 10 Tb/s
- Wavelength-division multiplexing
- Very expensive??



- Multi-mode fiber for short distance



Other Channels

- Storage Channel
  - Tape, Hard-drive, floppy
  - CD, DVD
  - RAM, ROM
- Undersea Acoustic channel
  - Low-bandwidth

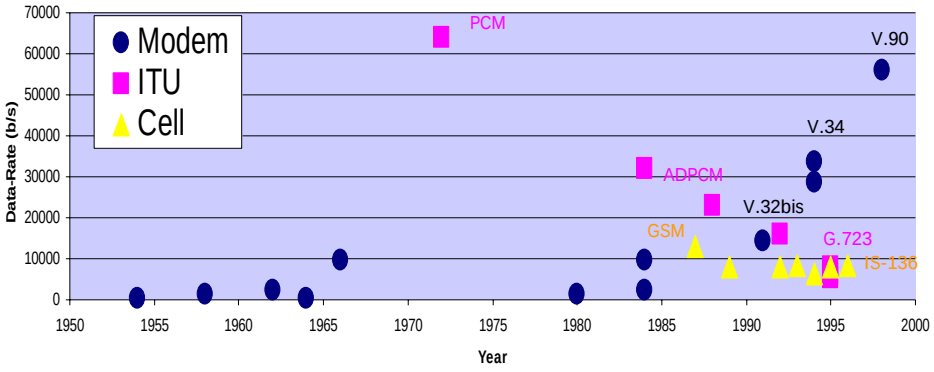
Other Channels (cont.)

- Wireless infrared (optical) channel
  - Diffusive (~50 Mb/s)
  - Light-of-sight (2.5 or 10 Gb/s)
- Power-line transmission
- Ultra-sound channel

Why Digital Communications?

- Analog
  - AM, FM, TV
  - Corrupted by noise and interference
  - Simple and cheap
- Digital
  - Data, PCS, GSM, CDMA, …
  - Efficient & reliable
  - Signal compression
  - Digital signal processing
  - VSLI implementation

Why Digital Communications? Speech compression



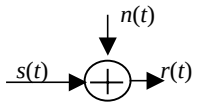
Why Digital Communications? Video Compression

- Analog video
  - 4.5 or 6 MHz bandwidth per channel
- Digital broadcasting
  - 8 VSB ~ 20 Mb/s
- Cable TV
  - 64 QAM ~ 36 Mb/s
- MPEG video compression
- VCD
  - 1.1 Mb/s
- DVD
  - 4 ~ 8 Mb/s
- HDTV
  - 16 Mb/s

Channel Models

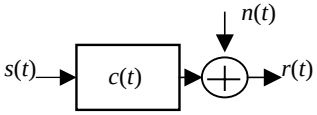
- Additive noise channel

$$r(t) = s(t) + n(t)$$



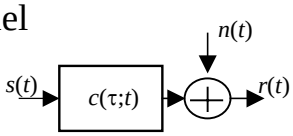
- Causal linear filter channel

$$r(t) = \int_0^\infty s(t-\tau)c(\tau)d\tau + n(t)$$



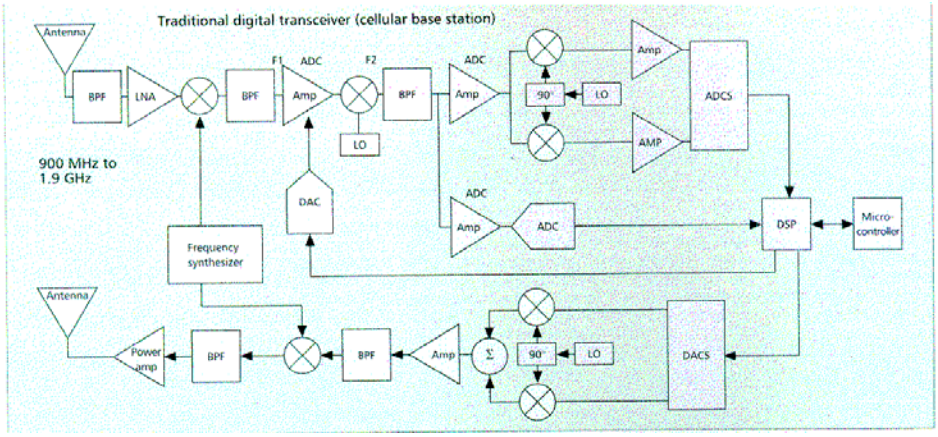
- Linear time-variant filter channel

$$r(t) = \int_0^\infty s(t-\tau)c(\tau;t)d\tau + n(t)$$

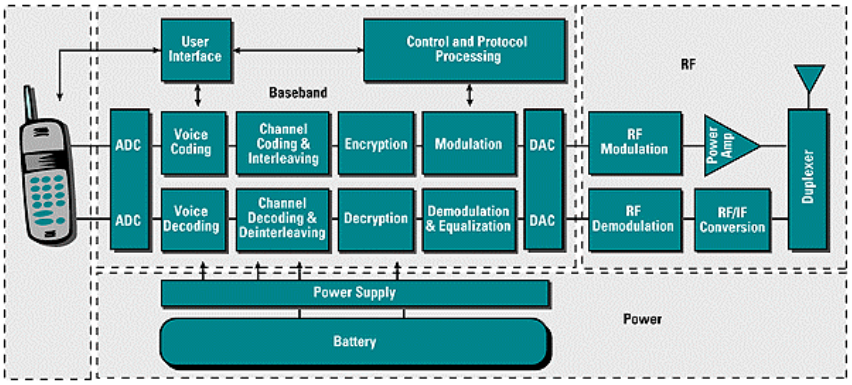


- Nonlinear channel

Traditional Transceiver



Generic Transceiver



DSP Based Transceiver