Mobile and Personal Communications

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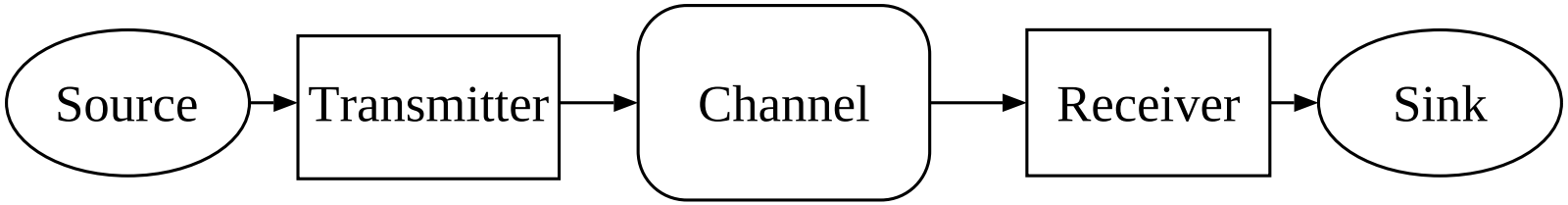
A Brief Introduction

to Wireless and PCS

Wireless Communication Networks — Key Characteristics

- Channels are troublesome
  - unknown coverage
  - multipath propagation
  - interference
- Multiple users
- Cellular architecture

Model of Communication System (Single Link)

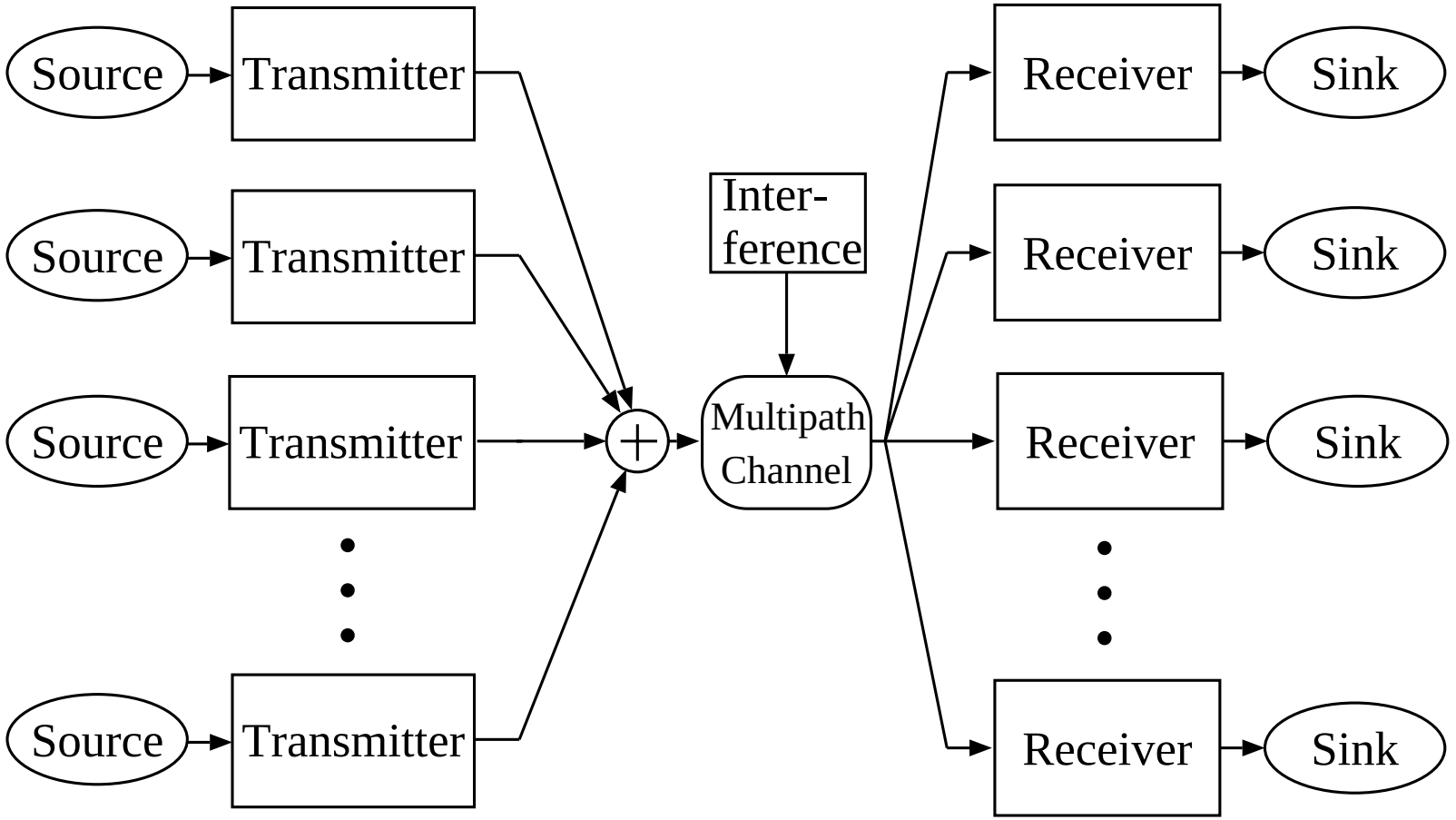


Single-user communication system

Transmitter: Source encoding, channel encoding, modulation, RF processing

Receiver: RF processing, demodulation, channel decoding, source decoding

Wireless Communication Network Model



The Cellular Approach

Idea: divide network geographical area into cells served by base stations

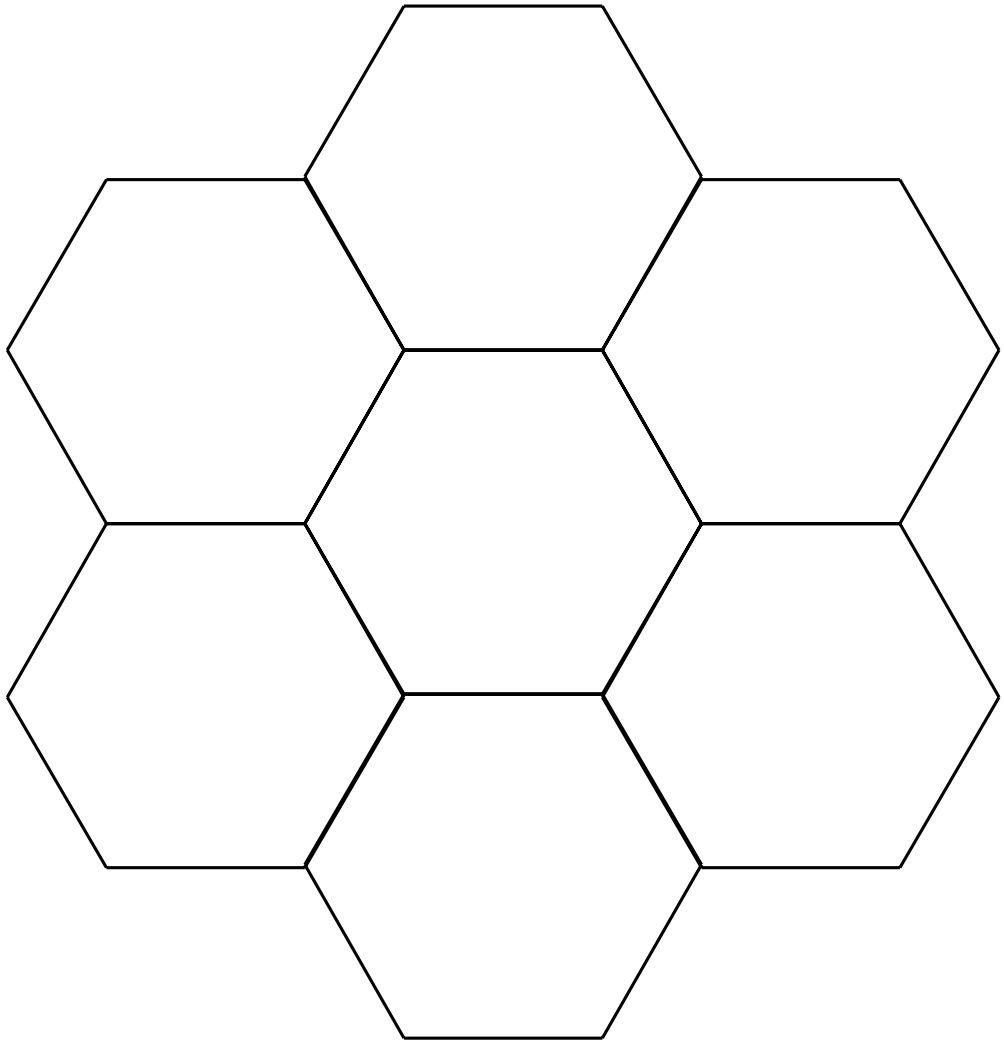
Motivations:

- Reduced required transmit power for mobiles
- Increased capacity through *frequency re-use*

Disadvantages:

- Increased network complexity
- Must perform hand-offs
- Interference can result from signals in other cells (co-channel interference)

The Cellular Approach



Can subdivide cells by
> cell splitting or
> sectoring
to improve capacity or reduce co-channel intereference

Personal Communication Systems (PCS)

PCS can be broadly defined as the next generation of mobile telephone service.[a]

Recent History:

1983 - AMPS (Advanced Mobile Phone System): cellular analog (NBFM) at 800 MHz

1994-1995 - digital cellular:

- IS-54 FDMA/TDMA
- IS-95 CDMA

——> PCS

[a] See S. Lipoff, "Personal Communications Networks Bridging the Gap Between Cellular and Cordless Phones," *Proc. IEEE*, vol. 82, pp. 564–573, April 1994.

PCS — Objectives

1. Convenience — very small, light portable phone with long usage times between battery charges
2. Personal numbering — dial a person, not a location
3. Call management — can refuse or redirect calls; user has control via caller filtering
4. Wired voice quality — improved over cellular

PCS — Regulatory Characteristics (U.S.)

- 900 – 950 MHz and 1.850 – 2.200 GHz
- "Broadband" and "narrowband" services
- Several bands
- Licensed and unlicensed services
- Voice (isochronous) and data (asynchronous) services

Narrowband PCS

- 901 – 902, 930 – 931, 940 – 941 MHz
- Licensed (auctioned summer '94)
- Purpose: advanced messaging
- Band allocations
  - two-way symmetrical: 50 KHz/50 KHz pairs
  - two-way asymmetrical: 50 KHz/12 KHz pairs
  - one-way: 50 KHz
  - acknowledgment/talk-back for existing systems 12.5 KHz

Broadband PCS

- 1.850 – 2.200 GHz
- Unlicensed
  - Data: 1900 – 1910, 1910 – 1920 MHz
  - Voice: 1890 – 1900, 1920 – 1930 MHz
- Licensed (pairs)
  - 1850 – 1880 and 1930 – 1960 MHz
  - 1880 – 1890 and 1960 – 1970 MHz
  - 2130 – 2150 and 2180 – 2200 MHz
- Auctioned late '94

Personal Communication Networks

PCS service will be provided by a Personal Communication Network (PCN) infrastructure

- Digital transmission technology
- Small cell size (micro/pico cells)
- Low transmitted power (and power consumption)
  - Reduced handset size/weight
  - Increased battery life
  - Reduced health concerns
- Approximately 2 GHz spectrum
- Less mobility (?)

PCN Technology

A. Switch/Operations Support

— required to support mobility, call management, personal numbering, voice mail, etc.

— complex billing for mobile users

B. Back-Haul Network

— links cells

C. Cell Structure

D. Air Interface

Cell Structure

PCN will use $\approx$ 1000' microcells (cf. cellular $\approx$ 0.5 mi) —

- Higher capacity (via frequency re-use)
- Low portable transmit power (10-100 mW)
  - long battery life
  - light, small
  - health/safety
- Reduced propagation losses (clutter/fading)
- Higher service availability (QOS) (serve 95% of locations vs. 90% for cellular)

Air Interface

– aspects of the system regarding communication between the handset and base station

Elements:

- Frequency band
- Channelization
  - bandwidth
  - time slot
  - spreading code
  - hybrids

Air Interface (cont'd)

- Duplex method
  - FDD
  - TDD
- Source coding – encoding of analog signal (e.g., voice) into digital data

  Trade-off: low bit rate (network capacity) vs. low complexity (reduced power requirement)
- Channel coding – redundancy added to encoded signal to improve system performance (error rate)

  Trade-off: cost vs. reliability/quality

  Remark: delay may be a factor

Air Interface (cont'd)

- Modulation – converts discrete-time encoded data stream into continuous waveform

  Trade-off: low complexity (cost) vs. performance/spectral efficiency

  Examples: FSK, QPSK

- Power control – remote and/or base station can adjust transmit power to minimum required for necessary transmission quality

  Trade-off: (low) complexity vs. performance (network capacity and battery life)

Example PCS System – DECT

DECT – Digital European Cordless Telecommunication:

- Bridges gap between cordless telephone and PCS
- Frequency Band: 1880-1900 MHz
- Duplexing Method: TDD
- Source Coding: 32 kb/s ADPCM

Example PCS System – DECT (cont'd)

- Modulation: GMSK
- Channel Coding: CRC
- CRC Error Detection (320-bit blocks)
- Channelization: hybrid FDMA/TDMA; four frequencies, each with 12 TDMA channels

Remark: DECT also being used to develop wireless data communication products

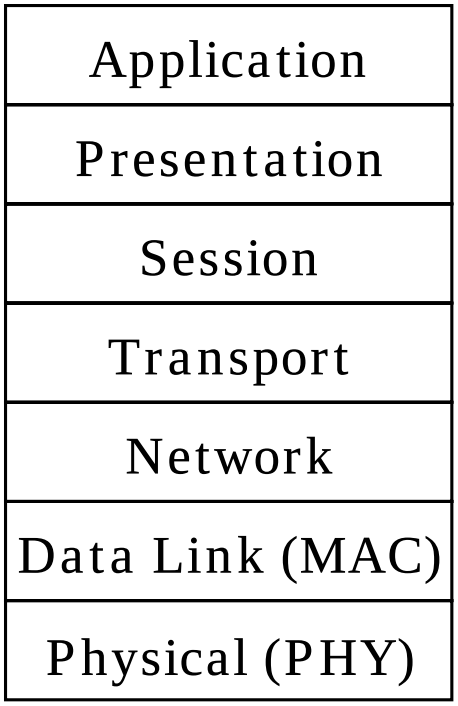
Other Digital Wireless Systems

- Cordless phone
  - Home
  - Business (PABX)
- Wireless Data
  - Wireless LAN's
  - Mobile data

Other Digital Wireless Systems (cont'd)

- Paging (one-way messaging —> acknowledgment)
- 2 GHz Cellular
- Wireless local loop
- Satellite-based systems
- Integrated voice/data systems (e.g., wireless ATM)

Digital Network Architecture



——> In this class, we will focus primarily on the PHY and MAC layers.