Wireless Networking: An Introduction

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Outline

- Networking as resource allocation
- A taxonomy of current practice
- Technical elements

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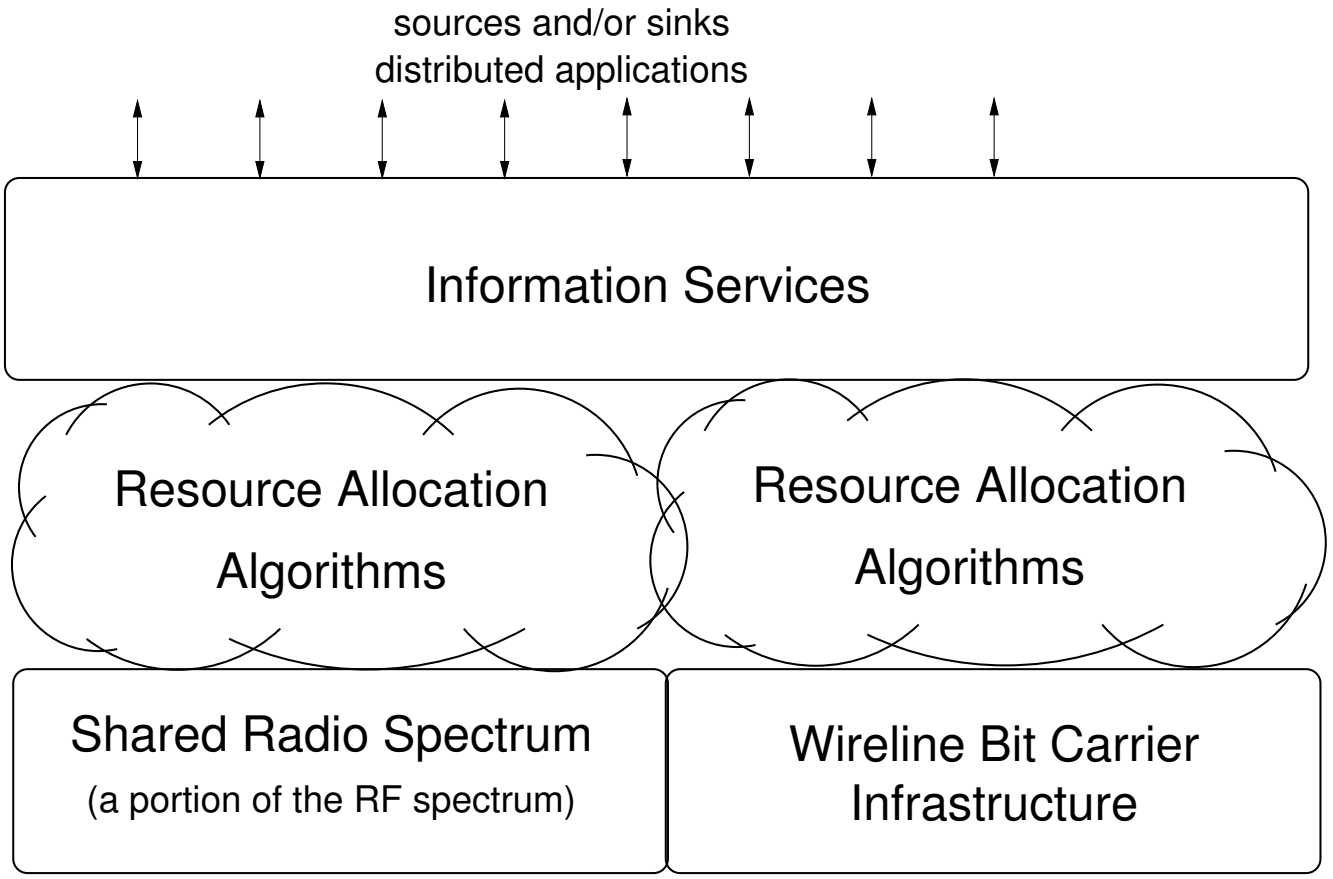
Networking as resource allocation



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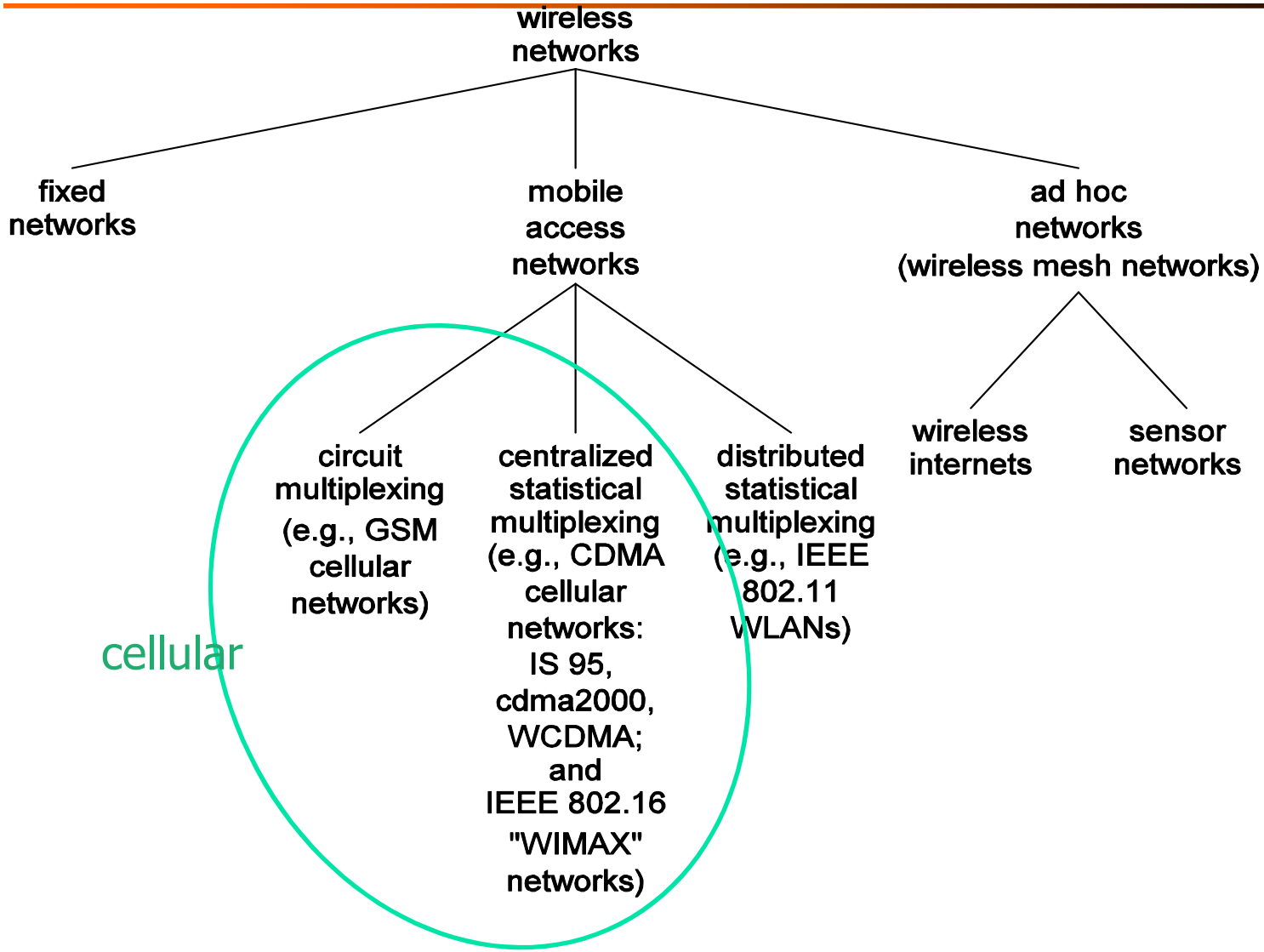
A taxonomy of current practice in wireless networking



Current practice

- Mobile access networks
  - Cellular
    - 2G, 2.5G/2.75G, 3G, 4G
  - WiMAX
  - WLAN
- Ad hoc networks
  - Mesh internet
  - Sensor network

Cellular: 2G

- FDM-TDMA
  - FDM
    - Divide spectrum into a contiguous up-link band and a contiguous down-link band, and each of these bands is further divided (statically or dynamically) into reuse subbands;

      each cell is allocated a pair of such subbands for up-link and down-link.
    - Each subband is further partitioned into channels
  - TDM
    - Each channel is digitally modulated and slotted to carry up to a fixed number of calls, in a TDM fashion
  - Used in GSM, which was first introduced in Europe

- CDMA
  - Entire available spectrum is reused in every cell
  - Each user is allocated a *pseudorandom sequence* (also called *spreading code*) to spread his/her signal
  - Performance is *interference limited*, thus requiring careful transmission power control and call admission control
    - These functions are mostly implemented by the base station controllers (BSCs)
  - First invented by Qualcomm

Cellular: 2.5G/2.75G

- 2.5G: GSM-GPRS (General Packet Radio Service)
  - Goal: to provide packetized data access
  - In 2G, flexibility is limited to assigning multiple channels to each user for data delivery, where each channel enables certain low bit rate data transmission
  - In GPRS, combining multiple TDM slots on an FDM channel/carrier enables shared packet switched access to mobile users
- 2.75G: EDGE (Enhanced Data rates for GSM Evolution)
  - in addition to combining TDM slots, higher order modulation schemes, with adaptive modulation, are utilized to enable speeds up to 474 Kbps

Cellular: 3G

- Based on CDMA technology
- Both voice and data are carried in packet mode
- *Amount of spreading, user bit rate, transmission power* can be adapted on a packet-by-packet basis
- Most widely adopted standard for 3G systems is WCDMA (wideband CDMA), which originated from Europe but now supported by 3G Partnership Project (3GPP) --- a consortium supported by US, Europe, China, Japan, & Korea
  - A competing standard is CDMA2000 proposed by Qualcomm

Cellular: 4G

- Goals
  - 100Mbps for mobiles and 1Gbps for static nodes
  - All IP, packet switched network (supporting IPv6)
  - Seamless handoff across heterogeneous networks such as 3G, WiMAX, and WLAN
- Key technologies
  - OFDM, MIMO, Turbo principle (to allow reliable operation in low SNR regime)
  - Adaptive radio interface, e.g., software-defined radio (SDR)
  - Relaying, including fixed relaying networks (FRN) and network MIMO (or cooperative relaying)

- Standardization
  - 3GPP is currently standardizing “LTE (long term evolution) Advanced” as future 4G standard
  - A first set of 3GPP requirements on LTE Advanced has been approved in June 2008

WiMAX

- High speed Internet access, e.g., >100Mbps down-link
- Physical layer: MIMO, OFDMA
- Access control
  - Time is divided into frames; each frame is partitioned into an up-link and a down-link part, which is called *time division duplexing* (TDD)
  - Base station (BS) allocates time on various subchannels to various down-link flows in the down-link part of the frame, and based on subscriber station (SS) requests, in the up-link part of the frame
- Standardization: IEEE 802.16/802.16e/802.16m

WLAN: statistical TDMA

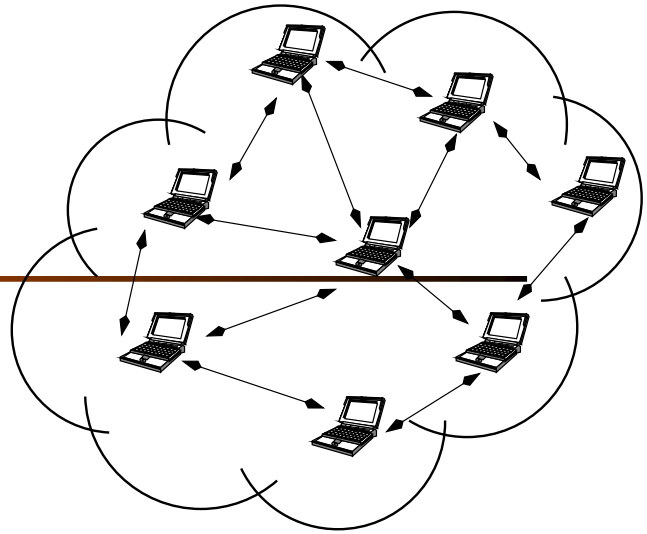
- 802.11 (1997)
  - 2.4-2.485 GHz unlicensed radio spectrum
  - 1Mbps or 2Mbps
  - Physical layer coding: Frequency Hopping Spread Spectrum (FHSS) or Direct Sequence Spread Spectrum (DSSS)
- 802.11b (1999)
  - 2.4-2.485 GHz unlicensed radio spectrum
  - up to 11 Mbps: 1, 2, 5.5, 11M depending on coding scheme
  - DSSS only (at physical layer)
    - *all hosts use same chipping code*
  - widely deployed, using base stations; ad hoc mode/mesh network at research/prototype stage

- 802.11a (1999)
  - 5-6 GHz range
  - up to 54 Mbps
  - Orthogonal Frequency Division Multiplexing (OFDM)

- 802.11g (2003)
  - 2.4-2.485 GHz range
  - up to 54 Mbps
  - OFDM

- 802.11n (2009)
  - Multi-input multi-output (MIMO) at physical layer
  - 2.4 GHz or 5 GHz
  - Up to 549 Mbps; ~50meters
- Related: 802.11p
  - Draft amendment to 802.11 to support ITS (Intelligent Transportation Systems) applications: DSRC (Dedicated Short Range Communication) for vehicle-to-vehicle and vehicle-to-roadside communication
  - Run in the *licensed* ITS band of 5.9 GHz (5.85-5.925 GHz)

Ad-Hoc networks



- Wireless internet mesh
  - 802.11s
- Sensor network
  - 802.15.4 for MAC
  - ZigBee for whole stack
- *Our focus in this course*

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Technical elements

- Transport of users' bits over shared radio spectrum
  - Modulation parameter adaptation: tx. power, amount of error protection, etc
  - Adaptive modulation
- Neighbor discovery, association and topology formation, routing
- Transmission scheduling
- Others:
  - Location determination: via GPS or GPS-free approaches
  - Distributed computation, including in-network processing

Summary

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