

## EE 5141 – Introduction to Cellular and Wireless Communications

Jan. to Apr., 2024

Outline

A-slot; ESB-350

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1. Why wireless? Analog versus Digital wireless communications; Evolution of mobile cellular access across the generations (see Chap.2 in [2]); Defining Energy, Power (peak, average), SNR, SINR, and Spectral Efficiency (link-level, system-level) of digital waveforms; *Aside: Sampling of bandpass signals*
  2. Wireless LoS Link (Large Scale Parameters) – Path loss, Shadow loss, Atmospheric effects; *Aside: Receiver sensitivity (see Appendix B in [2]), Link budget for noise-limited links, Relay channels*
  3. Wireless Multipath Link (Small Scale Parameters) – Doppler spread, delay spread, angular spread; Statistical modelling of multipath wireless channels (see Chap. 2 in [1] and Chap.5 in [2]), Going from Multipath to Multitap models, Outage, Fade Margin for Link Availability. *Aside: Hybrid ARQ*
  4. Multiple Access Principles – FDMA, TDMA, CDMA, and OFDMA; Downlink vs Uplink; (see Chap.4 from [1]); Uplink ranging and/or power control; *Running Example on Uplink Multiple Access; Aside: “SDMA”, PRMA, CSMA-CA, and Mobile Adhoc Networks*
  5. Cellular Concept – Why Spatial Reuse, SINR for different re-use factors in 2G cellular networks, Trunking Efficiency vs Spatial Reuse, (see Chap.3 and Appendix A in [2]), Fractional and Soft Frequency Reuse in 4G/5G cellular systems
  6. Why Block Modulation? -- Voice capacity of 2G TDMA cellular, Noise rise and soft-capacity of voice channels 2G/3G DS-SS-CDMA cellular (also see Chap.4 from [1]). Impact of Uplink and Multipath on variable data-rate support and link budget → Need for block modulation and OFDM/OFDMA
  7. OFDM Cellular Technology -- Quick look at 4G cellular OFDM standards (WiMax and LTE), Transmit configurations, Precoding, Receiver Algorithms (i) Freq and Time Sync, (ii) Channel Estimation, and (iii) MIMO Processing; How is 5G-NR different from 4G-LTE? *Aside: LLR based iterative decoding.*
  8. Capacity maximization in OFDM using Water-pouring, Capacity of wireless MIMO channels (Chap. 5 in [1]); *Aside: MIMO processing, Beamforming, and Diversity processing using multiple Tx and Rx antennas; Multi-antenna communications – Modeling (Chap. 7 in [1]) and Algorithms (parts of Chap. 8 in [1])*
  9. *Aside: Single-carrier and Generalized Block Modulation, MC-DS-SS-CDMA, OTFS, Integrated Sensing + Communications*

*Evaluation Scheme:* Open-book Mid-sem (30), Two Computational Assignments (25), and Mini-project\* (45).

\* Decision to be finalised by end March-2024, based on performance of the class in the mid-sem and assignments.

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*Text Book:* [1] D. Tse and P. Vishwanath, “Fundamentals of Wireless Communication”, Cambridge Press, 2005.

*Reference Book:* [2] T.S. Rappaport, “Wireless Communications – Principles and Practice”, Pearson (2<sup>nd</sup> Ed.), 2002.

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