# ICWMC/MAAZE: Wireless Communications: The March Towards Absolute Zero

K Vasudevan
Associate Professor
Telematics Lab
Department of EE
Indian Institute of Technology Kanpur
email: vasu@iitk.ac.in

September 14, 2016

# An Open Question



- What is the operating SNR per bit of the present day mobile phones?
  - No answer in the open literature
- Surprisingly, the SNR per bit has not been used as a performance measure in the context of wireless communications.

# Introduction



- A coherent receiver requires the minimum signal-to-noise ratio (SNR) per bit to achieve a given bit-error-rate (BER)
  - This translates to a longer battery life in the mobile
  - Sync and channel estimation required – training (preamble) needs to be transmitted along with the data
- Data is organized into frames, QPSK modulation
- A rate-$1/2$, 4-state turbo code is used to improve the BER
- A frequency selective Rayleigh fading channel having a uniform power delay profile is assumed
- Channel is static over one frame, varies independently from frame-to-frame

# Introduction – contd



- The other impairments considered are the carrier frequency offset (CFO) and additive white Gaussian noise (AWGN)
- Orthogonal frequency division multiplexing (OFDM) converts a frequency selective (multipath) channel into a frequency flat channel, thereby eliminating intersymbol interference (ISI)
- Two transmit and two receive antennas are considered ($2 \times 2$ MIMO OFDM system)
- Channel is independent across different transmit and receive antennas

# Contributions



- Discrete-time algorithms have been developed for carrier and timing synchronization and channel estimation
- The minimum SNR per bit for error-free transmission over fading channels has been derived and shown to be identical to that of the AWGN channel, that is, $-1.6$ dB
- Simulations results for a $2 \times 2$ turbo coded MIMO OFDM system indicate that a BER of $10^{-5}$, is obtained at an SNR per bit of just 5.5 dB, which is a 2.5 dB improvement over the earlier work[1]
  - The best so far in the open literature

[1] K. Vasudevan, "Coherent detection of turbo-coded ofdm signals transmitted through frequency selective rayleigh fading channels with receiver diversity and increased throughput," Wireless Personal Communications, vol. 82, no. 3, 2015, pp. 1623-1642. [Online]. Available: http://dx.doi.org/10.1007/s11277-015-2303-8

# Future Work



- The concepts can be extended to massive MIMO systems
- The peak-to-average power ratio (PAPR) of the transmitted signal needs to be addressed