CDMA vs. OFDM for Wideband Cellular Systems

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1. Motivation

- CDMA and OFDM are both proposed as candidates of the next generation wireless cellular networks.
- Each of which has its own advantages and disadvantages.
- Which is better? Answer should depend on, e.g.
  - Metric used for comparison
  - Channel conditions
  - System complexity, etc..
2. The Metric

- **Transport Spectral Efficiency (TSE):** the distance weighted sum rate of all users in the cell per unit frequency.
  - Unit: *bit-meter per second per Hertz* (bps · m/Hz).
  - Motivated by the concepts of *spectral efficiency* (bps/Hz) and *transport capacity* (bps · m).

For example: There are two users in one cell, they share 1000 Hz bandwidth,

- *user 1:* rate=100 bps, distance=10 m;
- *user 2:* rate=20 bps, distance=100 m;

\[
TSE = \frac{100 \times 10 + 20 \times 100}{1000} = 3 \text{ bps} \cdot \text{m/Hz}.
\]
3. Cellular Network Structure

![Diagram of a cellular network structure with labeled nodes and arrows indicating signal and interference directions.]

- Mobile Subscriber
- Downlink signal
- Intra-cell interference
- Inter-cell Interference
4. OFDM System Model

**Figure**: Cyclic prefix OFDM (CP-OFDM) and zero padding OFDM (ZP-OFDM) system model.
5. CDMA System Model

**Figure:** CDMA system model with RAKE (CDMA-RAKE) and LMMSE (CDMA-LMMSE) receivers.
6. Transport Spectral Efficiency

The TSE of CDMA is calculated as

$$T_{CDMA} = \mathbb{E} \left[ \frac{1}{Q} \sum_{k=1}^{K} d_0^{(k)} \log(1 + \Gamma_{CDMA}^{(k)}) \right] bps \cdot m/Hz$$

The TSE of OFDM can be calculated in a similar manner.
7. CDMA vs. OFDM

Variation with number of users

Figure: Comparison of the TSE with respect to different number of users per cell.
8. CDMA vs. OFDM

Variation with SNR

Figure: Comparison of the TSE of CP–OFDM and CDMA–RAKE with respect to different number of multipaths.
9. CDMA vs. OFDM
Variation with SNR (cont.)

Figure: Comparison of the TSE with respect to the input SNR.
10. CDMA vs. OFDM

Variation with cell radius

Figure: Comparison of the TSE with respect to the cell radius.
11. Conclusion

- Transport Spectral Efficiency:
  - (Flat fading) The TSE of all four schemes are approximately the same;
  - (Multipath fading)
    CP-OFDM > CDMA-LMMSE ≈ ZP-OFDM >> CDMA-RAKE;
- Complexity:
  CDMA-LMMSE ≈ ZP-OFDM >> CP-OFDM ≈ CDMA-RAKE;
- Base station density needed to achieve optimal TSE:
  CDMA-RAKE ≪ ZP-OFDM ≈ CDMA-LMMSE < CP-OFDM.