

IEEE 802.16m Multiple Access Techniques

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Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

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Multiple Access for 802.16m

- Design Goal
 - To comply with 802.16m systems requirements [1], while maximizing the re-usability of legacy 802.16e system
- Downlink
 - OFDMA in the current 802.16 standard has been proven as a spectral efficient multiple access technique for the support of high throughput data applications in a broadband communication system
 - OFDMA has also been adopted by other standards:
 - 802.11a/g/n, 3GPP LTE, 3GPP2 UMB
 - ⇒ Propose to use OFDMA for 802.16m downlink
- Uplink
 - Most users are not affected by Peak to Average Power Ratio
 - With proper power control and scheduling, only a small percentage of users at the cell-edge need to transmit at maximum power
 - ⇒ Propose to use OFDMA based multiple access technique

Orthogonal Frequency Division Multiple Access (OFDMA)

- Spectrally efficient multiple access technique
- Combining TDMA and OFDMA
- Allows Multi-user Diversity Gain to be fully exploited in both time and frequency dimensions
- Enables frequency diversity gain for individual user
- Supports MIMO technology efficiently
 - Feasible implementation of Maximum-Likelihood detection based receiver
- Good link performance can be achieved with equalizers with relatively low complexity
- Pilot tones can be distributed in frequency and time to enable efficient channel estimation

Alternative: DFT-S-OFDMA (SC-FDMA) for Uplink

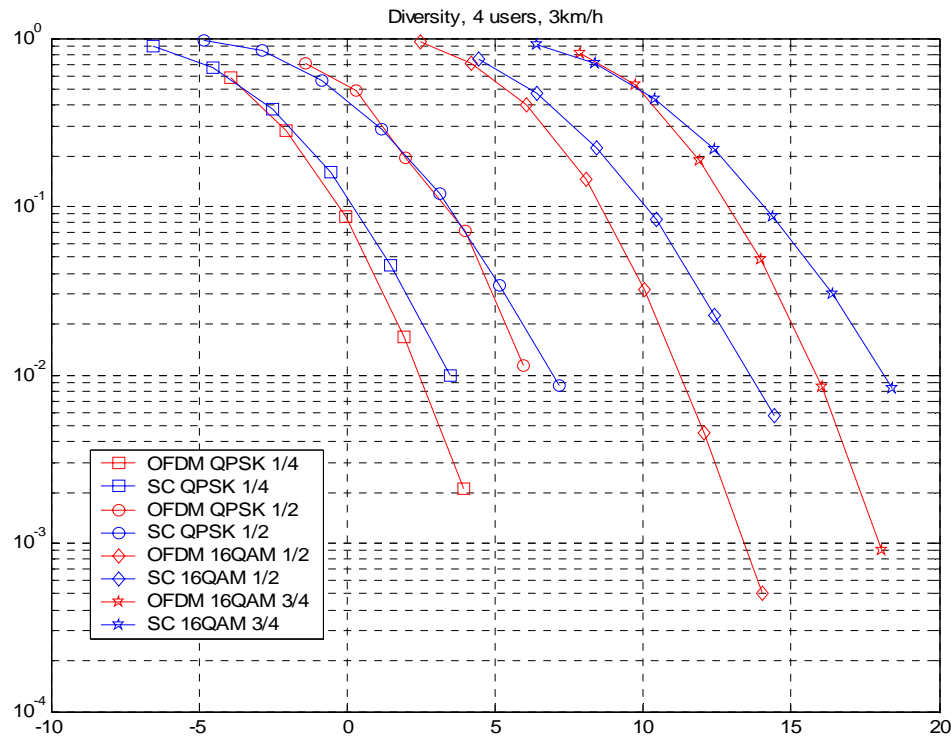
- Advantageous
 - Lower Peak to Average Power Ratio (PAPR) than OFDM signal
- Disadvantageous
 - Higher receiver complexity
 - Maximum Likelihood Detector not feasible for MIMO
 - Additional DFT processing increases mobile station complexity
 - Unlike OFDMA, Localized SC-FDMA cannot exploit full advantage of multiuser diversity
 - Distributed SC-FDMA has not been adopted by 3GPP LTE, because of multiple issues, e.g.,
 - Vulnerability to Doppler and frequency offset
 - Pilot design
 - Only TDM pilots can be supported by SC-FDMA
 - Low flexibility in multiplexing uplink control and data channels
 - Degraded link-level performance as compared to OFDMA

PAPR Issue

- Advantage of SC-FDMA over OFDMA
- Affects users who need to transmit near to the maximum power
 - Users with poor geometry
 - Cell edge users
 - With proper power control and user scheduling, transmissions from these users should constitute a small percentage of uplink transmissions, i.e., $< 5\%$ [3]
- These users can be scheduled on a smaller number of subcarriers, so as to increase the signal power density per symbol, improving the cell coverage
- PAPR reduction techniques may also been applied
 - For example, Tone Reservation method [4]

Link-level Simulation Results [2]

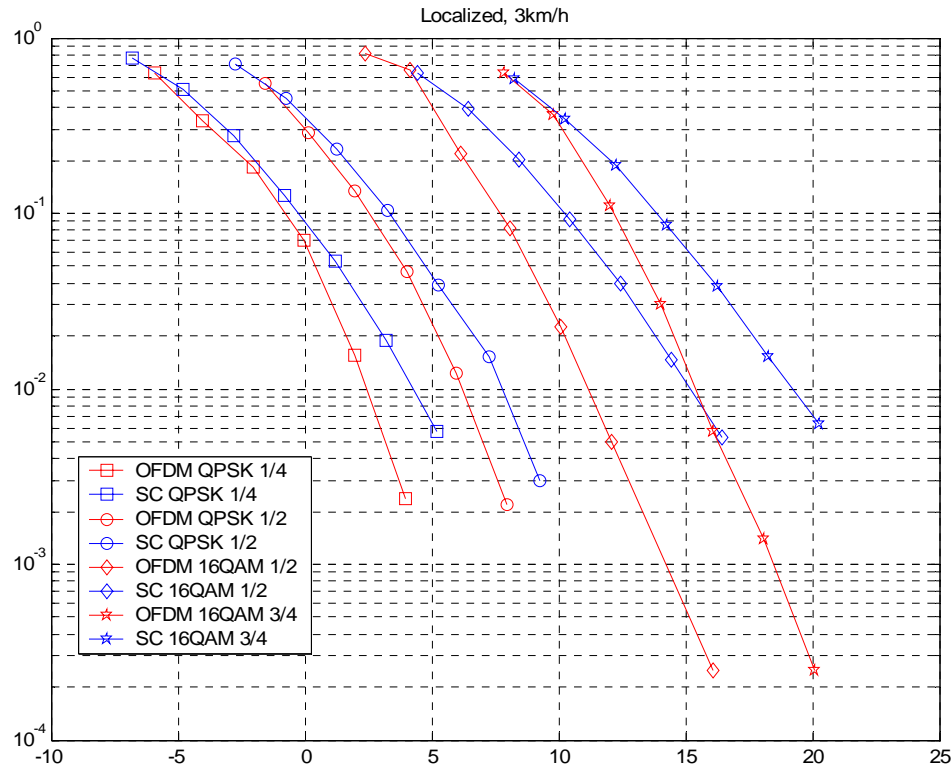
- Assumptions:
 - ITU-Pedestrian B channel model at 3 km/h
 - 1 transmit, 2 receive antennas
 - IFFT/FFT sizes: 1024
- Case (1): Distributed SC-FDMA
- $X = \text{SNR}$; $Y = \text{BLER}$ (Encoded block error rate)
- At 1% BLER, OFDMA outperforms SC-OFDMA by:
 - ~2.5 dB, for 16 QAM; ~1 dB for QPSK



Link-level Simulation Results [2]

- Case (2) Localized SC-FDMA

- X = SNR; Y= BLER (Encoded block error rate)
- At 1% BLER, OFDMA outperforms SC-OFDMA by:
 - ~4 dB for 16 QAM; ~2dB for QPSK



Conclusion

- Comparing SC-FDMA and OFDMA, SC-FDMA has many more disadvantages than advantages
- The overall effects of the disadvantage of OFDMA, i.e., higher PAPR, can be overcome by several different ways:
 - Power control and smart scheduling
 - PAPR reduction techniques
- Therefore, there is not a strong reason to use SC-FDMA in place of OFDMA as the uplink multiple access technique for 802.16m
- OFDMA should remain as the uplink multiple access technique as 802.16 evolves into 802.16m

References

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4. 'OFDMA UL PAPR Reduction', 3GPP R1-050891, Sept., 2005.
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