IEEE 802.16m Multiple Access Techniques

Document Number: IEEE S802.16m-08/112r1

Date Submitted: 2008-01-16 (Revised: 2008-01-21)

Source: Anna Tee, Jianglei Ma, Mo-Han Fong, Ming Jia, K. Sivanesan, Dongsheng Yu, Sang-Youb Kim

Nortel Networks E-mail: laikingt@nortel.com, mhfong@nortel.com

Venue: Levi, Finland

Base Contribution: IEEE C802.16m-08/112

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

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

  $\Rightarrow$ 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

  $\Rightarrow$ 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

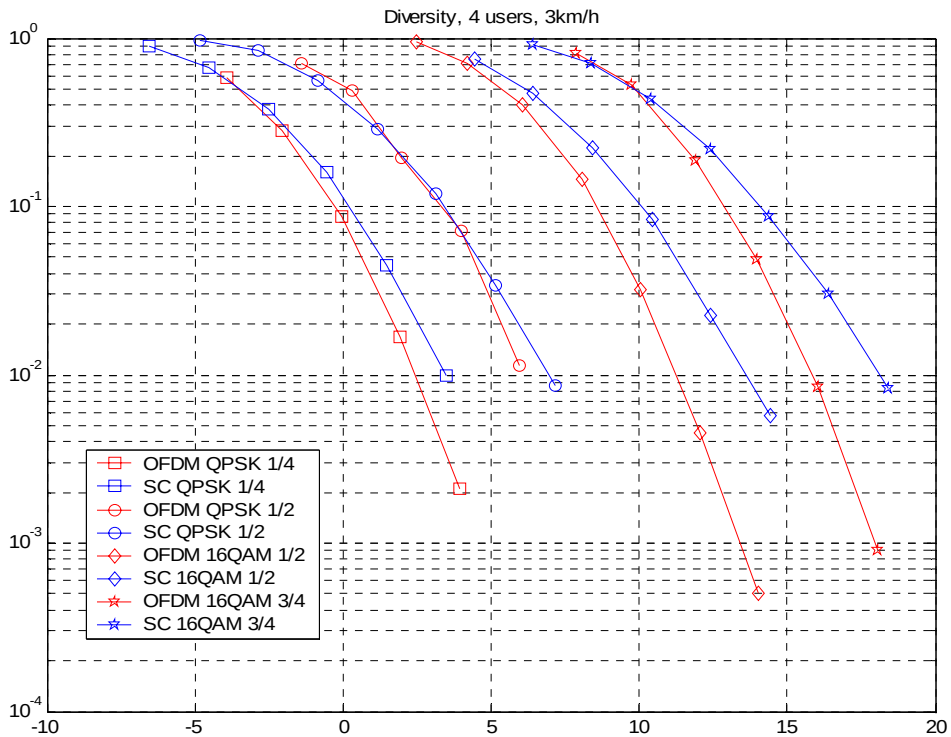
- Advantageous
  - Lower Peak to Average Power Ratio (PAPR) than OFDM signal
- Disadvantageous
  - Higher receiver complexity
  - Maximum Likelihood Detector not feasible for MIMO
  - Additional DFT processing increases mobile station complexity
  - Unlike OFDMA, Localized SC-FDMA cannot exploit full 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]

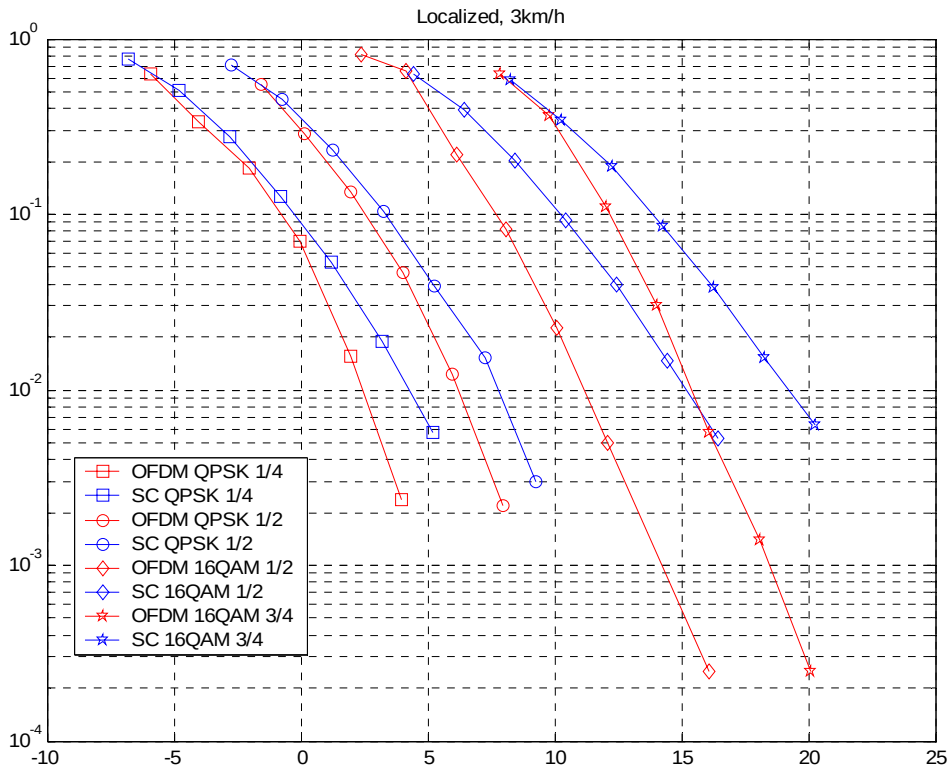
Link-level Simulation Results [2]

- 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 = SNR; Y= 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

1. ‘Project 802.16m System Requirements Document’, IEEE 802.16m-07/002r4, Oct 19, 2007
2. ‘UL Evaluation for DFT-S-OFDM and OFDMA with real channel estimation’, 3GPP R1-051161, October, 2005.
3. L. Tee, C. Van Rensburg, J. Tsai, ‘Uplink Power Control for an OFDMA Mobile Cellular System’, IEEE Vehicular Technology Conference Proceedings, Oct. 2007
4. ‘OFDMA UL PAPR Reduction’, 3GPP R1-050891, Sept., 2005.
5. ‘Link level comparison between Single carrier schemes and OFDM for Uplink’, 3GPP R1-050647, June 2005.