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Re:	IEEE 802.16m-07/047-Call for Contributions on Project 802.16m System Description Document (SDD) – Multiple access techniques
Abstract	This contribution discusses and compares multiple access techniques for Project 802.16m.
Purpose	To adopt the proposed multiple access techniques into the Project 802.16m System Description Document.
Notice	
Release	
Patent Policy	

IEEE 802.16m Multiple Access Techniques

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Introduction

Multiple access techniques for 802.16m are discussed in this contribution. According to the 802.16m Systems Requirements document [1], all enhancements to IEEE 802.16m should promote the concept of continued evolution of the legacy 802.16 technology. In the following, we will review the performance comparison [2] between the legacy 802.16 multiple access techniques and DFT-S-OFDM, which is proposed as a candidate multiple access technique for the uplink.

Orthogonal Frequency Division Multiple Access (OFDMA)

OFDMA is the multiple access technique used in the legacy 802.16 system, for both downlink and uplink transmissions. It has also been adopted by other similar mobile wireless standards such as 3GPP E-UTRAN (LTE) and 3GPP2 UMB.

OFDMA is a combination of TDMA and FDMA, in a flexible and spectrally efficient approach. With OFDMA, time and frequency resources can be allocated for transmission to various users, according to their channel conditions, to maximize the overall capacity of the mobile broadband wireless network. Multi-user diversity gain can be exploited in both time and frequency dimensions.

The multicarrier OFDMA signal eliminates the need of a complex equalizer for signals received in a highly frequency selective mobile channel environment. Channel estimation can be done through the use of pilot tones, which can be distributed flexibly over frequency or time dimension.

In addition, OFDMA enables the efficient application of MIMO technology to provide significant improvements on the system performance.

Comparison with other Uplink Multiple Access Techniques

DFT-spread-OFDM (DFT-S-OFDM) has been proposed as an alternative candidate for uplink multiple access technique.

The only advantage of DFT-S-OFDM over OFDMA is the lower peak to average power ratio (PAPR) of the signal waveform. The peak to average power ratio mainly affects users who need to transmit at the maximum power level. Typically, those users have poor geometry, e.g., those who are located at cell edge. This constitutes a relatively small percentage of all users in a base station sector.

A system-level simulation study [3] showed that, with appropriate uplink power control and user scheduling algorithms, the percentage of mobiles stations (MS) transmitting at the maximum power level is less than 5% of the total overall user transmission intervals in a base station sector. The simulation was based on full-buffer traffic applications. Thus, this percentage may be even lower when a more realistic traffic mix scenario that consists of VoIP traffic bursts is considered.

There are multiple ways to improve the link reliability for the cell edge users. One way is to schedule the user transmission over a smaller subchannel so as to boost power density. Besides, there are several well-known PAPR reduction techniques that can be implemented with reasonable complexity, e.g., Tone Reservation method [4].

One of the disadvantages of DFT-S-OFDM is the higher receiver complexity. With a wideband single carrier transmission, the equalizer complexity is relatively high.

While Maximum Likelihood (ML) detection based receiver can be implemented to improve uplink (UL) MIMO performance in the case of OFDM, it is not feasible in the case of DFT-S-OFDM. Thus, the UL MIMO performance will be degraded using DFT-S-OFDM, as compared to OFDM.

The additional DFT processing required for DFT-S-OFDM transmission also increases user terminal complexity.

Higher diversity gain can be achieved by the diversity channel for OFDMA UL, as compared to Localized DFT-S-OFDMA UL. For Distributed DFT-S-OFDMA, there are further problems such as vulnerability to Doppler and frequency offset and pilot design issues. As a result, it is not adopted by 3GPP LTE.

Another disadvantage is the impaired link performance as compared to OFDMA. Some link-level simulation results comparing DFT-S-OFDMA with OFDMA [2] will be discussed in the following section.

Link-level Performance Comparison

The link-level simulation has been performed for the ITU-Pedestrian B channel model at 3 km/h, with 1 transmit, 2 receive antennas. The IFFT/FFT sizes are 1024. Both Distributed (Diversity) DFT-S-OFDM and Localized DFT-S-OFDM have been simulated, as shown in Figure 1 and Figure 2.

The results in Figure 1 show that OFDMA outperforms Distributed DFT-S-OFDM by about 2.5 dB at 1% BLER, for 16-QAM modulation. The corresponding loss in performance for DFT-S-OFDM is about 1 dB for QPSK modulation.

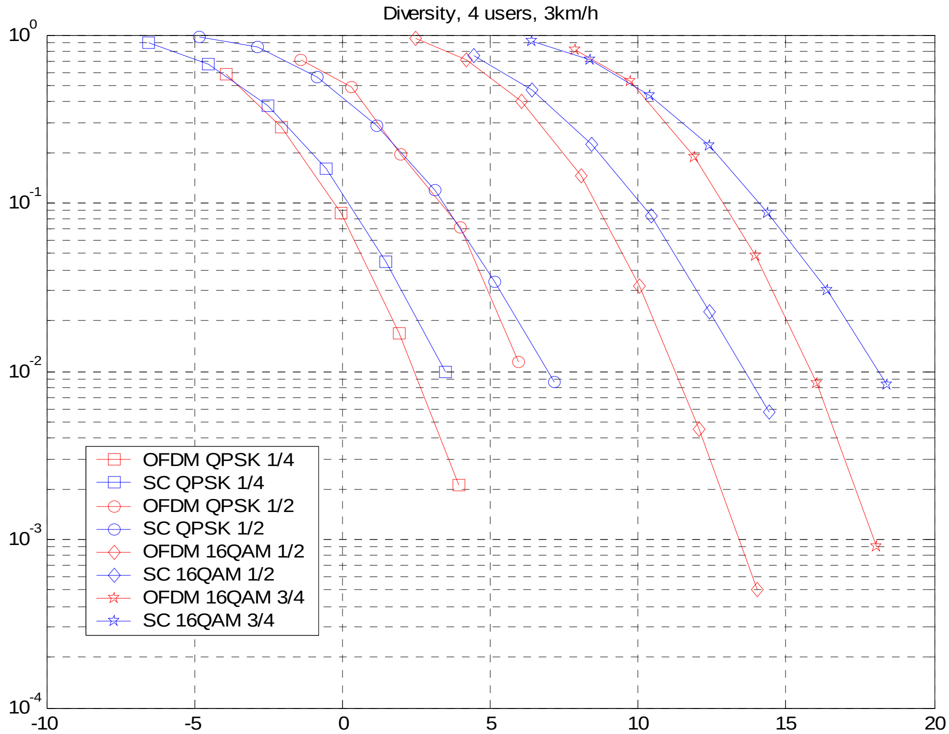

Figure 1. Link performance comparison between Distributed DFT-S-OFDM and OFDMA, Pedestrian B, 3km/h [x= SNR (dB); y = BLER]

The results in Figure 2 show that OFDMA outperforms localized DFT-S-OFDM by about 4 dB at 1% BLER, for 16-QAM modulation. The corresponding loss in performance for DFT-S-OFDM is about 2 dB for QPSK modulation.

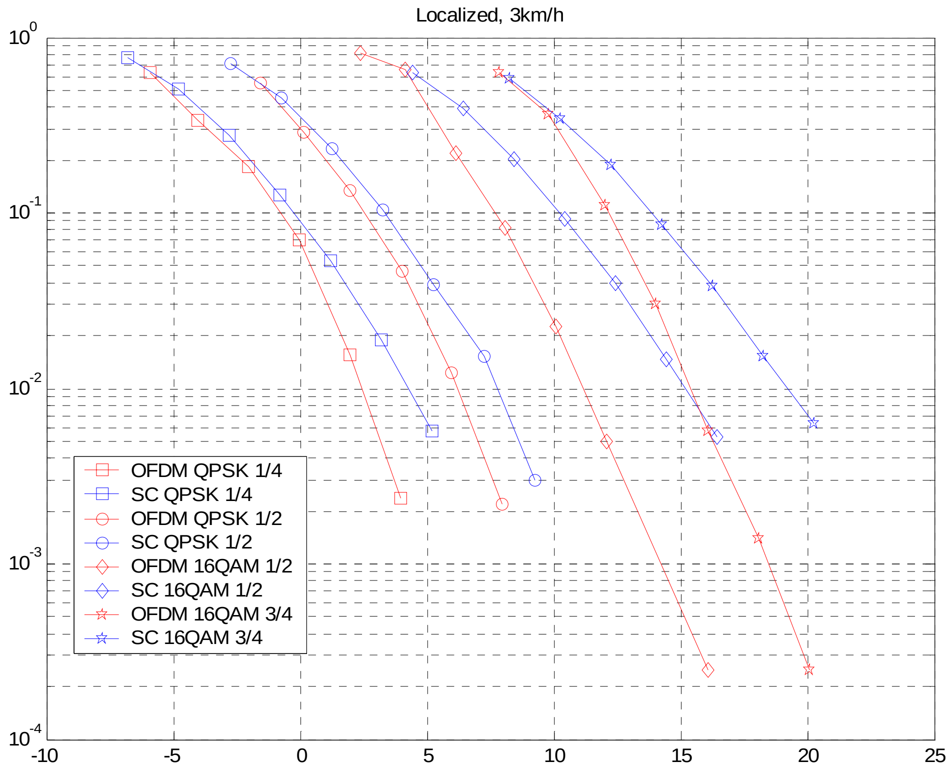

Figure 2. Link performance comparison between Localized DFT-S-OFDM and OFDMA, Pedestrian B, 3km/h [x= SNR (dB); y = BLER]

Conclusion

Comparing OFDMA and DFT-S-OFDM as candidates for uplink multiple access, DFT-S-OFDM has several major drawbacks, including degraded link performance, higher receiver complexity and restrictions on pilot tone multiplexing, despite the advantage of lower PAPR, which affects a small percentage of users in the cell site. For this small group of users, there are a number of techniques to improve the drawback in OFDMA, e.g., PAPR reduction, or smart scheduling.

Therefore, OFDMA should remain as the uplink multiple access technique for 802.16m, which is an evolution of the 802.16 standard.

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.

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[4] ‘OFDMA UL PAPR Reduction’, 3GPP R1-050891, Sept., 2005.