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Source: Cohere Technologies
Title: Performance Evaluation of OTFS Waveform in Multi User Scenarios
Agenda item: 8.1.2.1
Document for: Discussion

1. Introduction

OTFS (Orthogonal Time Frequency Space), a novel modulation technique presented in [1], [2], comprises of a 2-D FFT based preprocessing block on top of an OFDM or other multicarrier system resulting in improved performance. The performance of OTFS was presented in [3] for the case of a single user transmission occupying the full channel bandwidth. In this paper we evaluate the performance of OTFS when multi user transmissions are multiplexed in the Delay-Doppler domain.

2. Discussion

This document presents the performance of OTFS when multiplexing multi UE transmissions - in the Delay-Doppler domain. It is compared to the performance of OFDM for a SISO system on a carrier frequency of 4 GHz and vehicle speeds of 30 Km/h and 120 Km/h (111 Hz and 444 Hz max Doppler spread). We use ideal channel estimation and no control overhead in this comparison to focus on the performance of the modulation. We use an ML receiver for OFDM (which in this SISO case reduces to an MMSE receiver) and a turbo equalizer for OTFS. The turbo equalizer iterates between the decoder and the linear equalizer improving the performance in each iteration.

Table 1 summarizes the simulation parameters.

Table 1: Simulation Parameters

Parameter	Value
Carrier frequency	4 GHz
System BW	10 MHz
TTI length	1 msec
Subcarrier spacing	15 KHz
FFT size	1024
CP length	4.7 usec
Data size[1]	Single UE: 4 PRBs 3 UEs: 4-4-4, 23-4-23, 17-16-17 PRBs
Coding	Turbo code, 6144 max code-block length
MCS	16-QAM 1/2, 16-QAM 2/3, 64-QAM 1/2
Control overhead	No overhead
Channel estimation	Ideal
Channel	TDLC300-111 (30 Km/h), TDLC300-444 (120 Km/h)
Receiver	OTFS: Turbo equalizer, OFDM: ML/MMSE

[1] In OTFS the allocation is in the Delay-Doppler domain where each PRB is assigned 14 columns in the Doppler dimension and 12 rows in the Delay dimension.

The first two figures show the performance of 16-QAM rate ½ with three users, each with allocation of 4 PRBs in the Delay-Doppler domain. It can be seen that the performance of all three UEs is similar and not different from the case of allocation of 4 PRBs to a single UE. It can also be seen that OTFS outperforms OFDM (single UE with 4 PRB allocation) at the operating point of 1E-1 by approximately 3.5 dB when the UE speed is 30 Km/h and by 2.5 dB when the UE speed is 120 Km/h. Figure 3 and Figure 4 show similar results for 16-QAM rate 2/3 with similar gains over OFDM. The performance in 64-QAM rate ½ is shown in Figure 5 and Figure 6, again showing similar results and outperforming OFDM.

The performance of OTFS was also evaluated using different bandwidth allocations. As shown in the last 4 figures, performance of OTFS is not affected by the size of the data allocation.

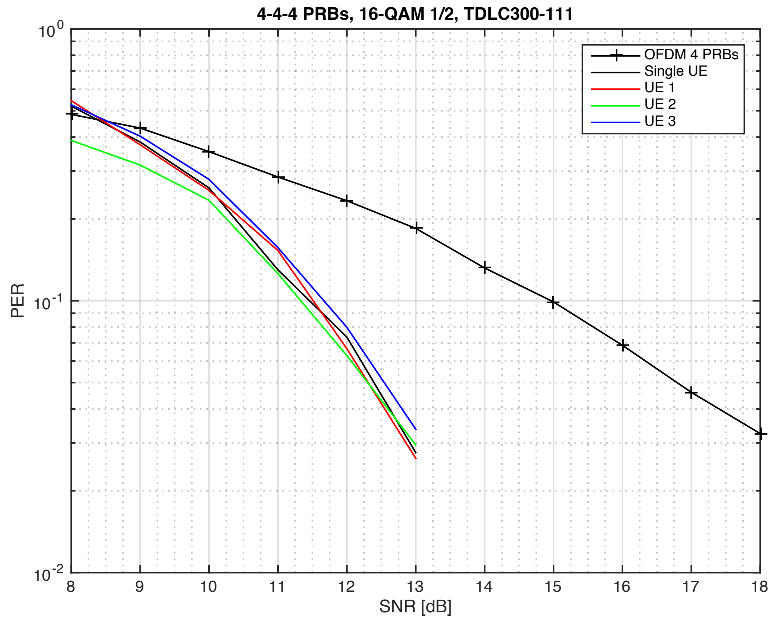

Figure 1: BLER performance for 16QAM, R=1/2, 30kmph in TDL-C, DS=300ns Channel

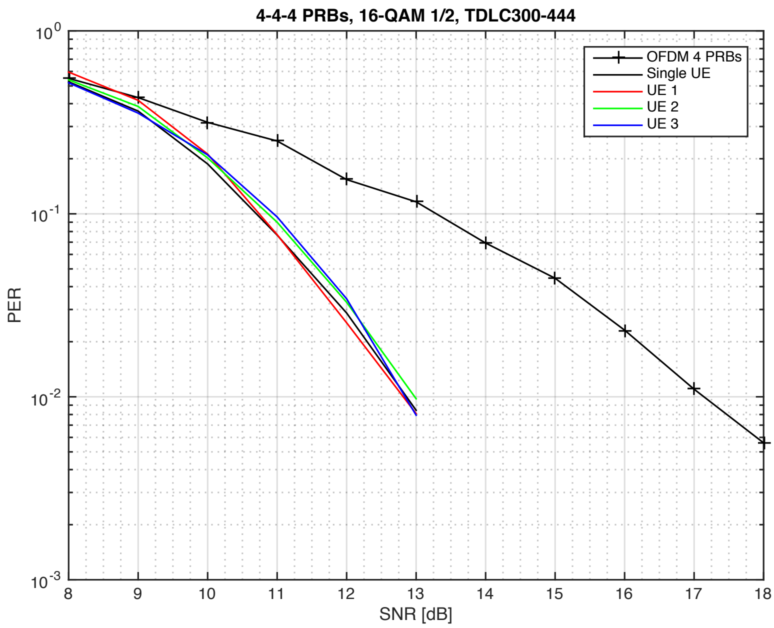

Figure 2: BLER performance for 16QAM, R=1/2, 120kmph in TDL-C, DS=300ns Channel

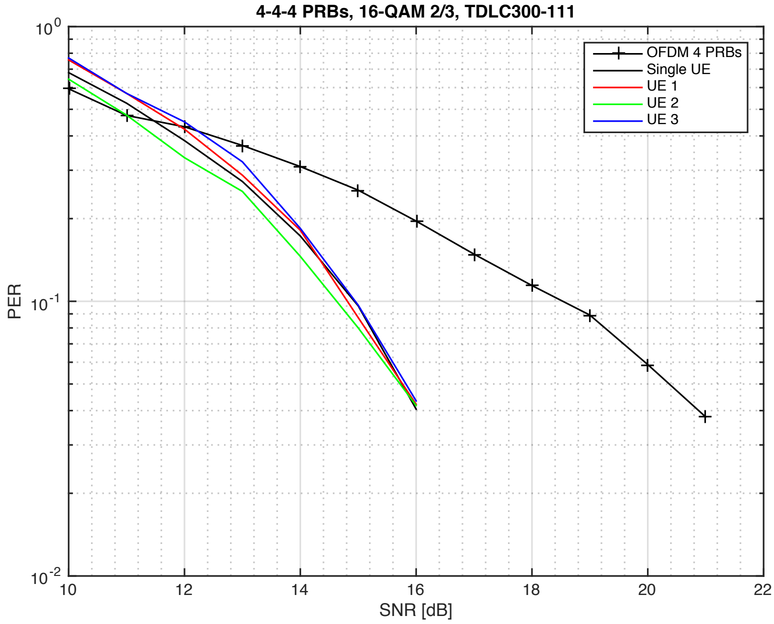

Figure 3: BLER performance for 16QAM, R=2/3, 30kmph in TDL-C, DS=300ns Channel

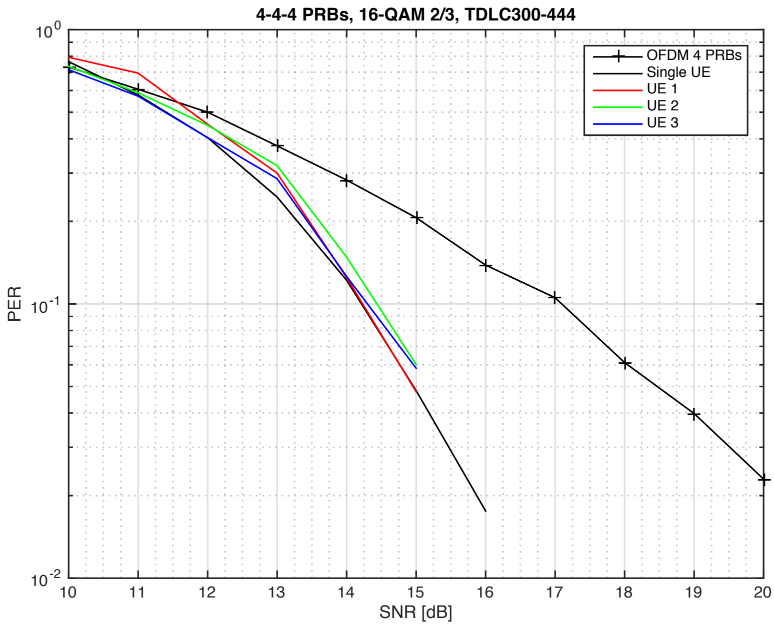

Figure 4: BLER performance for 16QAM, R=2/3, 120kmph in TDL-C, DS=300ns Channel

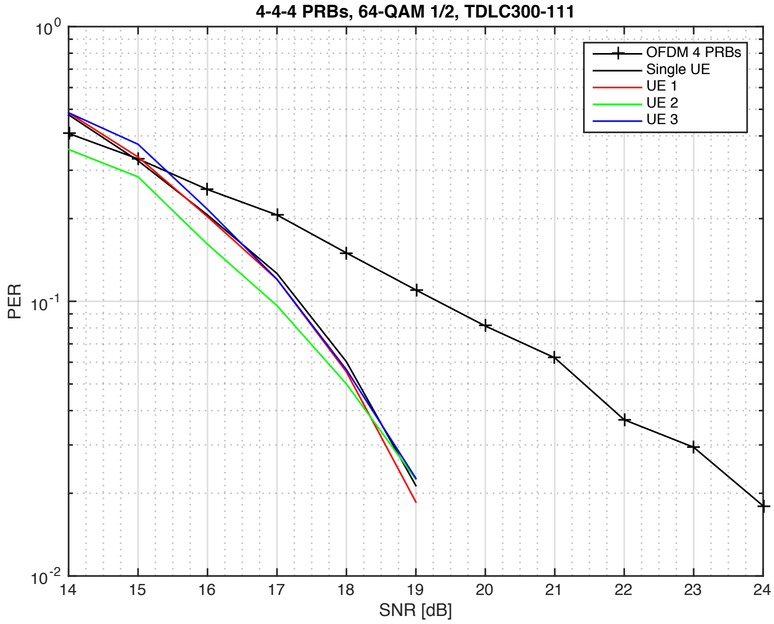

Figure 5: BLER performance for 64QAM, R=1/2, 30kmph in TDL-C, DS=300ns Channel

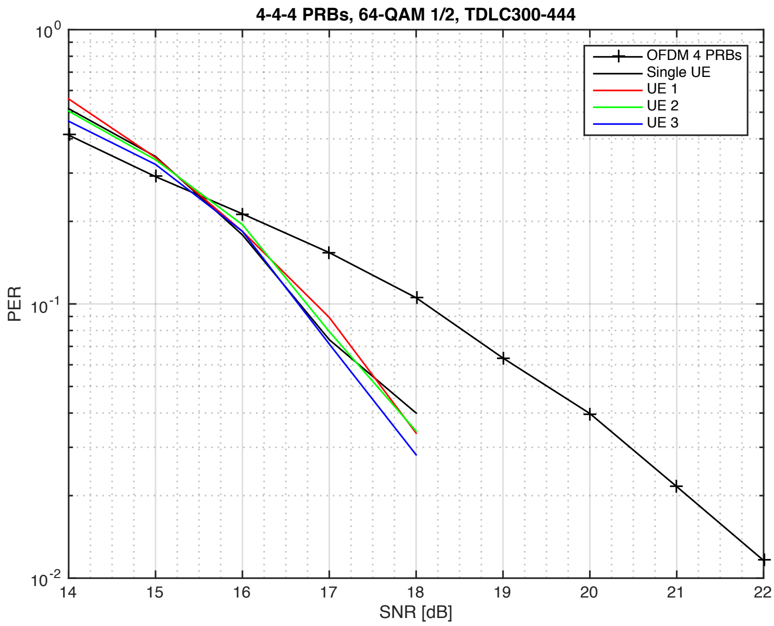

Figure 6: BLER performance for 64QAM, R=1/2, 120kmph in TDL-C, DS=300ns Channel

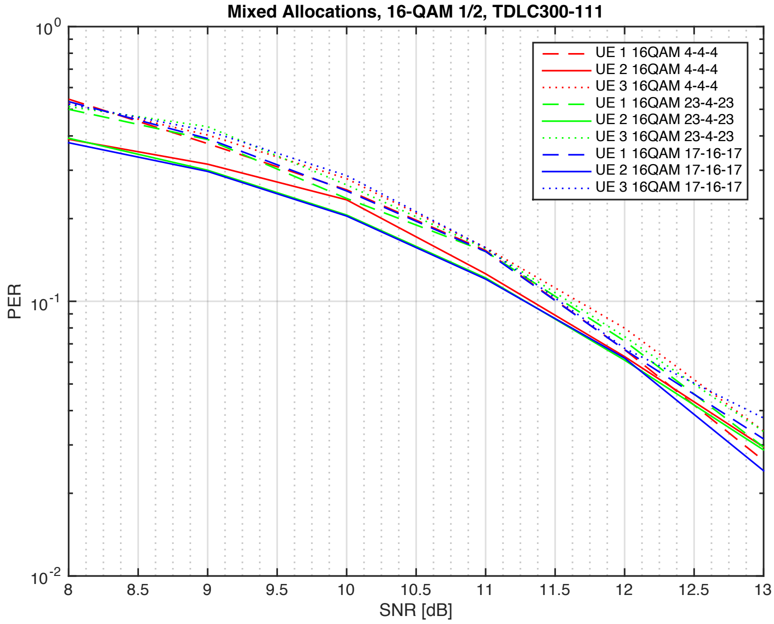

Figure 7: Comparison of OTFS performance with different data allocations for 16QAM, R=1/2, 30kmph in TDL-C, DS=300ns Channel

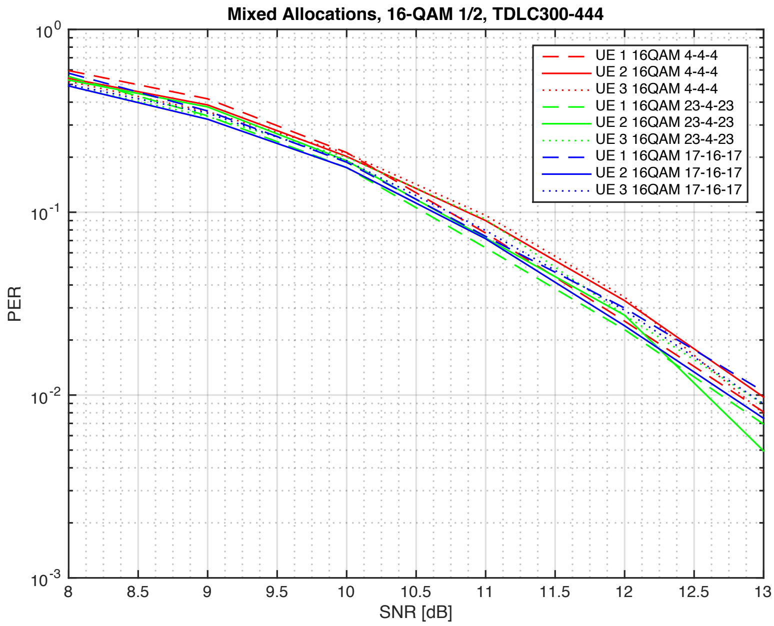

Figure 8: Comparison of OTFS performance with different data allocations for 16QAM, R=1/2, 120kmph in TDL-C, DS=300ns Channel

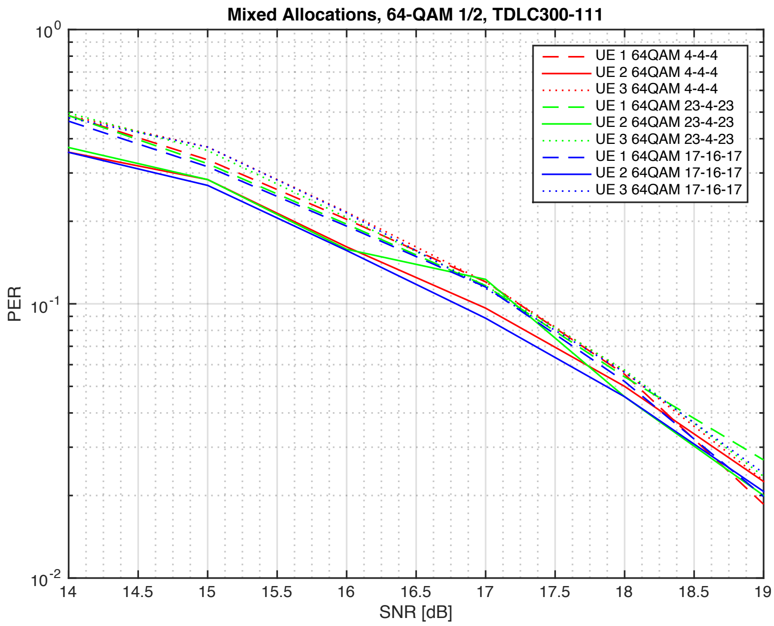

Figure 9: Comparison of OTFS performance with different data allocations for 64QAM, R=1/2, 30kmph in TDL-C, DS=300ns Channel

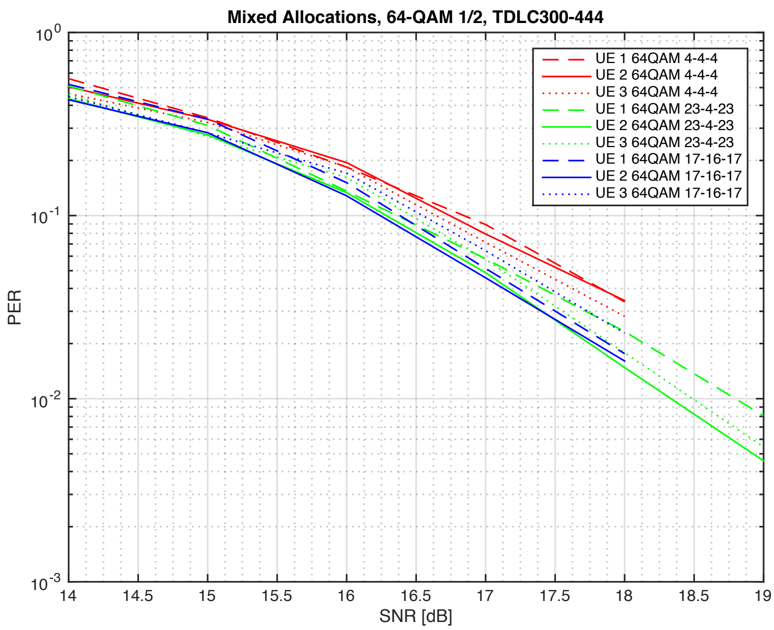

Figure 10: Comparison of OTFS performance with different data allocations for 64QAM, R=1/2, 120kmph in TDL-C, DS=300ns Channel

3. Conclusion

In this contribution we have shown that OTFS can support multi user scenarios with no degradation in performance at different levels of Doppler spreads and at different MCSs. We have also shown that the gain of OTFS over OFDM in the single user case is maintained when moving to the multi user case.

4. References

[1] R1-163619, “OTFS Modulation Waveform and Reference Signals for New RAT,” Source: Cohere Technologies

[2] R1-162929, “Overview of OTFS Waveform for Next Generation RAT,” Source: Cohere Technologies

[3] R1-165620, “Performance Results for OTFS Modulation,” Source: Cohere Technologies