Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Turbo Equalization/Estimation for Downlink MIMO Schemes**
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Re:	Downlink MIMO schemes @ "IEEE 802.16m-08/016r1 - Call for Contributions on Project 802.16m System Description Document (SDD)"
Abstract	We propose an iterative equalization and decoding (turbo-equalization) for OFDM modulated signals over MIMO frequency-selective fading channels to be applied in WiMax downlink. The goal is to propose an efficient low complexity solution in this context.
Purpose	[Description of what *specific* action is requested of the 802.16 Working Group or subgroup.]
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Turbo Equalization Estimation for Downlink MIMO Schemes

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1 Abstract

We propose an iterative equalization and decoding (turbo-equalization) for OFDM modulated signals over MIMO frequency-selective fading channels to be applied in WiMax downlink. The goal is to propose an efficient low complexity solution in this context.

2 Scheme

For the downlink MIMO scheme, we consider a simple iterative joint channel-estimation data detection technique. Proposed technique assumes Convolutional (or Turbo) FEC encoder at the base station (Fig.1) and a iterative joint detection/estimation is performed at the receiver mobile station (Fig.2).

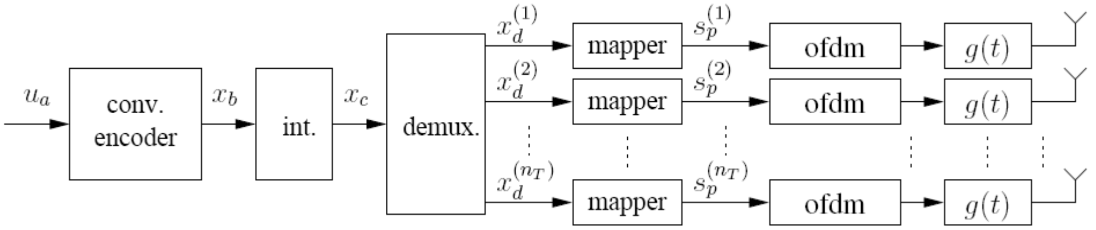

Figure 1: Transmitter with convolutional encoder

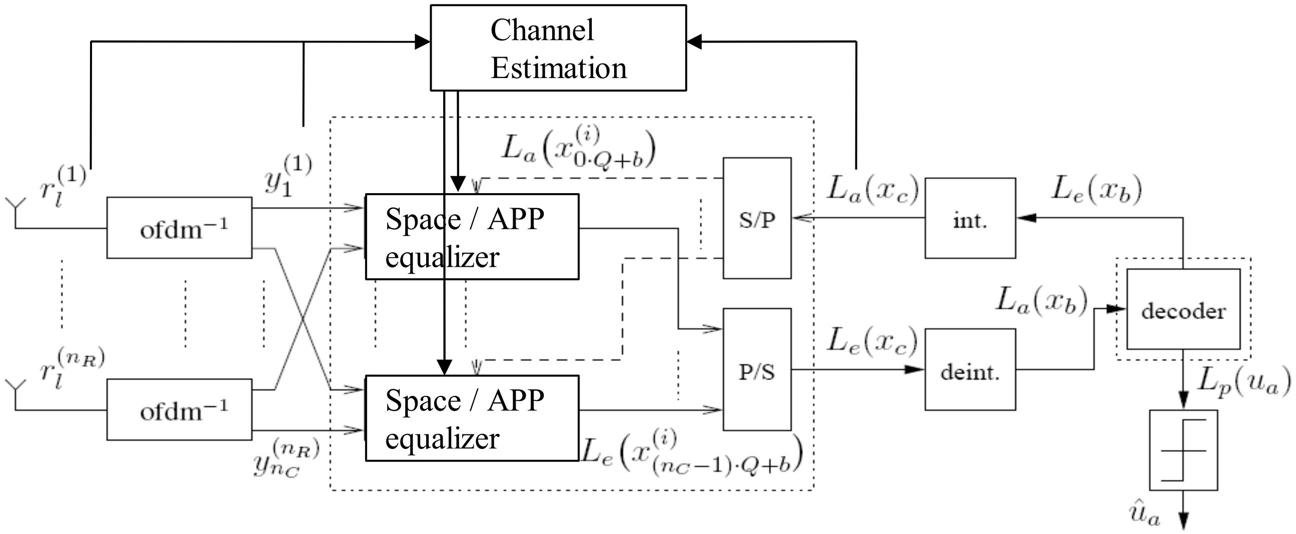

Figure 2: Receiver at the mobile

3 System Model

At the receiver antenna "k", we model the observation vector $\boldsymbol{r}_k$ as:

$$\boldsymbol{r}_k = \Sigma_{i=1}^{N_t} \boldsymbol{S}_i \boldsymbol{h}_{i,k} + \boldsymbol{n}_k$$

where ;

$\boldsymbol{h}_{i,k}$ = $L \times 1$ channel tap gain vector

$\boldsymbol{S}_i$ = $N_c \times L$ transmission matrix and its elements are taken from IFFT taken symbol vector $\boldsymbol{s}_i \times \boldsymbol{W}$

N_c = Number of OFDM subcarriers

L = Maximum tap length in the system

$\boldsymbol{n}_k$ = Noise vector

3.1 Channel Estimation

Channel estimation methods mentioned here are detailedly explained in [Ch7. of 1] . To estimate the channel, the proposed scheme utilizes iterative Unbiased-Least Squares (ULS) algorithm such that,

$$\tilde{\boldsymbol{h}}_k = (E[\boldsymbol{S}; P]^H E[\boldsymbol{S}; P])^{-1} E[\boldsymbol{S}; P]^H \boldsymbol{r}_k$$

where;

$\tilde{\boldsymbol{h}}_k$ = $(\boldsymbol{h}_{1,k}^{T}, \ldots, \boldsymbol{h}_{N_t,k}^{T})^T$,

$E[\boldsymbol{S}; P]$ = the expectation of the $\boldsymbol{S} = (\boldsymbol{S}_{1,}.., \boldsymbol{S}_{N_t})$ matrix w.r.t. Probability distributions P . Note that the $\boldsymbol{S}$ matrix is obtained by IFFT of estimated soft symbols but not pilots, thus we need an initial CSI to conduct this iterative channel estimation procedure. This is performed using pilot aided parametric estimation. Note that the estimated channel tap gain vector $\tilde{\boldsymbol{h}}_k$ is supposed to be constant for entire OFDM symbol duration.

3.2 Symbol Detection

In each iteration, updated channel estimates are fed to symbol equalizer (APP or Space Equalizer [2]) to have symbol/bit extrinsic probabilities and these values are fed to SISO decoder. Thus in each iteration updated $\boldsymbol{S}$, P values are obtained.

4 Simulation Results

The performance of the proposed iterative scheme depends on many factor such as the choice of FEC encoder, Mapping or Pilot positioning. Thus, as a first step, in order to obtain the system performance limits we compared the effect of mapping and symbol equalizer for perfect channel state information (CSI) case. For the simulation we assumed 2 transmit and 2 receive antenna setup with a ½ rate non systematic convolutional code with [5 7] encoder. As seen from figure 3, Natural Mapping outperforms Gray Mapping for high SNR regions when targeting BER but it is always better when targeting FER. In addition APP decoding always outperforms Space Equalizer (S-T) and both have similar computational complexity.

The performance of the proposed scheme with channel estimation for different transmit – receive setups is given in fig.4. As seen from the figures, iterative channel estimation is always beneficial for 1by1 setup but after high SNR values for 2by2 setup. Thus according to the operation mode, iterative channel estimation can be performed.

Finally, performance of the proposed scheme for 2by2 setup over suggested channel conditions in EMD [3] are shown in fig.5. Again, perfect CSI is assumed at the receiver. Even tough the simulations are not completed, the results suggest that the proposed scheme is able perform BER-wise comparable for static or fading channel conditions.

5 Conclusion

From the simulation results, it can be seen that, BICM/TURBO error control coding is a promising candidate to be utilized at the transmitter. And using the proposed joint channel-estimation data detection technique at the receiver, it can provide desired BER/FER performance. It should be noted that in addition to code design, mapping has also an important influence on the performance and under different conditions, different mapping, code pairs can be adapted at the DL MIMO. At the moment, the work is not conclusive on the selection policy for adaptation issues but from our point of view use of BICM/TURBO encoding is essential.

6 Bibliography

[1] Xavier Wautelet, **"Turbo equalization and turbo estimation for multiple-input multiple-output wireless systems,"** Faculté des Sciences Appliquées, Université catholique de Louvain, N°110/2006, September 2006, 208pp.

[2] Damien Zuyderhoff, Xavier Wautelet, Antoine Dejonghe, Luc Vandendorpe, **"MMSE turbo receiver for space-frequency bit-interleaved coded OFDM,"** *VTC 2003-Fall - IEEE 58th Vehicular Technology Conference*, Orlando, USA, vol. 1, pp. 567-571, October 6-9, 2003.

[3] IEEE 802.16m-08/004r1, Project 802.16m Evaluation Methodology Document (EMD) [as approved] (2008-03-17)

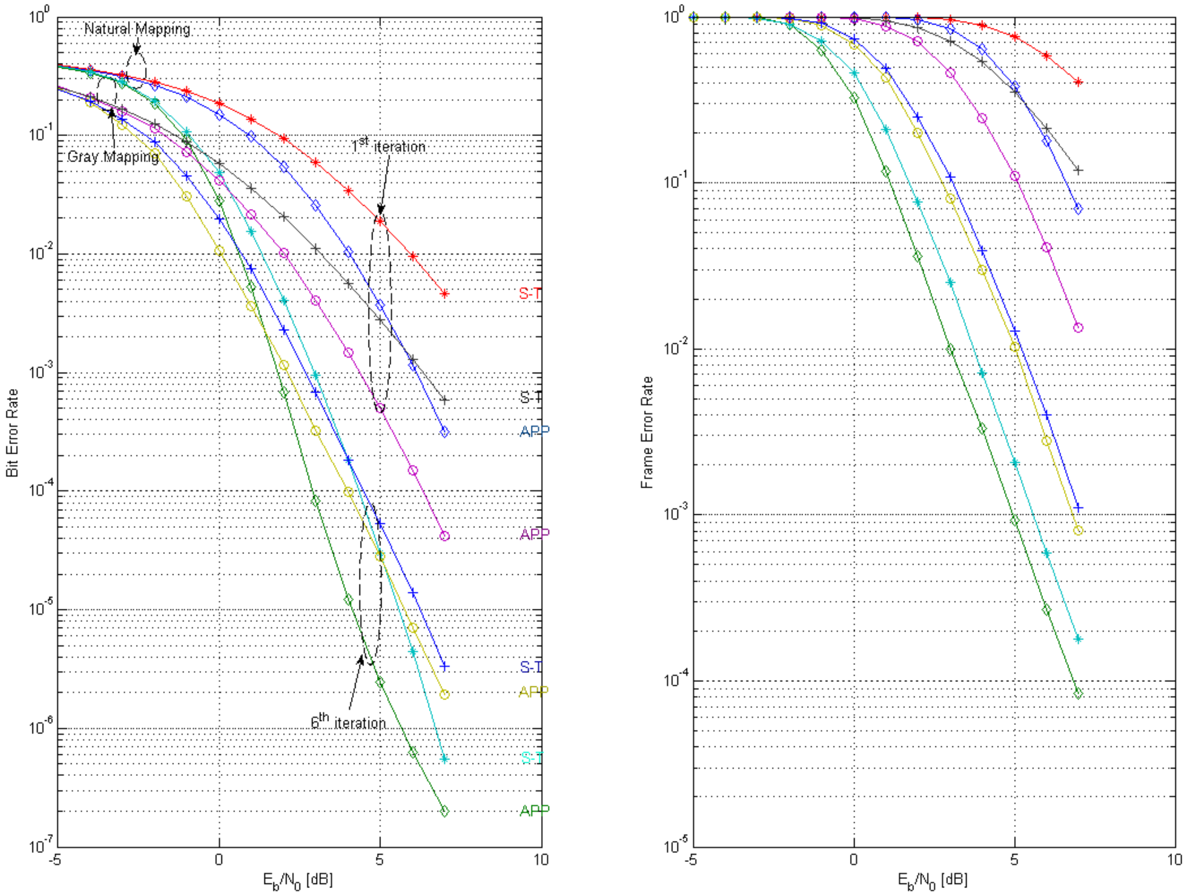

Figure 3: BER/FER Performance of proposed scheme with Perfect CSI

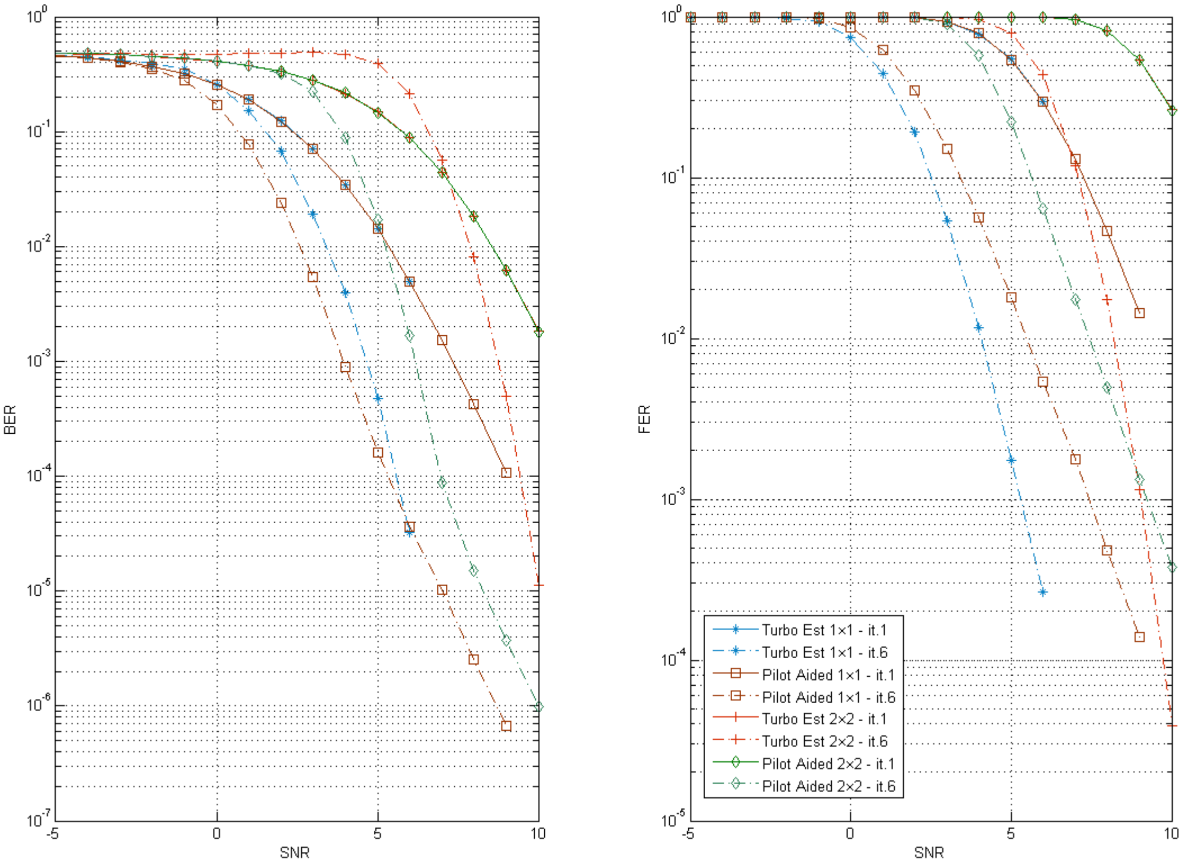

Figure 4: BER-FER performance with Channel Estimation

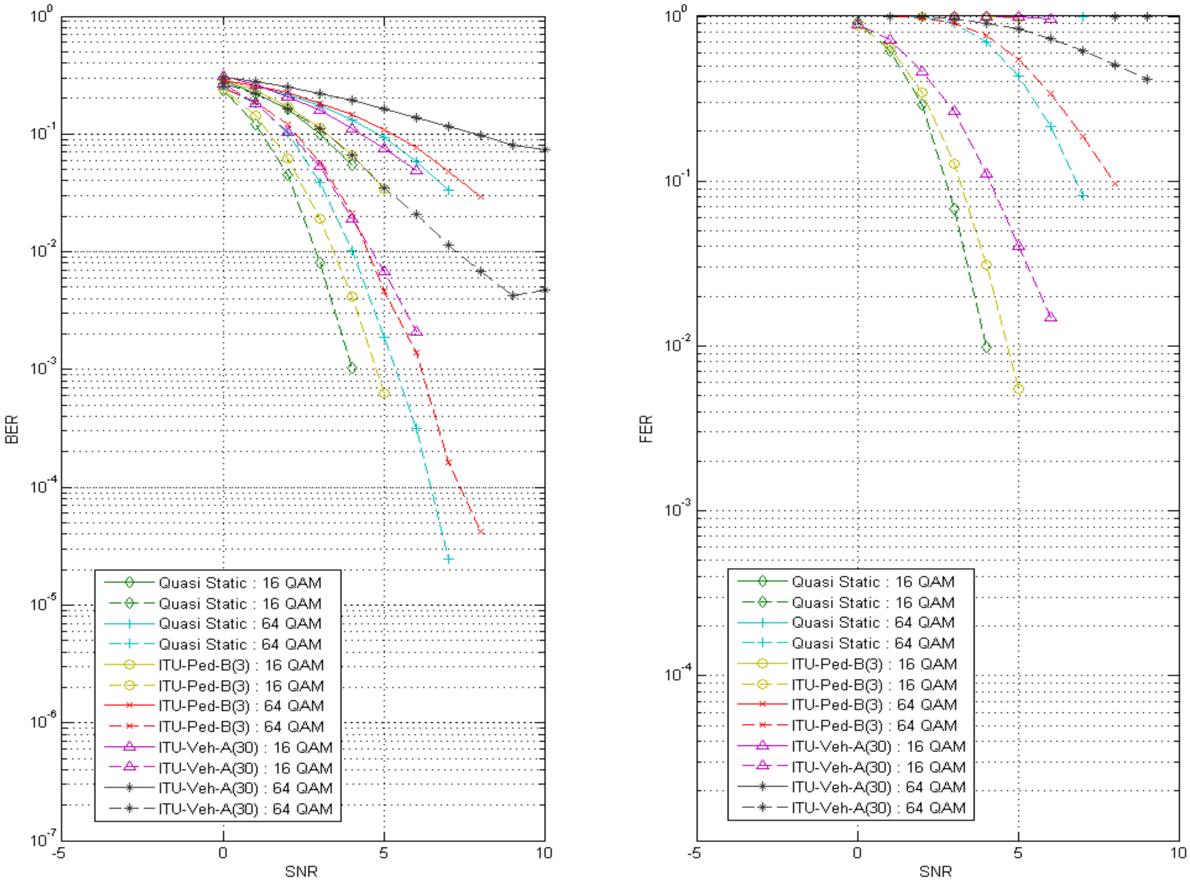

Figure 5: Ber-Fer performance with Perfect CSI under Proposed scenarios