

Project	<b>IEEE 802.16 Broadband Wireless Access Working Group</b> < <a href="http://ieee802.org/16">http://ieee802.org/16</a> >	
Title	<b>Turbo Equalization/Estimation for Downlink MIMO Schemes</b>	
Date Submitted	<b>2007-05-05</b>	
Source(s)	Luc Vandendorpe, Onur Oguz Université catholique de Louvain (UCL) Place du Levant 1 1348 Louvain-la-Neuve Belgium	Voice: +32-10-47.23.12 +32-10-47.80.71 E-mail: {luc.vandenrope , onur.oguz}@uclouvain.be
Re:	Downlink MIMO schemes @ “EEE 802.16m-08/016 - 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 <i>specific</i> action is requested of the 802.16 Working Group or subgroup.]	
Notice	<i>This document does not represent the agreed views of the IEEE 802.16 Working Group or any of its subgroups. It represents only the views of the participants listed in the “Source(s)” field above. It is offered as a basis for discussion. It is not binding on the contributor(s), who reserve(s) the right to add, amend or withdraw material contained herein.</i>	
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.	
Patent Policy	The contributor is familiar with the IEEE-SA Patent Policy and Procedures: < <a href="http://standards.ieee.org/guides/bylaws/sect6-7.html#6">http://standards.ieee.org/guides/bylaws/sect6-7.html#6</a> > and < <a href="http://standards.ieee.org/guides/opman/sect6.html#6.3">http://standards.ieee.org/guides/opman/sect6.html#6.3</a> >. Further information is located at < <a href="http://standards.ieee.org/board/pat/pat-material.html">http://standards.ieee.org/board/pat/pat-material.html</a> > and < <a href="http://standards.ieee.org/board/pat">http://standards.ieee.org/board/pat</a> >.	

# Turbo Equalization Estimation for Downlink MIMO Schemes

Luc Vandendorpe and Onur Oguz

Université catholique de Louvain (UCL)

## 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).

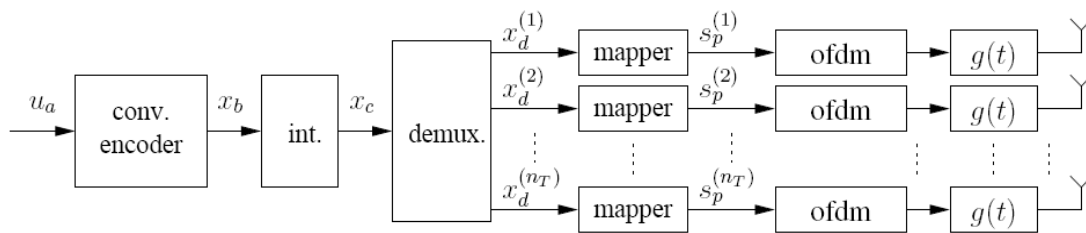


Figure 1: Transmitter with convolutional encoder

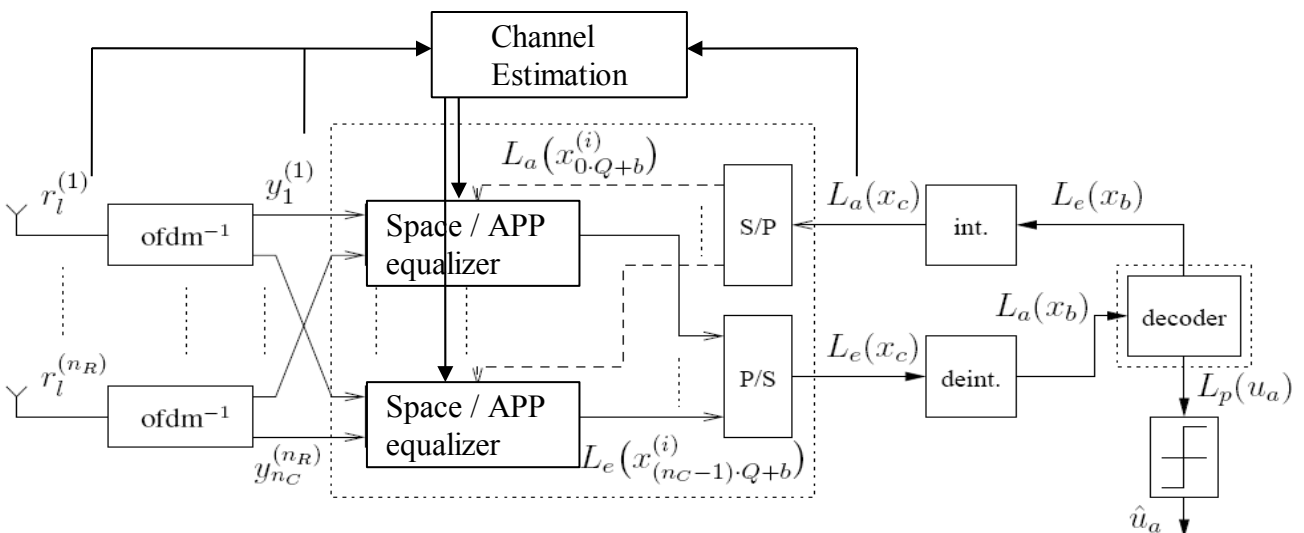


Figure 2: Receiver at the mobile

### 3 System Model

At the receiver antenna “ $k$ ”, we model the observation vector  $\mathbf{r}_k$  as:

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

where ;

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

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

$N_c =$  Number of OFDM subcarriers

$L =$  Maximum tap length in the system

$\mathbf{n}_k =$  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,

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

where;

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

$E[\mathbf{S}; P] =$  the expectation of the  $\mathbf{S} = (\mathbf{S}_1, \dots, \mathbf{S}_{N_t})$  matrix w.r.t. Probability distributions  $P$  . Note that the {bold 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.

#### 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  $\mathbf{S}$  ,  $P$  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 1/2 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 are shown in fig.5. Again, perfect CSI is assumed at the receiver. Even though 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 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.

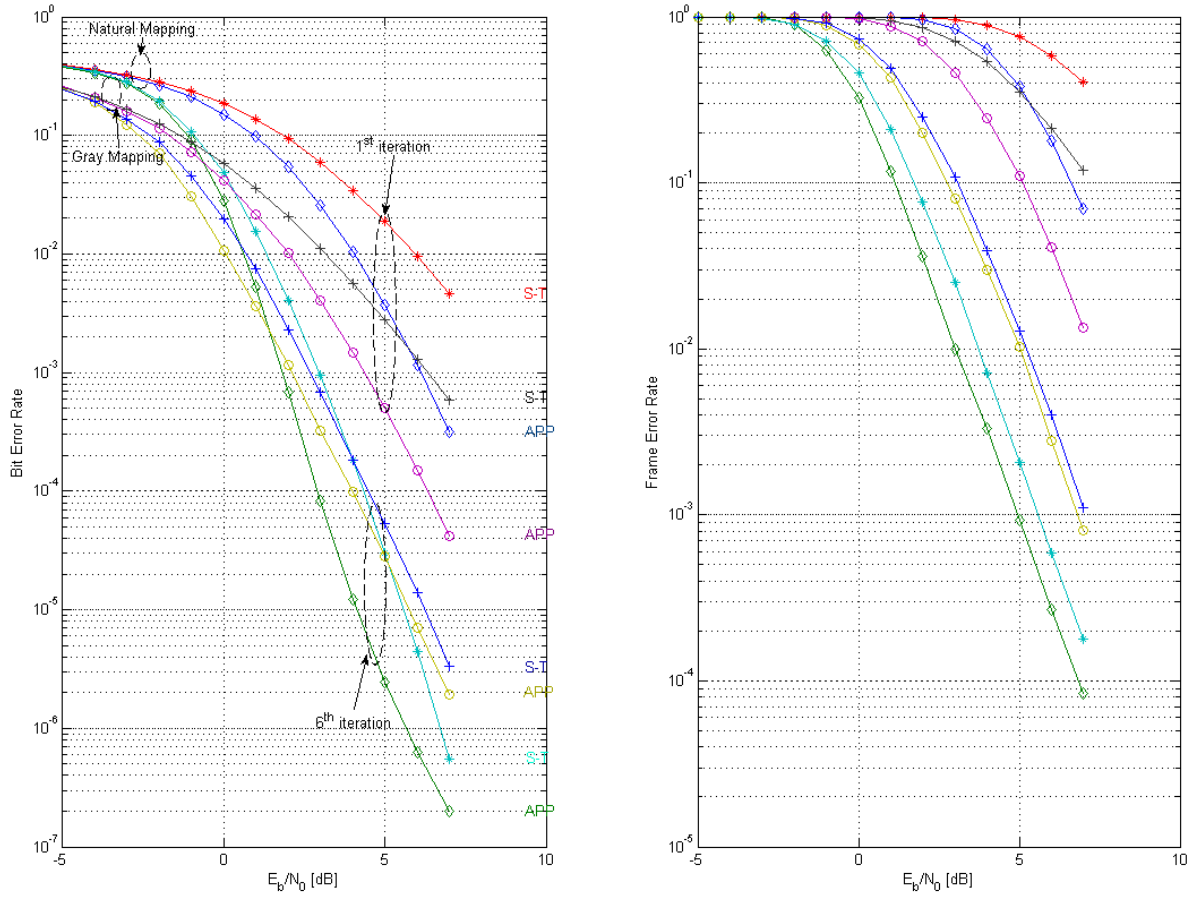


Figure 3: BER/FER Performance of proposed scheme with Perfect CSI

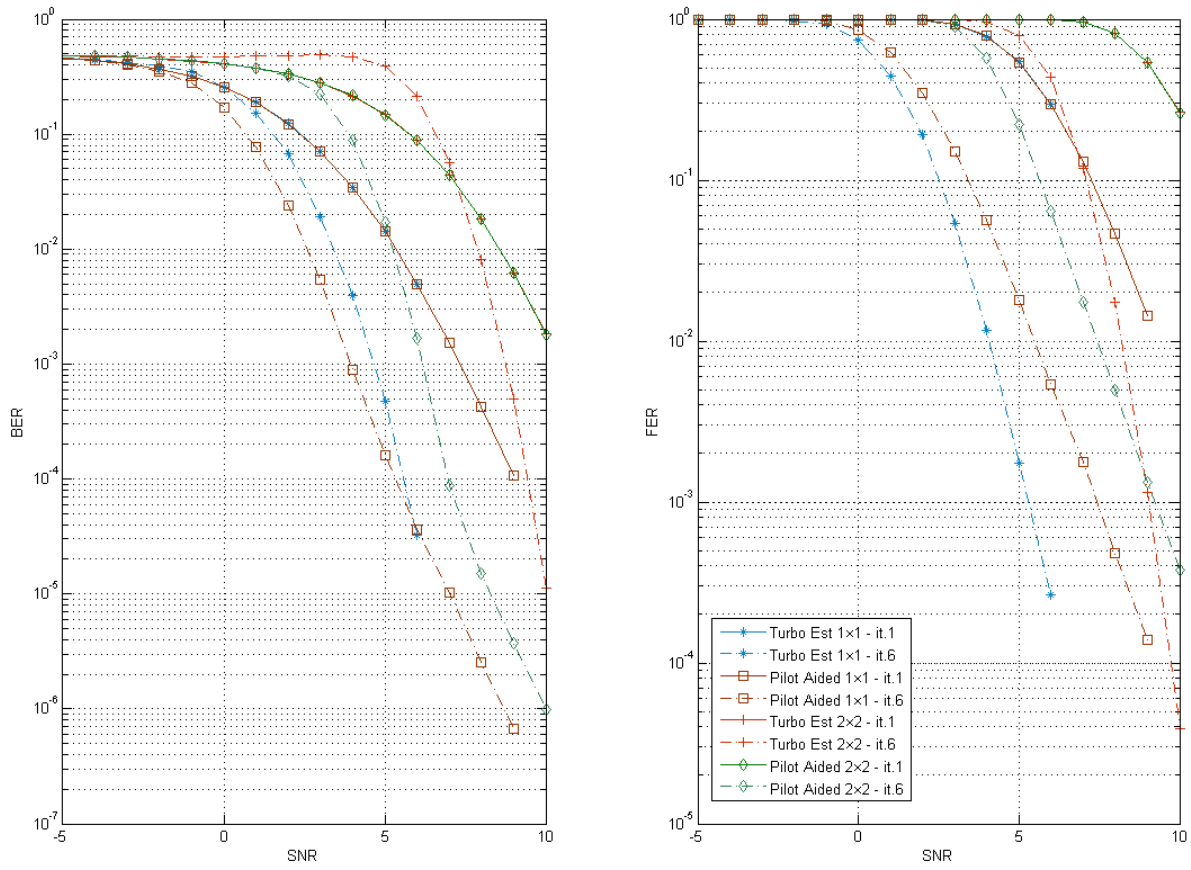


Figure 4: BER-FER performance with Channel Estimation

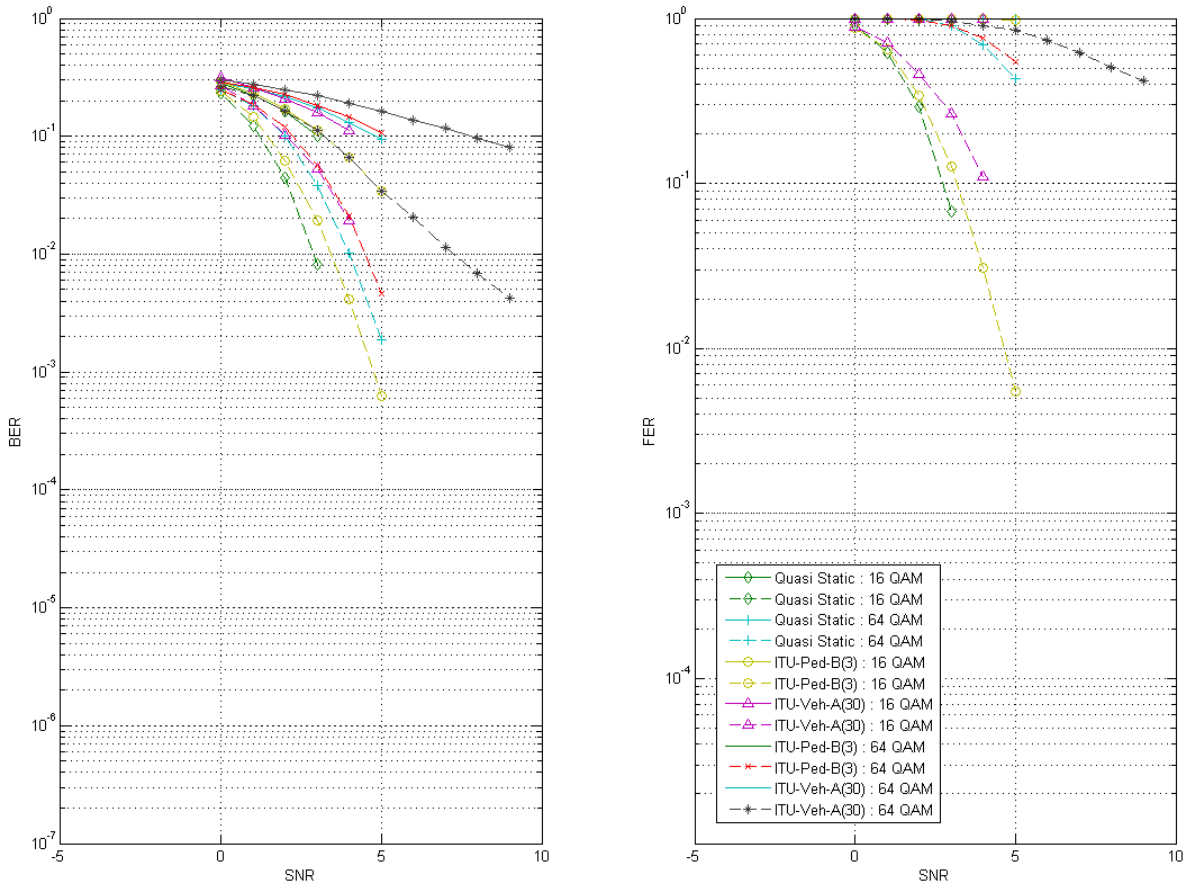


Figure 5: Fer-Fer prformance with Perfect CSI under Proposed scenarios