Abstract

Next generation mobile systems will use multiple antennas at the transmitter and receiver to achieve higher capacity and diversity gain at high speeds. By transmitting through multiple transmitting and receiving antennas, multiple wireless data pipes are created. A transmitted signal while propagating through the wireless channel, undergoes multipath fading effect accompanied by noise and interference. Mitigation of these effects and increase in throughput is only possible if the channel is accurately estimated at the receiver in order to perform coherent detection. Existing literature mentions both coherent and noncoherent detection. However, here the work focus on coherent detection due to its advantages of low power transmission and less complex transmitting and receiving methods compared to noncoherent detection. Coherent detection consists of two steps; the first one being channel estimation and the second is data detection.

As a first step of Coherent Detection in MIMO systems, different channel estimation methods are investigated. Literature describes pilot assisted as well as blind methods in terms of performance, spectral efficiency, convergence speed and complexity. Depending on slow/fast channel fading conditions, several authors suggested adaptive MMSE, LS, LMMSE, RLS based pilot channel estimators, which either require statistical information of the channel or are not efficient enough in terms of performance or computations.

In order to overcome the above effects, the work focuses on the QR-RLS based channel estimation method for MIMO-OFDM systems. The proposed estimator uses preamble for time domain channel tracking, thus avoiding error spreading over the whole band as in its frequency domain conterpart. Use of RLS avoids the need for channel statistical information like MMSE, LMMSE estimators while the use of QR decomposition also avoids matrix inversion as in RLS estimators. For low and moderate channel fading condition, the proposed estimator is used in DDCE(Decision Directed Channel Estimator) mode. In this, the first order markov model is used in conjucion with the proposed estimator to estimate channel variations, symbol by symbol. For improving performance in a fast fading environment, the work is advanced for QR-LS based joint coarse-fine channel estimation. In the proposed work, QR-RLS estimated coarse channel component is used jointly with scattered frequency domain pilots for fine symbol by symbol channel estimation. The proposed method gives better performance compared to pilot interpolation based estimators.

Moving to the second step of Coherent Detection, spatial multiplexing (SM) is a technique to increase throughput by allowing multiple spatial streams in MIMO systems. At the receiver, MIMO streams are separated using linear or VBLAST/OSIC detectors. Literature compares linear as well as OSIC detectors in terms of performance and complexity. Many authors have suggested optimal QR based OSIC detectors which achieve hard ML(Maximum Likelihood) performance but
suffer from Empty Vector Set (EVS) problem while achieving soft ML performance. EVS problem is more severe in terms of performance when the modulation order is low. Several remedies have been described by many authors to mitigate EVS. However, they fall short in terms of performance or complexity while achieving Soft ML performance.

To mitigate Empty Vector Set (EVS) problem effectively, two solutions are proposed here. In the first one, an enlargement of candidate vector set of QRLRL (QR - Least Reliable Layer) based MIMO detector for efficient soft output generation is proposed. The overall enlarged candidate vector set consists of vectors with every constellation point tried at each layer. The proposed detector thus effectively removes EVS problem and achieves soft ML performance while keeping the computation complexity low at low modulation order. QR-LRL based IDD (Iterative Detection and Decoding) is another solution, which exchanges the extrinsic information between detector and decoder. Based on feedback knowledge from the decoder, a decision is made to update candidate vector set for soft output generation. Simulation results show that significant performance improvement is achieved while keeping the receiver design simple.

Thesis contribution:

1. A novel method for OFDM-MIMO channel estimation using QR-RLS (Square Root-Recursive Least Square) estimator is presented.

2. QR-RLS based MIMO (Multiple input Multiple output) channel estimation is combined with scattered pilots for coarse-fine channel estimation in Mobile Wimax 802.16m system.

3. MIMO OSIC detectors suffer from EVS (Empty Vector Set) problem while generating soft output. Two solutions are proposed to mitigate EVS.

   (a) Candidate Vector set of QR-LRL MIMO detector is effectively enlarged to mitigate empty vector set problem and achieve soft ML performance.

   (b) QR-LRL based SM-MIMO detector is iteratively used with TURBO decoder to achieve soft ML performance without adding any extra computational complexity to the receiver.