Automatic Modulation Classification in Mobile OFDM Systems with Adaptive Modulation

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Abstract

Adaptive modulation is an efficient way to combat the effects of deep fades in broadband orthogonal frequency division multiplexing (OFDM) systems with time-varying multipath propagation channels. Modulation schemes are adapted to the current channel state. Bandwidth efficient modulation schemes are applied on subcarriers with high channel quality, while robust modulation schemes or even no modulation are preferred for subcarriers in deep fades. The resulting benefit in terms of required transmit power was demonstrated for a fixed data rate in [1], where a gain of $5 \cdots 15$ dB was recorded for a BER of 10^{-3} over the OFDM system with a fixed modulation. Alternatively, adaptive modulation can also be used to improve the bandwidth efficiency. The advantage in terms of throughput was shown for a predefined quality of service in [2]. In literature, several algorithms have been proposed for adaptive modulation with different emphasis on bandwidth efficiency and implementation complexity [3], [4], [5]. In the thesis, the algorithm proposed in [6] is used.

A main drawback of adaptive modulation is that it requires information about the adapted modulation scheme at the receiver to enable demodulation. Traditionally, this information can be provided in forms of explicit signalling, which reduces the bandwidth efficiency due to the signalling overhead. In the thesis, proposals are developed to reduce this undesirable overhead. These proposals exploit the correlation properties inherently existing in the transmission channel in both time and frequency domain. These correlations lead to memory effects in the signalling source. State-dependent Huffman coding schemes are then applied to reduce the redundancy resulting from these memory effects [7].

This signalling overhead can be totally eliminated via automatic modulation classification (AMC). In the past, AMC was mainly of interest in military fields like threat analysis and electronic surveillance [8], where no prior knowledge about the used modulation scheme is available. Under such circumstance, maximum likelihood (ML) based AMC provides the optimum solution in the sense that the classification error probability is minimized. Nowadays, AMC is drawing more and more research interest also in civilian applications like systems with adaptive modulation, where certain cooperations are organized as in the system considered in this thesis. These cooperations provide certain prior information, which can be utilized to improve the classification reliability. Consequently, the ML based approach does not deliver the minimum error probability any more [9], [10] [11]. Investigations have to be conducted to verify how much the performance can be improved by incorporating this prior information into the AMC algorithm. As one focus in this thesis, a maximum a posteriori (MAP) based AMC is developed, which is potentially

able to minimize the classification error probability again. Another focus is to reduce the implementation complexity to enable the application of AMC in systems with high time requirements, e.g. real-time systems.

In the last part of the thesis, comparisons are performed between these two approaches, namely explicit signalling and signalling-free AMC, in terms of end-to-end packet error probability. To ensure a fair comparison, the net data rate is maintained as a constant in both operation modes.

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