Co-channel interference (CCI) has already become the limiting factor in the performance of orthogonal frequency division multiplexing (OFDM) based cellular systems. CCI cancellation algorithms can be divided into two classes based on the number of antennas used for transmission and reception. The first class, named multiple antenna interference cancellation (MAIC), usually exploits transmit, receive, or space diversity, or directional gain provided by multiple antennas and additional coding schemes. The second class, called single antenna interference cancellation (SAIC), cancels CCI by only one receive antenna. CCI cancellation by MAIC is particularly challenging in the downlink since the cost of the performance enhancements is the added cost of deploying multiple antennas, the space, multidimensional signal processor and circuit power requirements of these extra antennas. Therefore, this thesis focuses on the SAIC techniques, which will still perform an important role in the near future. However, since the use of additional antennas in the mobile terminal has already been specified in the next generation mobile communication systems, the analysis and results are also extended to the domain of receiver diversity.

Joint detection (JD) and filter based blind interference cancellation (BIC) are the two most prominent classes of SAIC. BIC does not need to demodulate the interfering signals and is capable of canceling a single interferer if the modulation scheme is only one-dimensional, e.g., BPSK and GMSK. BIC is not applicable when the desired signal occupies two dimensions per transmitted symbol, e.g., QPSK and 16QAM. On the other hand, JD detects the interfering signals in addition to the desired signal. It can obtain very accurate reconstruction and mitigation of the interfering signals compared to BIC but at a cost of increasing complexity.

Joint maximum a posteriori (JMAP) produces a posteriori probability for each symbol, which can be exploited in the turbo code. In Chapter 3, a SAIC algorithm named sequential channel estimation-adaptive JMAP (SCE-AJMAP) is proposed. SCE-AJMAP sequentially estimates channel transfer functions at every received symbol. SCE-AJMAP decodes the desired and interfering data based on a joint trellis. The joint trellis is generated by combining the trellis of each convolutional encoder of the desired and interfering base stations. The sequentially updated channel estimates are used to update the joint trellis to track the rapid amplitude changes caused by fast fading channels. However, the calculation complexity of SCE-AJMAP depends on the constraint length of the encoder and channel length, which makes it impractical due to the prohibitive complexity.

Similar to JMAP, the time domain joint maximum likelihood sequence estimation (JMLSE) searches the joint trellis to find the most likely transmitted symbol sequence out of all the possible sequences by using the maximum likelihood criterion. The total number of states in the joint trellis depends on the total channel memory length and therefore, the computational complexity and processing delay can be prohibitive.

In Chapter 4, a frequency domain JMLSE algorithm named least mean square-blind JMLSE (LMS-BJMLSE) is proposed for OFDM systems. In OFDM, the channel transfer function for each subcarrier can be represented by a single complex coefficient and this leads to a low complexity algorithm, whose computational complexity is independent of the channel length. LMS-BJMLSE employs the least square estimation (LSE) for initial channel estimation of the desired signal and is blind with respect to the interfering signals. LMS-BJMLSE employs LMS for joint channel estimation and JMLSE for the joint symbol detection.

However, LMS-BJMLSE requires a long training sequence (TS) for channel estimation, which reduces the transmission efficiency. The reason is that JMLSE is very sensitive with respect to channel estimation errors. In order to solve this problem, a subcarrier identification and interpolation algorithm is proposed, in which the subcarriers are divided into small groups based on the channel’s coherence bandwidth, and the slowest converging subcarrier in each small group is identified by exploiting the correlation between the mean-square error (MSE) produced by LMS and the mean-square deviation (MSD) of the desired channel estimate. The identified poor channel estimate in each group is replaced by the interpolation result using the adjacent subcarriers’ channel estimates. Simulation results demonstrate that the proposed algorithm
can reduce the required training sequence dramatically for both the cases of single interference and dual interference. The work is also extended to the domain of receiver diversity, which provides a huge improvement in the BER performance.

Furthermore, despite the fact that the error probability of JMLSE is very critical for analyzing performance, to the best of our knowledge, its mathematical expression has not been derived for MQAM-OFDM yet. One way to compute the error probability is to condition on each of all the possible transmitted signal pairs and compute the probability that the received signal will cross a decision region boundary. This involves integrating a multi-dimensional Gaussian distribution that has no closed-form solution and the accuracy may be limited by the chosen numerical integration routine. Another way is to upper and lower bound the error probability with computable quantities. In Chapter 5, firstly, both the upper bound (UB) and the conventional lower bound (CLB) are derived based on a genie-aided receiver, which is originally developed for the BPSK modulation scheme. Secondly, in order to reduce the gap between CLB and the simulation results, a new tighter lower bound (TLB) is derived by replacing the genie with a less generous one. TLB is proved to be much tighter compared to CLB. Finally, those derived error probability bounds are generalized for the receiver diversity scheme and verified by simulation results.