Space-Time Codes for Diversity Enhancement in Wireless Communication Systems

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The great popularity of wireless communication devices as cellular phones and portable internet access demonstrates rising demand for these services. Further applications with an increasing demand on quality and higher data rates can be expected.

Unlike the Gaussian channel, the wireless channel is not only affected by noise but also by attenuation effects, the so called fading. If the transmitted signal suffers from strong attenuation, it is impossible for the receiver to determine the signal in an accurate manner. Thus it is desirable to provide the receiver more than one replica of the transmitted signal to increase the error-rate performance. This resource is known as diversity and is the most important technique to assure reliable wireless communication over fading channels. In addition to other techniques, diversity can be obtained by using multiple antennas in the transmitter or in the receiver. If these antennas are sufficiently separated in space, independent fading paths can be assumed.

In the presentation we consider a single user to user wireless link, where the transmitter has more than one transmitting antenna. An efficient approach to use antenna diversity in such an environment is to employ coding techniques appropriate to multiple transmit antennas, namely space-time coding. Space-Time Codes introduce temporal and spatial correlation into signals transmitted form different antennas, in order to provide diversity at the receiver, and coding gain over an uncoded system without impairing bandwidth efficiency.

There have been several proposals for space-time coding in the last years. We have observed two distinct coding schemes: Space-Time Trellis Codes (STTC) and Space-Time Block Codes (STBC).

STTC use several convolutional codes to achieve correlation in temporal and spatial dimension. The receiver performs a kind of maximum-likelihood sequence estimation, e.g. by means of a Viterbi algorithm, to decode the received signals. Hence possible code sequences are given by a trellis, coding gain is achieved. These codes have shown considerable performance gains for wireless communication at the expense of a rising decoding effort with increasing numbers of transmit antennas or trellis states.

To decrease decoding complexity STBC are a remarkable technique to utilize transmit diversity. On basis of Alamouti's scheme for two transmit antennas a more general block coding theory was developed in the last years. The scheme supports a maximum-likelihood detection based only on linear processing at the receiver and can easily established in existing systems. In contrast to STTC it generally does not provide coding gain but achieves also the full diversity promised by the number of transmit and receive antennas.

We present an introduction to space-time coding with respect to error rate performance and code construction. The basic structure of space-time block coding and trellis coding is explained by some code examples. Simulation results are provided to demonstrate the performance gains of both schemes.