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In order to access the viability of ultra-wideband communications for military applications, a framework for adccurately analyzing system performance is required. This research project addresses the need for a tractable, outdoor ultra-wideband (UWB) channel model which will provide the foundation for performance evaluation an and the examination of various design tradeoffs that exist at the physical layer. The other major thrusts of the research include channel estimation and error control coding which are essential to the successful realization of and implementation of UWB communication systems.

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In our research, supported on the above mentioned contract, various aspects of analyzing the performance of ultrawideband communication was considered. The performance of ultra-wideband (UWB) and large-bandwidth communication systems operating in slowly fading channels was examined for different receiver architectures, channel estimation techniques, and diversity combining schemes. Because of cost and complexity constraints, large-bandwidth systems employ suboptimal receivers which must attain sufficient energy capture without incurring significant combining loss from imperfect estimation or noncoherent reception. The performance of rake receivers with non-selective diversity combining and minimum linear mean-square (LMS) estimation or maximum likelihood (ML) estimation was evaluated for frequency-selective, Rician fading channels over a wide range of bandwidths. When the receiver is able to track and combine resolvable paths which contain a specular, or nonfading, component, the combining loss can be smaller than the case in which only diffuse resolvable paths are combined. The corresponding performance gap between these two cases for finite and infinite bandwidths depends upon the power of the specular components relative to the power of the diffuse channel components. The performance of reduced-complexity rake receivers, as well as autocorrelation receivers, was also examined for previously measured UWB indoor channels. Whereas rake receivers perform multiple correlations with a locally generated reference signal to exploit the multipath diversity present in the received signal, autocorrelation receivers simply employ a previously received signal as the reference signal and do not require any diversity combining schemes. The operation of an autocorrelation receiver which averages previously received reference signals to reduce the combining loss resembles a rake receiver with non-selective diversity combining and ML estimation. Furthermore, the combining loss associated with noncoherent reception can be offset by employing M-ary orthogonal modulation at the expense of reduced bandwidth efficiency. The asymptotic ($M \to \infty$) performance of M-ary orthogonal modulation with Reed-Solomon (RS) coding and diversity reception in multichannels, or multiple frequency-nonselective, slowly fading channels, is examined. The analysis indicates that coherent and noncoherent implementations of diversity combining schemes yield the same performance asymptotically. The results of the research conducted were published in various conference papers and journal articles listed below and a Ph.D. thesis by John Choi. Dr. Choi is now employed at MIT Lincoln Laboratory. Another topic investigated under this contract was characteerization of fading channels. In this work the performance of different communication systems under various channel conditions was investigated. We were able to determine, under suitable conditions, that the performance depnds on the channel characteristics via a single parameter we call the normalized mean square covariance. Using this parameter it is possible to roughly characterize the set of channels and determine roughly what performance could be expected using a modulation and coding technique. As a result, the performance of a communication system need only be investigated on a few select channels and then the performance of other channels can be determined by examining this parameter.

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