Single and multi-antenna MC-DS-CDMA with joint detection for broadband block-fading channels

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In the context of broadband wireless communications, using code division multiple access (CDMA), the main multiple access (MA) options include single-carrier direct sequence CDMA (SC-DS-CDMA) using time-domain direct sequence spreading, multicarrier CDMA (MC-CDMA) using frequency-domain spreading and multicarrier DS-CDMA (MC-DS-CDMA) using time-domain direct sequence spreading of the individual subcarrier signals.

Research conducted in the Department of Electrical, Electronic and Computer Engineering showed that MC-DS-CDMA has the highest degrees of freedom in the family of CDMA schemes that can be beneficially exploited during the system design and reconfiguration procedures. An amalgam of MC-CDMA and MC-DS-CDMA, known as time and frequency domain spreading (TF-domain spreading) MC-DS-CDMA, was proposed.

TF-domain spreading MC-DS-CDMA has several benefits over conventional MC-DS-CDMA with regard to both capacity and performance. However, in contrast to conventional MC-DS-CDMA, TF-domain spreading MC-DS-CDMA introduces multi-user interface (MUI), which necessitates the use of joint detection at the receiver. Recently, multiple input multiple output (MIMO) or multi-antenna TF-domain spreading MC-DS-CDMA schemes have been proposed that efficiently exploit both the spatial and frequency diversity available in MIMO frequency-selective channels.

Although an extensive amount of research has been done on single- and multi-antenna TF-domain spreading MC-DS-CDMA schemes that achieve both spatial and frequency diversity in frequency-selective slow fading channels, very little research considers the time selectivity of the wireless channels encountered. Thus, the abovementioned schemes may not be sufficiently efficient when communicating over wireless channels that exhibit both frequency-selective and time-selective fading. There are very few MC-DS-CDMA schemes that consider the time selectivity of the wireless channels encountered.

This study considered the design of single- and multi-antenna TF-domain spreading MC-DS-CDMA, for frequency-selective block-fading channels, which are capable of exploiting the full diversity available in the channel (i.e. spatial, frequency and temporal diversity), using various methods of joint detection at the receiver.

It was shown that the diversity gain in block-fading channels can be improved by coding across multiple fading blocks. Single-antenna TF-domain spreading MC-DS-CDMA was considered for the quasi-synchronous uplink channel, and multi-antenna TF-domain spreading MC-DS-CDMA was considered for the synchronous downlink channel. Numerous simulated bit error rate (BER) performance curves, obtained using a triply selective MIMO channel platform, were presented in this study using optimal and suboptimal joint detection algorithms at the receiver. In addition, this study investigated the impact of spatial correlation on the BER performance of the MC-DS-CDMA schemes considered.

From these simulated results, one would be able to conclude that TF-domain spreading MC-DS-CDMA that is designed for frequency-selective block-fading channels performs better than previously proposed schemes designed for frequency-selective slow-fading channels, owing to the additional temporal diversity exploited under the block-fading assumption.

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