

Editorial

Reliable Communications over Rapidly Time-Varying Channels

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Wireless communications have become an important part of everyday life. Think for instance about mobile telephone applications, wireless local area networks (WLANs), and wireless ad hoc networks. Most of these systems have been designed assuming that the channel can be regarded as constant over a block of data. Nonetheless market studies predict a rapid growth of high data rate mobile applications such as TV broadcast and video streaming and multiperson wireless gaming. In such mobile applications, Doppler shifts introduce temporal channel variations, which become more pronounced as the carrier frequency increases, and basically violate the time-invariance assumption. Further, with high mobility, terrain changes induce rapid changes in the channel response. As a result, many existing wireless systems can only provide low data rates at high mobility (e.g., UMTS) or even break down completely at high speeds (e.g., DVB-T and IEEE802.16).

This special issue therefore focuses on communications over rapidly time-varying channels, which cannot be viewed as time-invariant over a frame. It is intended to gather new and insightful results in this challenging research area that is gaining increasing attention due to its importance in future wireless applications.

Different models have recently been proposed to track time-varying channels, such as the basis expansion model (BEM) and the Gauss-Markov model (GMM). Such channel models can be used to efficiently estimate the unknown time-varying propagation channel. In the first two papers,

the authors rely on the complex exponential BEM to develop training-based and semiblind channel estimators. Tugnait et al. exploit superimposed pilots in the first paper, whereas Barhumi et al. exploit time-multiplexed pilots in the second paper. In the third paper by Misra et al., the GMM is considered, and optimal time-multiplexed training is discussed. Channel models like the BEM or the GMM are mainly aimed at modeling the short-term fading. Long-term fading is usually assumed to be constant, but can also be modeled as a stochastic process. This has been studied in the fourth paper by Olama et al. In addition, this paper presents power control strategies that are related to this new stochastic long-term fading channel model.

Serial time-varying equalizers can be adopted to equalize the time-varying channel. They can either be designed based on channel knowledge, or directly estimated by exploiting pilots. In the fifth paper, Tomasin proposes to equalize the time-varying channel by means of a bidirectional time-varying decision feedback equalizer (DFE), consisting of a time-invariant frequency-domain feedforward part and a time-varying time-domain feedback part. The method relies on a linear BEM model for the channel, and shows improved performance over time-invariant methods. If one models the channel by means of a complex exponential BEM, the complexity of equalizer design can often be reduced by structuring the equalizer also as a complex exponential BEM. Equalizer design in this context has been discussed in the second paper as well as in the sixth paper by

Verde. Another approach that can be taken is a so-called variable burst transmission approach, in which the burst size over which the channel is assumed to be constant is changed according to the variation of the channel. Assuming limited feedback from the receiver to the transmitter, one can then also adapt the modulation scheme from burst to burst, depending on the instantaneous signal-to-noise ratio. These are subjects studied in the seventh paper by Bui and Hatzinakos.

In multicarrier transmissions, fast time-variations destroy the orthogonality among carriers and introduce what is known as intercarrier interference (ICI). Simulations show that the ICI is generally limited to neighboring carriers, a feature that can be enforced by appropriate time-domain windowing techniques. Exploiting this property, low-complexity equalization schemes have been developed by Hwang and Schniter in the eighth paper and by Rugini et al. in the ninth paper. Both papers also present training-based channel estimation algorithms exploiting frequency/time-multiplexed pilots. The tenth paper by Mallik and Koetter proposes a generalized multicarrier scheme for time-varying channels with modulating and demodulating functions that are localized in time and frequency. In addition, this paper presents multilevel codes matched to the new modulation scheme.

Multiantenna systems, also known as multiple-input multiple-output (MIMO) systems, have been shown to significantly increase the data rate and/or the performance of a wireless communications system through the use of appropriate coding. However, channel estimation (and thus also data detection) is far more complicated in a MIMO system than in a traditional single-input single-output (SISO) system, and this is accentuated when time-varying channels are involved. That is why channel estimation and data detection over fast fading MIMO channels will become a severe problem in future wireless systems. In this special issue, a few papers already deal with this problem. In the eleventh paper, Şenol et al. propose a training-based channel estimator for space-time and space-frequency coded MIMO multicarrier systems exploiting frequency/time-multiplexed pilots. Note though that in contrast with the multicarrier papers mentioned above, the channel here is assumed to change from multicarrier symbol to multicarrier symbol and to be static within a symbol, that is, no ICI is assumed. Further, Mikhael and Yang propose a purely blind MIMO channel tracker based on independent component analysis (ICA) in the twelfth paper. Finally, a semiblind iterative joint channel estimation and data detection approach for MIMO channels exploiting error-correcting codes and time-multiplexed pilots is presented in the thirteenth paper by Simoens and Moeneclaey. A related approach has been introduced by Schoeneich and Hoehner in the fourteenth paper, but in the context of a code-division multiplexing/multiple-access system. To keep track of the channel, this method relies on error-correcting codes as well as on code-multiplexed pilots.

To conclude, this special issue gives a partial update of the state-of-the-art in the field of wireless communications

over rapidly time-varying channels. We hope that the presented results will enable interesting new ways to enjoy the benefits of wireless communications, and that the remaining open problems will inspire researchers to continue or start working in this exciting research area.

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