EDITORIAL

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Special issue on broadband mobile communications at very high speeds

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Future mobile communication systems aim at providing very high-speed data transmission, even under very high mobility scenarios such as high speed wheel-track trains (up to 574.8 km/h test speed or 380 km/h commercial speed), maglev trains (up to 581 km/h test speed or 431 km/h commercial speed), airplanes (about 400-1000 km/h commercial speed), guided missiles (about 980–20,000 km/h) or spacecraft (at least 28,440 km/h to remain on an earth orbit, at least 40,320 km/h to leave earth). A related and particularly important commercial application is the strong worldwide increasing demand for broadband wireless communications in high speed railways to provide information and onboard entertainment services to passengers, train control, train dispatch, train sensor status transmission, video surveillance, *etc.*

Consequently, increasing demand on data rates to support broadband high speed communication systems in the presence of frequency selective fading channels with very high mobilities has resulted in research on designing computationally efficient yet faster new algorithms for channel estimation, equalization and detection, as well as fast handover, location update, modeling of rapidly time-varying channels, fast power control and dedicated network architectures, etc. Orthogonal frequency-division multiplexing (OFDM) is becoming a backbone structure of such systems, being standardized as the IEEE's 802.16 family - better known as Mobile Worldwide Interoperability Microwave Systems for Next-Generation Wireless Communication Systems (WiMAX) - and by the Third-Generation Partnership Project (3GPP) in the form of its Long-Term Evolution (LTE) project. Both systems employ orthogonal frequency division multiplexing/multiple access (OFDMA) as well as a new single-carrier frequency-division multiple access (SC-FDMA) format. To promote the IEEE 802.16 standards, recently, a high mobility feature has been introduced (IEEE 802.16 m) to enable mobile broadband

services at vehicular speeds beyond 120 km/h. Since the signal transmission under very high speed scenarios will inevitably experience serious deterioration, it is imperative to develop key broadband mobile communication techniques for such very high speed vehicles.

This special issue aims at putting together the major achievements and developments in this field. There are 18 papers in this special issue, which have been organized into three thematic groups. The first group of five papers deal with the rapidly time-varying channel modeling and estimation, the next group of seven papers address data transmission under high mobility scenarios, and the last group of six papers are related to fast handover schemes, location prediction, etc.

Among the five papers dealing with channel modeling and estimation, two papers are concerned with channel estimation methods, namely, "Doubly Selective Channel Estimation for Orthogonal Frequency Division Multiplexing (OFDM) Modulated Amplify-and-Forward Relay Networks Using Superimposed Training" (Zhang Han), and "Channel Estimation in OFDM Systems Operating under High Mobility Using a Wiener Filter Combined with a Basis Expansion Model" (Ke Zhong, *et al.*). The former proposes a novel superimposed training (ST) strategy that allows the destination node to separately obtain the channel information of the source-relay link and the relay-destination link, from which the optimal ST signals are derived by minimizing the channel mean-square-error; and the latter proposes to combine the Wiener filter (WF) with a basis expansion model (BEM) to deal with channel estimation in various mobile environments, especially in high speed cases. The third paper, "A Highly Efficient Channel Sounding Method Based on Cellular Communications for High-Speed Railway Scenarios" (Liu Liu, et al.), proposes an efficient channel sounding method based on a channel data recorder, by making use of the real time-dispersive channel measurements conducted along Zhengzhou-Xi'an (ZX) and Beijing-Tianjin (BT) high speed railways. The fourth paper, "Iterative Equalization for OFDM Systems over Wideband MSML Channels" (Tao Xu et al.), seeks to quantify the

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amount of interference resulting from wideband OFDM channels, which are assumed to follow the multi-scale multi-lag (MSML) model, then a conjugate gradient (CG) algorithm is used to equalize the channel iteratively. In the last paper of this group,"Frequency Tracking by the Method of Least Squares Combined with Channel Estimation for OFDM over Mobile Wireless Channels" (Rainfield Y Yen, et al.), rather than a common maximum-likelihood (ML) frequency tracking algorithm, least squares (LS) using repeated OFDM training blocks is employed which requires no channel knowledge, and can not only circumvent complications of ML estimation, but also obviates the need for the lengthy adaptive iteration process of joint estimation.

Concerning the seven papers related to the topic of data transmission under high mobility scenarios, the first paper, "Effect of Power and Rate Adaptation on the Spectral Efficiency of an MQAM/OFDM System under Very Fast Fading Channels" (Zhicheng Dong, et al.), proposes an adaptive MQAM/OFDM system under fast fading channels, resulting in substantial gains in spectral efficiency over the non-adaptive counterparts with perfect channel state information (CSI) or moderately imperfect CSI, and derives lower bounds on the maximum spectral efficiency and a closed-form expression for the average spectral efficiency of the proposed adaptive OFDM system. In the paper "Optimal Pilot Symbol Power Allocation under Time-variant Channels" (Michal Simko, et al.), the issue of how to distribute available power between data symbols and pilot symbols over time-varying channels is considered in order to maximize the overall throughput by choosing the post-equalization signal-to-interference-plus-noise ratio (SINR) as the cost function. As a non-coherent transmission scheme that does not require CSI at either transmitters or receivers, unitary space-time modulation is a promising technique that can be applied in high mobility scenarios where the fading channel parameters are changing too rapidly to be tracked and estimated, which is the emphasis of the paper "Multi-cell Cooperative Transmission Based on Unitary Space-time Modulation" (Heng Liu, et al.). The next paper, "Successive Interference Cancellation and MAP Decoding for Mobile MIMO OFDM Systems and Their Convergence Behavior" (Vamadevan Namboodiri, et al.). presents a suboptimal, successive interference cancellation (SIC) method based on maximum a posteriori probability (MAP) decoding over doubly dispersive channels for OFDM MIMO systems. With the appropriate use of the network topology, predictable location and speed information, Opportunistic beamforming (OBF) with dumb antennas, which does not require channel feedback, is useful for high speed railway applications. In the paper "Location Information-assisted Opportunistic Beamforming in LTE Systems for High-speed Railway" (Meng Cheng, et al.), two algorithms that can improve OBF system performance significantly are presented.

The sixth paper, "On the Applicability of Steerable Beams in LTE-Advanced Networks with High User Mobility" (Christos Papathanasiou, et al.), deals with the problem of applying scanning narrow beams to LTE-Advanced networks with fast moving mobiles, aiming at providing low complexity hardware implementation and low power consumption. The last paper in this group, "Realizing Broadband Wireless Communication for High Speed Trains" (Qinglin Luo, et al.), proposes a novel cloud-based high speed train communication (C-HSTC) system framework, featuring a new virtualized single cell design that mitigates the impact of conventional handover failure and guarantees continuous services. In conjunction with this design it also proposes a highly efficient joint transmit beamforming algorithm targeted at compensating the inter-carrier interference (ICI) caused by Doppler frequency shift due to mobility.

The six remaining papers deal with several fast handover schemes and other topics. The paper "A CoMP Soft Handover Scheme for LTE Systems in High Speed Railway" (Wantuan Luo, et al.), proposes an optimized handover scheme, in which the coordinated multiple point transmission technology and dual vehicle station coordination mechanism are applied to improve the traditional hard handover performance of LTE. In networks with highly mobile users, the inter-relay handoffs can occur very frequently, thus the paper "Inter-relay Handoff in Two-hop Relaying Networks with Highly Mobile Vehicles" (Di Wu, et al.), studies the inter-relay handoff decision problem in a two-hop cellular network with highly mobile vehicles using a semi-Markov decision process (SMDP) and taking into consideration speed and other factors. The next paper, "The Cross Layer RMPA Handover: A Reliable Mobility Pattern Aware Handover Strategy for Broadband Wireless Communications in the High Speed Railway Domain" (Marina Aguado, et al.), proposes an improved handover strategy for railway applications, the RMPA handover, an IEEE 802.16 handover strategy but specially "customized" and enhanced for high speed mobility scenarios. As transport layer (L4 in ISO layers) protocols such as stream control transmission protocols can support seamless handover in high-speed mobility scenarios, the paper "Adaptive Transport Layer Protocol for Highly Dynamic Environments" (Hala Eldaw Idris Jubara, et al.), discusses an adaptive transport layer protocol in mobile WiMAX networks supporting seamless handover and guaranteeing quality-of-service (QoS) for rapid handover rates. The last two papers deal with location prediction and connectivity analysis in high speed vehicular ad-hoc networks (VANETs). In particular, the paper "A Novel Vehicular Location Prediction Based on Mobility Patterns for Routing in Urban VANETs" (Guangtao Xue, et al.), proposes a novel approach by adopting a variable-order Markov model to abstract vehicular

mobility pattern (VMP) from real trace data in Shanghai for predicting the possible trajectories of moving vehicles. To handle the rapidly moving inter-vehicle information exchange within limited radio ranges and self-organize VANETs, the last paper, "Available Connectivity Analysis under Free Flow State in VANETs" (Chen Chen, et al.), is concerned with the connectivity issue, both one-hop direct connectivity and multi-hop indirect connectivity by defining a new metric termed "available connectivity".

Competing interests

The authors declare that they have no competing interests.

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