

# Editorial

## Special Section on Relay Communications

**T**HE RELAY channel was first introduced by van der Meulen in 1971 and later analyzed by Cover and Gamal in 1979. In particular, they determined the capacity region for the physically degraded version of the relay channel. Recently, the relay has received much attention, as it is an effective technique to provide cooperative diversity and range extension. Research topics include bidirectional two-way relaying, relay scheduling, multi-antenna relaying, and many others. The relay has also been adopted by many international communications standards, such as IEEE 802.16j and the Third-Generation Partnership Project-Long Term Evolution (3GPP-LTE). This Special Section consists of ten papers that cover various aspects of relay communications.

We next briefly introduce the papers in this Special Section. The first two papers deal with the amplify-and-forward relay strategy. Yang *et al.* evaluate the performance of downlink multiuser relay networks in the paper entitled “Outage Probability of Multiuser Relay Networks in Nakagami-*m* Fading Channels.” They provide new results for channel-state-information-based gain relaying and fixed-gain relaying for a single amplify-and-forward relay. They also study the impact of the relay location on the system performance and develop a design criterion for the relay placement. In the other paper, entitled “Improving Achievable Rates in MPSK Amplify-and-Forward Relay Networks via Clipping,” Zhang *et al.* propose to employ clipping to improve the achievable rates for M-ary phase shift keying amplify-and-forward cooperative communications.

In the cases that there are multiple relays, the problem of relay selection becomes important. In the paper entitled “Joint Opportunistic Subchannel and Power Scheduling for Relay-Based OFDMA Networks with Scheduling at Relay Stations,” Kim and Lee suggest that, if the opportunistic scheduling is allowed not only at the base station but also at each relay station, more efficient radio resource allocation is possible. They develop a joint opportunistic subchannel and power-scheduling algorithm for orthogonal frequency-division multiple access (OFDMA) transmissions at both base station and relay station. Next, in the paper entitled “Distributed Optimal Relay Selection in Wireless Cooperative Networks with Finite State Markov Channels,” Wei *et al.* consider finite state Markov channels in a distributed relay-selection problem. They design a relay-selection policy that has an indexability property, which dramatically reduces the on-line computation and implementation complexity. Zhou and Lau, in the paper entitled “Performance Bounds of Opportunistic Cooperative Communications with CSI-assisted Amplify-and-Forward Relaying and MRC

Reception,” derive upper and lower performance bounds, including outage probability, ergodic achievable rate, and average symbol error rate for CSI-assisted amplify-and-forward cooperative networks that select the best relay to carry out the relay transmission.

Next, two papers apply the hierarchical modulation in relay communications. In the paper entitled “Signal Transmission with Unequal Error Protection in Wireless Relay Networks,” Nguyen *et al.* use hierarchical amplitude shift keying modulation to provide different protection to different classes of information. They find optimal thresholds to minimize the bit error rate (BER) for the less-protection class, while the BER of the more-protection class satisfies a given requirement. Park *et al.*, in their paper entitled “Hierarchically Modulated Network Coding for Asymmetric Two-way Relay Systems,” propose a scheme called hierarchically modulated network coding to combine hierarchical modulation and network coding, aiming to achieve spectral efficiency using network coding and to remedy the asymmetric relay problem using hierarchical modulation.

The IEEE 802.16j standard has been developed to provide performance enhancement to the existing IEEE 802.16e network by incorporating the multihop relay technology. In this section, three papers investigate the application of the relay in communication standards. In the paper entitled “Handoff Minimization through a Relay Station Grouping Algorithm with Efficient Radio Resource Scheduling Policies for IEEE 802.16j Multihop Relay Networks,” Yang *et al.* design a relay grouping algorithm to minimize handoffs by utilizing a greedy grouping policy. They also propose two centralized scheduling policies, one to maximize the system throughput and the other to minimize the average packet delay. Ge *et al.* study vehicle-to-infrastructure communications in the paper entitled “Optimal Relay Selection in IEEE 802.16j Multihop Relay Vehicular Networks.” They solve for the optimal relay locations that guarantee maximal end-to-end capacity to a vehicular subscriber station. Rong and Hafid study the support of reliable multicast using cooperative communications for the deployment of mobile internet protocol television service in wireless mesh networks in the paper entitled “Cooperative Multicast for Mobile IPTV over Wireless Mesh Networks: The Relay Selection Study.”

CHAU YUEN, *Associate Editor*  
Institute for Infocomm Research  
Singapore 138632



**Chau Yuen** received Ph.D. degree from Nanyang Technological University, Singapore, in 2004.

He was with Lucent Technologies Bell Labs, Murray Hill, NJ, during 2005. On 2008, he was with Hong Kong Polytechnic University, Kowloon, Hong Kong, as a Visiting Assistant Professor. He is currently a senior research engineer with the Institute for Infocomm Research, Singapore.

Dr. Yuen is an Associate Editor of the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY.