Advances in Satellite Communications Part 2: Guest Editorial

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I. Introduction

THIS special issue is devoted to the satellite communications (SatCom) advances so as to gather the most important contributions in this field from academia and industry. In particular, the importance of this issue is also due to the fact that the last issue appearing on IEEE JSAC about SatCom is dated back to 2004 and therefore many important technology advances have been testified in the meantime, actually revolutionizing the satellite industry. In particular, important innovations have been brought to the design of both ground and space segments, spanning physical layers up to upper layers of the protocol stack.

In the introduction of this second part, we highlight several more technological advancements. One such advancement pertains to the efforts by researchers worldwide toward attaining the goal of massive throughput for satellite broadband and broadcasting applications. This is achieved by maximizing the utilization of satellite resources on many levels, including payload mass efficiency [1]. More specifically, a single transponder is used to relay multiple carriers that employ high-order modulation with strong forward error-correction codes from DVB-S2/DVB-S2X. Multicarrier nonlinear solutions are thus developed [1]–[3] so that the on-board high-power amplifier is operated near saturation for maximum power efficiency. Multicarrier satellite operation is exploited as part of a comprehensive design of next-generation medium-earth orbit (MEO) satellite constellation [4] that uses extremely high-frequency Q/V band or even optical wavelengths.

Faster-than-Nyquist transmission additionally increases the spectral efficiency of SatCom systems [5], [6], for which receivers are designed to substantially mitigate the controlled distortion over realistic nonlinear satellite channels.

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Digital Object Identifier 10.1109/JSAC.2018.2848378

Another advancement intended to address the satellite spectrum scarcity problem is via the application of cognitive communications [7], wherein suitable cognitive techniques are developed to support spectral co-existence of satellite and terrestrial networks. Moreover, advancement in multiuser precoding [8], applied at the gateway and optimized for broadband multibeam satellite systems, is fulfilling the aggressive reuse of user-link frequency resources. Furthermore, compensation for forward-link multibeam co-channel interference can be effectively achieved at the user-terminal side [9] by adopting direct-sequence code-division multiplexing schemes along with de-centralized multiuser detection.

In line with the aforementioned satellite technology advances supported by both academia and industry, the present IEEE JSAC Special Issue comprehensively illustrates the main trends and the expected evolutions of the satellite ecosystem, providing an exhaustive summary of the main research activities and the most relevant results achieved in the last five years.

Given the large number of accepted papers, the special issue has been subdivided into two parts, the second one being reported in this issue. In the following section, a short overview of each paper being accepted is given, classified according to the main paper scope: Precoding and multicast, cognitive satellite communications, networking, and Other (including three papers dealing with mission scheduling, LEO optical downlink and rainfall estimation, respectively).

II. Summary of Accepted Papers

A. Precoding and Multicast

The paper "Precoding, scheduling and link adaptation in mobile interactive multibeam satellite systems," by M. A. Vasquez *et al.*, deals with the problem of precoding, scheduling and link adaptation in next-generation mobile interactive multibeam satellite systems, providing a framework for the performance evaluation when, due to the time-varying mobile channel, the precoding subsystem can only rely on a delayed version of the channel state information (CSI). The analysis and the numerical simulations in realistic conditions, show that precoding can offer an attractive gain in the system throughput compared to conservative frequency reuse allocations and that, in contrast to general multiuser multiple-input-multiple-output terrestrial systems, the CSI degradation in multibeam mobile applications has a very limited impact for typical fading channel and system configurations.

The paper "Cooperative multigroup multicast transmission in integrated terrestrial-satellite networks," by X. Zhu *et al.*, investigates the downlink multigroup multicast transmission in an integrated satellite-terrestrial network, in which base-stations and the satellite cooperate to provide the multicast service by using the entire bandwidth. The proposed approach for system optimization takes into account beamforming, quality of service, and operator revenue maximization problems. Numerical results are reported to evaluate the cooperative multicast schemes as well as the proposed pricing strategy.

The paper "Two-color scheme for a multi-beam satellite return link: impact of interference coordination," by Y. Couble *et al.*, addresses the return-link radio resource allocation challenges, from spectral resource allocation to user scheduling including modulation and coding scheme (MODCOD) selection. The authors propose a coordinated MODCOD selection process that alleviates the need for estimating interference and reduces drastically the number of decoding failures. A joint user scheduling and MODCOD selection problem across all beams is also formulated and solved through a heuristic approach obtaining gains up to 77% with respect to state-of-the-art implementations.

The paper "Joint coding and multicast subgrouping over satellite-eMBMS networks," by G. Araniti *et al.*, considers the problem of multicast satellite transmission for live video streaming (LVS) in land mobile satellite (LMS) channels and presents the combined use of multicast resource allocation schemes and application layer joint coding to enhance the performance of LVS. The performance assessment, carried out by considering a satellite-based long-term evolution (S-LTE) forward link, shows that the proposed technique allows high-throughput transmissions with satisfactory user quality-of-experience over different satellite channel propagation environments.

B. Cognitive Satellite Communications

The paper "Joint beamforming for secure communication in cognitive satellite terrestrial networks," by M. Min *et al.*, investigates secure communications in a cognitive satellite-terrestrial network with a software-defined architecture, in the presence of eavesdroppers on the satellite channel, and frequency sharing between the satellite and terrestrial segments. Simulation results demonstrate the effectiveness of the proposed beamforming schemes obtained as solutions of an optimization problem.

The paper "Multi-objective reinforcement learning for cognitive SatCom using deep neural network ensembles," by P. V. R. Ferreira *et al.*, addresses the challenging problem of software-defined radios controlled by artificial-intelligence algorithms, by proposing a novel radio resource allocation algorithm leveraging multi-objective reinforcement learning and artificial neural-network ensembles. Simulation results are presented to show the performance of the proposed solution for different communication mission profiles and error benchmarks.

C. Networking

The paper "Modeling reliable M2M/IoT traffic over random access satellite links in non-saturated conditions," by M. Bacco *et al.*, presents a framework to analyze the stability of random access-based satellite channels under the application of IoT traffic. A key consideration aspect of the paper is that it considers the use of the CoAP protocol, which implements an ARQ strategy and a TFRC-like approach to control the sending rate. The paper focuses on the interaction between the random-access scheme and the CoAP protocol, shedding some light on the related design implications.

The paper "Analytical framework for effect of link disruption on bundle protocol in deep-space communications," by S. Burleigh *et al.*, deals with the usage of the DTN protocol architecture in a deep-space environment, putting particular emphasis on the impact of link disruptions on the performance of the bundle protocol. Particularly relevant is the theoretical model worked out by the authors to take into consideration the different cases in which link disruption can occur during the transmission of a sequence of bundles.

The paper "Elastic reliability of video transfer over lossy satellite links," by X. Li *et al.*, proposes a retransmission scheme as an alternative to TCP and UDP strategies for video streaming. These latter can cause either excessive delay penalties upon recovery procedure initiation or unreliable data delivery. The design is performed on the basis of prediction schemes applied to track the oscillations of the channel and therefore tune the quality of the video being transmitted.

D. Other

The paper "Channel-aware mission scheduling in broadband data relay satellite networks," by D. Zhou *et al.*, deals with resource allocation in data-relay satellite systems, with particular attention on power allocation. The formulated problem assumes quite some importance in the context of future constellations systems and it is approached by means of a mixed-integer nonlinear program (MINLP), which is eventually decomposed into two optimization problems that lose the nonlinearity characteristics and therefore become tractable.

The paper "Centralized rainfall estimation using carrier-to-noise of satellite communication links," by A. Gharanjik *et al.*, discusses a real-time method for centralized rainfall estimation using carrier-to-noise power ratio (C/N) measurements from broadband satellite communication networks. In particular, a machine-learning algorithm based on neural networks is applied to estimate rainfall. The algorithm distinguishes between dry and rain events with high accuracy.

The paper "Performance estimation of optical LEO downlinks," by C. Fuchs *et al.*, addresses the use of free-space optical downlinks to provide users with high data rates, by analyzing the network design implications in terms of number of ground stations and related geographical location. The paper focuses in particular on the feasibility of the full-free space optical networking concept against its well-known RF-based counterpart, by taking advantage of a large cloud-set database to properly dimension links and hence carry out proper dimensioning of the system.

ACKNOWLEDGMENT

We would like to thank all the authors who submitted their valuable contributions to this special issue. They provided both the reviewers and the editors with a full picture of the most appealing advances in satellite communications, with particular emphasis on the new technologies that are expected to play a pivotal role in the next decade. We like also to thank the reviewers who provided thorough and timely reviews, hence contributing to the success of this special issue. Finally special thanks go to Prof. Muriel Medard, IEEE JSAC Editor-in-Chief, and Laurel Greenidge, Executive Editor, for their support in the preparation of this special issue and the continuous assistance in the various phases of the special-issue review and paper acceptance.

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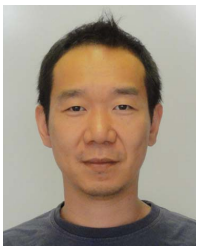

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