Guest Editorial of the Special Issue on IEEE WiSEE 2023 Conference

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THE IEEE JOURNAL OF RADIO FREQUENCY IDENTIFICATION (JRFID) has the pleasure to host a Special Issue collecting extended versions of papers coming from the 11th IEEE International Conference on Wireless for Space and Extreme Environments (WiSEE), sponsored by the IEEE CRFID. WiSEE 2023 was held in Aveiro, Portugal, on September 6-8, 2023 and was co-located with the the 13th edition of the IEEE RFID-TA Conference, sharing part of the sessions and the keynote speakers in common areas of interest.

WiSEE was an in-person event aimed at sharing the latest results in terms of integration of advanced methodologies and innovative frameworks in the ever-evolving landscape of space communications and related activities. The rich conference program was a suitable combination of regular sessions and 4 full-day workshops on Space Terrestrial InterNetworks (STINT), Space Solar Power (SSP), Non-terrestrial Networks for 6G Systems (NTN6G) and Glue Tech for Extreme Application Scenarios (GTEAS).

Three outstanding keynote speakers distinguished each day of the conference: Jasmin Grosinger presented solutions for Space Tags; Harry Shaw discussed opportunities and challenges for future interoperability and international cooperation in space communications; and Vartan Piroumian proposed perspectives for Digital Twins in Space and Extreme Environments.

This special issue of our journal highlights significant contributions across space-related areas such as Delay Tolerant Networks, optical wireless communications, and space technologies, such as in-space energy harvesting and in-space measurements and 3D-objects reconstruction.

Delay Tolerant Networks are becoming increasingly vital as the complexity and scale of space missions grow. However, there remains significant potential for development in certain areas to ensure robust, efficient, and secure communications. The work in [A1] focuses on enhancing the Quality of Service (QoS) and enable quasi-real-time communications in DTNs through traffic prioritization. This approach leverages a three-state Markov Chain model to realistically simulate the channel between Earth and the Moon, demonstrating that traffic prioritization can significantly improve the timeliness of high-priority bundles, crucial for quasi-real-time communications in upcoming lunar missions. The study proposes a priority grid highlighting the need for a common policy for DTN nodes, ensuring interoperability across different space communication networks.

In the realm of efficient routing within DTNs, the research in [A2] presents a cognitive routing strategy aimed at optimizing energy management. By employing a reinforcement learning approach, this strategy minimizes latency and extends the operational lifetime of nodes. The study details the implementation within the High-Rate Delay Tolerant Networking (HDTN) framework, showcasing substantial reductions in bundle losses and improved network reliability. This cognitive routing method, which balances delay and

energy consumption, is a significant step forward in maintaining robust communications in challenging space environments.

The work in [A3] addresses the critical issue of security within DTNs, particularly as space information networks become more heterogeneous. The paper explores the adoption of Bundle Protocol Security (BPSec) to safeguard these networks, proposing adaptable security models that evolve based on traffic conditions and node knowledge. This holistic approach to security within DTNs highlights the protocol's flexibility and underscores the need for comprehensive security policies in space communication infrastructures.

In the same area [A4], is dedicated to the extensive description of an open source Bundle Protocol for DTN to be integrated with a wide ecosystem, including DTNsuite, and provides example of applications demonstrating a strong interoperability of the proposed solution.

As heterogeneity and interoperability emerge as foreseeable challenges, the contribution in [A5] centers on demonstrating the practical application of DTNs through in-orbit validation and end-to-end simulation. The paper describes two demonstration activities conducted using the ESA Ground Segment, which include interoperability testing across multiple space agencies and partners. These demonstrations highlight the readiness of DTN technologies for broader adoption and offer valuable insights into operational requirements and coordination within multi-agency environments.

[A6] addresses the need for autonomy in deep-space exploration and proposes Trajectory-Aware Extended Kalman Filter (TA-EKF) designs for orbit determination (OD) using Global Navigation Satellite System (GNSS) data. These solutions aim to support GNSS at high altitudes where the signal is particularly weak and integrate its operations by either aiding observations in the observation domain, or state prediction errors due to mis-specified process dynamics.

In the field of exploitation of technologies for in-space operations and for future sustainability of large deployment of small and nano satellites in the LEO and VLEO, the study in [A7] presents a high-speed Optical Wireless Communication (OWCT). This work highlights the potential of OWCT systems to enhance data transmission capabilities in space. The system operates at 1 Gbit/s over a directed optical link within a 3U CubeSat, utilizing a Vertical Cavity Surface Emitting Laser (VCSEL) and a PIN Photo-Diode (PD) for transmission and reception, respectively. OWTC is tested under conditions simulating the rigors of space missions, including mechanical vibrations, temperature variations, and radiation exposure, and robust performance and suitability for Low Earth Orbit (LEO) missions are demonstrated.

In the field of sustainability of space technologies, especially in LEO and Very Low Earth Orbit (VLEO) , where the number of new launches will grow exponentially in the coming years, [A8] introduces the design and fabrication by additive manufacturing, of optically transparent meshed patch antenna

arrays to be co-located with photovoltaic (PV) panels. This architecture is foreseen to be exploited in future swarm of small satellites for collaborative energy exchange with the goal of maintaining optimal solar power production, and of minimizing the Sats area. A network of energy exchange among satellites, exploiting high-efficiency energy conversion, is proposed to enhance and extend their lifetime.

Machine learning approaches are applied in the groundbreaking field of 3D objects reconstruction and for automated Monitoring. [A9] introduces a high-performance learning-based frameworks for monocular 3D point cloud reconstruction. Two main frameworks are proposed, Fast-Image2Point (FI2P), based on a CNN-based autoencoder, and TransCNN3D, a transformer-based network, leverage deep learning techniques to achieve real-time 3D object reconstruction from single-view images. FI2P offers a rapid reconstruction capability, while TransCNN3D provides superior accuracy without compromising computational efficiency. This research addresses a key challenge in 3D reconstruction applications, providing scalable solutions for real-time data processing in various space and vehicular applications, such as space-based surveillance systems. and autonomous navigation, to name a few.

[A10] proposes a predictive model of microchannel plate (MCP) current for Fast Plasma Investigation (FPI), to autonomously monitor the MCP currents. The predictive model is based on the combination of a physically informed model of MCP resistance with an empirically-derived model of FPI instrument temperature, enabling accurate detection of current anomalies.

In closing, we would like to express our appreciation to all the authors contributing to this IEEE JOURNAL OF RADIO FREQUENCY IDENTIFICATION Special Issue. The works included in this issue not only address current challenges but also pave the way for future developments of in-space infrastructures.

We look forward to the next edition of the IEEE WiSEE series, which will be held in Daytona, USA, on December 16-18, 2024 (https://attend.ieee.org/wisee-2024/).

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