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EDITORIAL

IEEE ACCESS SPECIAL SECTION: INTERNET of SPACE: NETWORKING ARCHITECTURES AND PROTOCOLS to SUPPORT SPACE-BASED INTERNET SERVICES

This Special Section focused on gathering the most recent scientific research and insights on the evolution of communication architectures and protocols able to boost the creation of a truly global internet by means of the integration of the current internet with a new *Internet of Space*; how to support the operation of Tier-1, Tier-2, or even Tier-3 airborne/spaceborne networks; how to address interoperability, within and across different protocol layers in the network architecture, leveraging cross-layer design; and finally how to design a more unified next-generation internet architecture able to transparently include spaceborne and airborne platforms in a way that allows for user-centric services, and a smooth operation of transient networks.

In total, 30 articles were submitted to the Special Section, nine of which were accepted. The articles cover a wide range of topics, from scheduling aspects to multi-layer networking architectures.

In [A1], Al-Hraishawi *et al.* propose a multi-layer multi-orbit space information network to provide high-speed continuous broadband connectivity for space missions (nanosatellite terminals) from the emerging space-based internet providers.

In [A2], Wang *et al.* propose an expanded-field search (EFS) algorithm for software-defined satellite networks, which improves existing algorithms significantly in terms of latency (run time) and memory (storage compression).

In [A3], Priyadarshini *et al*. describe an overall architecture for the Internet of Space Things (IoST), compatible with current IoT-based services.

In [A4], Afhamisis and Palattella propose SALSA, a novel TDMA-based scheduling algorithm for LoRa to LEO satellite constellations.

In [A5], Schubert *et al*. present, i.e., network simulator v3 modules for network mobility and link characteristics of Low Earth Orbit (LEO) satellite mega- constellations.

In [A6], Wang *et al*. propose a network capacity analysis framework for LEO mega-constellations with a basis on link packet loss rate.

In [A7], Kumar *et al*. debate multi-access computing (MEC) based video on demand (VoD) services across satellite and terrestrial integrated 5G networks.

In [A8], Li *et al*. present a survey on laser communications ranging from terminal, link, and architectures.

In [A9], De Rango and Tropea propose a bundle management layer that can be coupled to routing approaches for InterPlanetary Networks or Delay Tolerant Networks. The authors show that the proposed approach brings significant improvements in terms of delivery time when applied to Earliest Arrival Optimal Delivery Ratio (EAODR) routing.

The Guest Editors hope that this Special Section will benefit the scientific community and contribute to the knowledge base for the next-generation internet, where satellite-based networks are becoming an integrated part of the internet infrastructure. The Guest Editors would like to take this opportunity to applaud the contributions of the authors to this Special Section.

Rute C. Sofia, *Lead Editor*
fortiss GmbH
80805 Munich, Germany

Paulo Mendes, *Guest Editor*
Airbus
21129 Hamburg, Germany

Vassilis Tsaoussidis, *Guest Editor*
Democritus University of Thrace
69100 Komotini, Greece

Tomaso de Cola, *Guest Editor*
DLR
51147 Cologne, Germany

Scott Burleigh, *Guest Editor*
California Institute of Technology
Pasadena, CA 91125, USA

Mianxiong Dong, *Guest Editor*
Muroran Institute of Technology
Muroran 050-8585, Japan

Eduardo Cerqueira, *Guest Editor*
Federal University of Para
Belém 66075-110, Brazil

APPENDIX: RELATED ARTICLES

[A1] H. Al-Hraishawi, M. Minardi, H. Chougrani, O. Kodheli, J. F. M. Montoya, and S. Chatzinotas, "Multi-layer space information networks: Access design and softwarization," *IEEE Access*, vol. 9, pp. 158587–158598, 2021.

[A2] S. Wang, K. Liu, C. Jiang, J. Yan, and L. Kuang, "EFS: Efficient storage optimization for multistage flow-table in software-defined satellite network," *IEEE Access*, vol. 10, pp. 391–400, 2021.

[A3] I. Priyadarshini, B. Bhola, R. Kumar, and C. So-In, "A novel cloud architecture for Internet of Space Things (IoST)," *IEEE Access*, vol. 10, pp. 15118–15134, 2022.

[A4] M. Afhamisis and M. R. Palattella, "SALSA: A scheduling algorithm for LoRa to LEO satellites," *IEEE Access*, vol. 10, pp. 11608–11615, 2022.

[A5] T. Schubert, L. Wolf, and U. Kulau, "ns-3-leo: Evaluation tool for satellite swarm communication protocols," *IEEE Access*, vol. 10, pp. 11527–11537, 2022.

[A6] N. Wang, L. Liu, Z. Qin, B. Liang, and D. Chen, "Capacity analysis of LEO mega-constellation networks," *IEEE Access*, vol. 10, pp. 18420–18433, 2022.

[A7] S. Kumar, N. Wang, Y. Rahulan, and B. Evans, "Edge computing-based layered video streaming over integrated satellite and terrestrial 5G networks," *IEEE Access*, vol. 10, pp. 19971–19985, 2022.

[A8] R. Li, B. Lin, Y. Liu, M. Dong, and S. Zhao, "A survey on laser space network: Terminals, links, and architectures," *IEEE Access*, vol. 10, pp. 34815–34834, 2022.

[A9] F. De Rango and M. Tropea, "DTN architecture with resource-aware rate adaptation for multiple bundle transmission in InterPlanetary networks," *IEEE Access*, vol. 10, pp. 47219–47234, 2022.

RUTE C. SOFIA (Senior Member, IEEE) received the Ph.D. degree, in 2004. She is currently the Industrial IoT Head at fortiss—research institute of the Free State of Bavaria for software-intensive services and systems. She is also an Invited Associate Professor with the University Lusófona de Humanidades e Tecnologias and an Associate Researcher at ISTAR, Instituto Universitário de Lisboa. Her research background has been developed in industrial and academic contexts. She is a co-founder of the COPELABS Research Unit and was the COPELABS Scientific Director from 2013 to 2017, where she was a Senior Researcher from 2010 to 2019. She co-founded the Portuguese startup Senception Lda (2013–2019), a startup focused on personal communication platforms. She holds over 70 peer-reviewed publications in her fields of expertise, one book, 14 book chapters, and nine patents. Her current research interests include network architectures and protocols, the IoT, edge computing, in-network computing, and network mining. She is an ACM Europe Councilor (2021–2025) and an ACM Senior Member. She was an IEEE ComSoc N2Women Awards Co-Chair from 2020 to 2021.

PAULO MENDES (Senior Member, IEEE) received the Ph.D. degree, in 2004, and the Habilitation degree, in 2019. He is currently an Expert in communication network architecture and design at Airbus Central Research and Technology, Germany. He is also an Invited Associate Professor at the University Lusófona, Portugal, and an Associate Researcher at the Technical University of Munich, Germany, and the iSTAR-IUL Institute, Portugal. He is also collaborating with the European Commission as an Expert. Before joining Airbus, he co-founded the start-up Senception Lda (2013–2019) and the COPELABS Research Center (2010–2019). He was also a Senior Researcher at INESC TEC from 2007 to 2010, and at the NTT Docomo Research Center (2003–2007). He holds over 80 peer-reviewed publications, ten book chapters, and 18 patents. His current research interests include network architectures and protocols, wireless communications, self-organized networks and network orchestration, information-centric networking, and service-centric networking. He is an ACM Member.

VASSILIS TSAOUSSIDIS was born in Drama, Greece, in November 1966. He received the degrees in applied mathematics from Aristotle University, Greece, and the Ph.D. degree in computer networks from Humboldt University, Berlin, Germany, in 1995. He held a postdoctoral appointment at the Department of Computer Science, Rutgers University, New Brunswick, NJ, USA, and faculty appointments at the CS Department, SUNY Stony Brook, NY, USA, and Northeastern University, Boston, MA, USA. He returned to Greece in May 2003 to join the Faculty of the Department of Electrical and Computer Engineering, Democritus University, where he was elected as a Full Professor, in 2007, and a member of the University Board of Directors, in 2012. He served as a Visiting Professor at MIT Aero-Astro, in 2009. He has graduated over 15 Ph.D. students. He frequently represented the European Space Agency (ESA) in the DTN workgroup of the Consultative Committee for Space Data Systems (CCSDS). He was the National Representative for FP7 Cooperation—Space and has served as a member of the Board of Directors of the Hellenic Space Agency. He coordinated several European projects, including FP-7 SPACE-DATA Routers, FP-7 SPICE, and HORIZON 2020 Project UMOBILE. He was/is an Editor for well-known journals including IEEE TRANSACTIONS ON MOBILE COMPUTING, *Computer Networks*, and *Ad Hoc Networks*.

TOMASO DE COLA (Member, IEEE) worked at the Italian Consortium of Telecommunications (CNIT), University of Genoa Research Unit, as a Scientist Researcher, from 2002 to 2007. Since 2008, he has been with the German Aerospace Center (DLR), where he has been involved in several projects funded by EU and ESA programs, focusing on different aspects of DVB standards, CCSDS protocols, emergency communications, and testbed design. He has been taking part in different standardization activities within ETSI, IETF, DVB, and CCSDS, where he serves as the Area Director of the Space Internetworking Services (SIS). He is the coauthor of more than 100 papers published in venues including international conferences and journals. He served on the Technical Program Committee for many IEEE International Conferences and as the TPC Chair for the satellite track in many ICC and GLOBECOM editions. Has also been a Guest Editor for IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS and *IEEE Wireless Communication Magazine*. He is currently serving as an Associate Editor for IEEE COMMUNICATION LETTERS, IEEE WIRELESS COMMUNICATION LETTERS, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, and *IEEE Network*. Finally, he also served as the Chair of the Satellite and Space Communications (SSC) Technical Committee (TC) within ComSoc.

SCOTT BURLEIGH (Member, IEEE) recently retired from a position as a Principal Engineer at the Jet Propulsion Laboratory, California Institute of Technology, where he had been developing flight mission software, since 1986. He is a member of the Delay-Tolerant Networking (DTN) Research Group, Internet Research Task Force. He is the coauthor of the DTN Architecture definition (Internet RFC 4838). He is also the coauthor of the initial specification for the DTN Bundle Protocol (BP, Internet RFC 5050) supporting automated data forwarding through a network of intermittently connected nodes, and of its successor, RFC 9171. In addition, he is the coauthor of the specifications for the Licklider Transmission Protocol (LTP, Internet RFCs 5325 through 5327) supporting data block transmission reliability at the data link layer. He led the development and maintenance of implementations of BP and LTP that are designed for integration into deep space mission flight software, with the long-term goal of enabling the deployment of a delay-tolerant solar system internetwork. He has received the NASA Exceptional Engineering Achievement Medal and four NASA Space Act Board Awards for his work on the design and implementation of these communication protocols.

MIANXIONG DONG received the B.S., M.S., and Ph.D. degrees in computer science and engineering from The University of Aizu, Japan. He is the youngest ever Vice President and a Professor at the Muroran Institute of Technology, Japan. He was a JSPS Research Fellow with the School of Computer Science and Engineering, The University of Aizu, and was a Visiting Scholar with the BBCR Group, University of Waterloo, Canada, supported by the JSPS Excellent Young Researcher Overseas Visit Program, from April 2010 to August 2011. He was selected as a Foreigner Research Fellow (a total of three recipients all over Japan) by NEC C&C Foundation, in 2011. He was a recipient of the IEEE TCSC Early Career Award, in 2016, the IEEE SCSTC Outstanding Young Researcher Award, in 2017, the 12th IEEE ComSoc Asia–Pacific Young Researcher Award, in 2017, the Funai Research Award, in 2018, and the NISTEP Researcher 2018 (one of only 11 people in Japan) in recognition of significant contributions in science and technology. He is a Clarivate Analytics 2019 Highly Cited Researcher (Web of Science).

EDUARDO CERQUEIRA received the Ph.D. degree in informatics engineering from the University of Coimbra, Portugal, in 2008. He was an Invited Auxiliary Professor at the Department of Informatics Engineering, University of Coimbra, from 2008 to 2009, and a Visitor Scholar at the Computer Science Department, University of California in Los Angeles, from 2013 to 2014. He is now an Associate Professor with the Faculty of Computer Engineering and Telecommunications, Federal University of Para, Brazil. His publications include eight edited books, ten book chapters, four patents, and over 220 papers in national/international refereed journals/conferences. He is involved in the organization of several conferences and workshops, including the Future Multimedia Networking (IEEE FMN), the Future Human-Centric Multimedia Networking (ACM FhMN), the ICST Conference on Communications Infrastructure, Systems and Applications in Europe (EuropeComm), the Latin American Conference on Communications (IEEE LATINCOM), the Latin American Conference on Networking (IFIP/ACM LANC), and the Latin American Computer Conference (CLEI). He has served as a Guest Editor for six special issues for various peer-reviewed scholarly journals. His research interests include edge computing, multimedia, smart cities, mobility, and wireless networks.