
IEEE ComSoc
IEEE Communications Society
COMMUNICATIONS SOFTWARE
Fall 2023
COMMUNICATIONS SOFTWARE TECHNICAL COMMITTEE
CommSoft TC
Chair: Abd-Elhamid M. Taha
Vice-Chair: Hassine Moungla
Secretary: Moayad Aloqaily
https://commsoft.committees.comsoc.org/

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# CommSoft Team

**Executives for current term (2023-2024)**

Chair: Abd-Elhamid M. Taha

Vice Chair: Hassine Moungla

Secretary: Moayad Aloqaily

**Special Interests Group Coordinator**

Marwane Ayaida

**Newsletter EiCs**

Aiman Erbad

Moayad Aloqaily

**Standards Liaison**

Mohannad Alharthi

**Student Competition Program**

Hyunbum Kim

**Website Administrators**

Safa Otoum

Ouns Bouachir

# Awards/Distinctions

- **Dr. Melike Erol-Kantarci** received the Special Jury Recognition in **AI Awards North America 2023**! These awards recognize and celebrate the outstanding contributions of women in the field of Artificial Intelligence across Canada, USA, and Mexico.


- **Dr. Kapal Dev** received 2023 The Tom Brazil Excellence in Research Award from SFI Funded CONNECT Research centre.

- **Dr. Aiman Erbad** and the **"Smart and Cognitive Cities & Communities (SCCC) Symposium"** organizers win the **best symposium award** in IWCMC 2023, Marrakesh, Morocco, June 2023.

IEEE

2023 IWCMC

***BEST Symposium AWARD***

***Presented to***

Title "***Smart and Cognitive Cities & Communities (SCCC) Symposium***"

***Organizers: Merouane Debbah, Bassem Ouni, Wael Guibene, Aiman Erbad, and Yu Keping***

*in the* ***IWCMC 2023 Conference***

*Marrakesh, Morocco, June 19th – 23rd 2023*

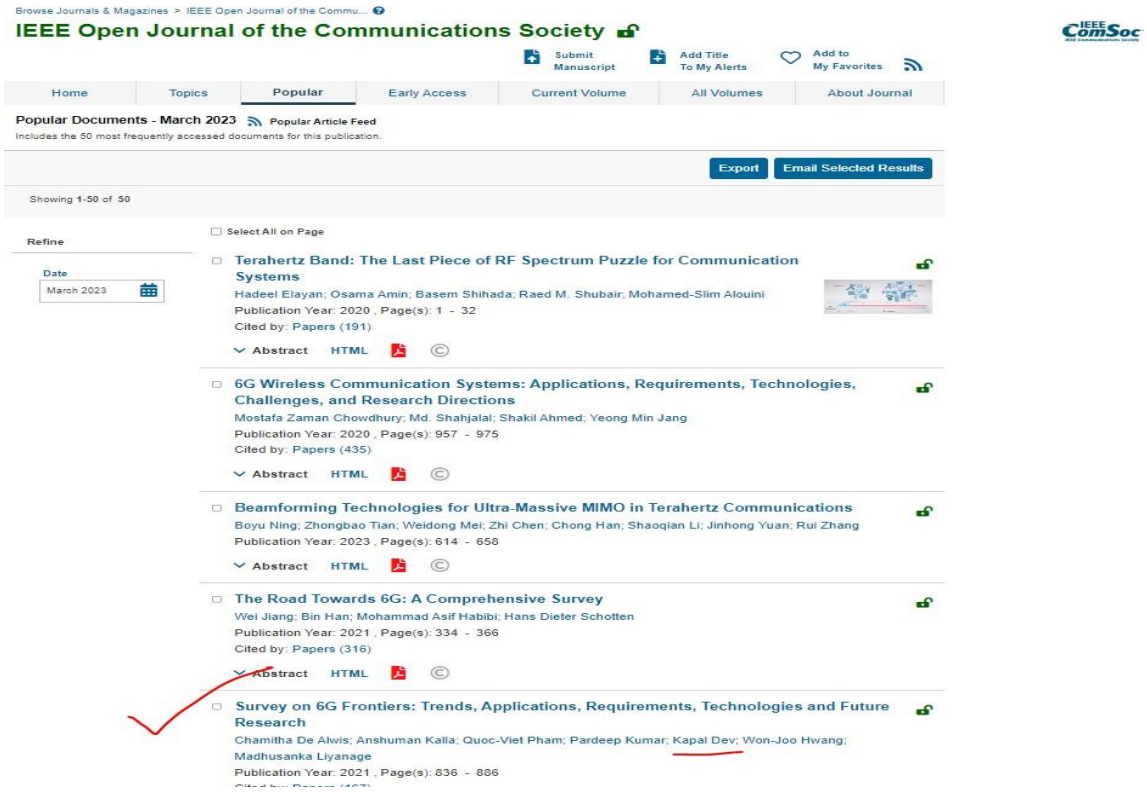
*M. Adel Serhani*

IWCMC

***Prof. Mohsen Guizani***, Steering Committee Chair, IWCMC 2023

# Popular Articles

- **K. Dev** paper titled "Survey on 6G Frontiers: Trends, Applications, Requirements, Technologies and Future Research" is among the 6th most popular article in IEEE Open Journal of the Communications Society from last 24 months.
  Link to the paper: https://ieeexplore.ieee.org/document/9397776




# Editorial Appointments

- **A. Erbad** has Joined the IEEE Networking Letters Editorial Board as an Associate Editor https://www.comsoc.org/publications/journals/ieee-lnet/ieee-networking-letters-editorial-board

- **A. Erbad** has joined the Board of Directors of Qatar Mobility Innovation Center (QMIC) https://www.qmic.com/. The Qatar Mobility Innovations Center (QMIC) is the first independent innovations center in the Gulf region with a focus on using R&D to develop and deploy Intelligent Mobility and Smart Cities platforms and technologies.

- **A. Refaey Hussein** has joined IEEE Systems Journal Editorial Board as an Associate Editor https://ieeesystemscouncil.org/publication/ieee-systems-journal/ieee-systems-journal-editorial-board

# Special Interest Groups Activities

The CommSoft TC currently has the following active SIGs. TC's SIG Coordinator is *M. Ayaida*.

- Special Interest Group on "Performances Evaluation"
  - Coordinator : Abdellatif Kobbane (abdellatif.kobbane@um5.ac.ma)
- Special Interest Group on "Big Data and Communication software"
  - Coordinator : H. Moungla (hassine.moungla@parisdescartes.fr)
- Special Interest Group on "Communication software for Vehicular AdHoc Networks"
  - Coordinator : H. Fouchal (Hacene.Fouchal@univ-reims.fr)
- Special Interest Group on "Security in Software Communication"
  - Coordinator : Dr. Safa Otoum (Safa.Otoum@zu.ac.ae)
- Special Interest Group on "NFV and SDN technologies"
  - Coordinator : S. Misra (smisra.editor@gmail.com)
- Special Interest Group on "Blockchains and Applications"
  - Coordinator : M. Aloqaily (maloqaily@xanalytics.ca)
- Special Interest Group on "ML and AI for Networking"
  - Coordinator : M. Erol-Kantarci (Melike.erolkantarci@uottawa.ca)

## SIG on Blockchains and Applications: *Coordinator: Moayad Aloqaily*

***Keynotes and Panels***

- Keynote on **"Towards AI-assisted blockchain for Metaverse and Industry 5.0"**, CIND-ML, 2023.
- Panel on **"Metaverse Advancements: Pioneering the Future in the UAE",** GITEX Future Blockchain Summit - Dubai Harbour, 2023.
- Panel on **"Security of LLMs"**, IEEE Cyberscience Congress – ADNEC, 2023.
- Panel on **"Applying AI Research to Blockchain Business Models"**, Cardano Summit – Grand Hyatt Conventional Center, Dubai, 2023.
- Panel on **"The Role of AI and Blockchain in Advancing Financial Services and Applications"**, 2023.

***Conferences and Congress***

- The fifth International Conference On Blockchain Computing and Applications (BCCA 2023), 2023.
- Track chair, IEEE GC, WC Symposium, 2023.
- Kuwait Fintech and Blockchain Summit, 2023.

***Special Issues:***

- IEEE JSAC, Special Issue: Zero Trust for Next-Generation Networking, 2024-2025.

# SIG on Performances Evaluation
## *Head: Abdellatif Kobbane*

***Conferences***


***Project***

- PHC-MAGHREB (France, Morocco, Tunisia) - **ANGEL: Agriculture Numérique et "diGital twin" face aux changEments climatiques pour une sécurité aLimentaire**

***Invited talk***

- Talk Title: **Resources Management in SDN-Mobile Slicing**, at University of Polytechnic Hauts-de-France, France september 20, 2023.

***Upcoming***

- Winter School on Mean-Field-Type Game theory, at ENSIAS, Mohammed V University, Morocco from 10 to 17 January, 2024
- WINCOM 2024, Conference at Leets University, 23-25 July, 2024

# SIG on Security
## *Head: Safa Otoum*

***Best paper award***

- Dr. Safa Otoum and her contributor Mehdi Letafati won **the best paper award from IEEE International Conference on Intelligent Metaverse Technologies & Applications** (iMeta 2023) in Estonia for the research on ``Global Differential Privacy for Distributed Metaverse in Healthcare Systems".

***Keynotes and Panels***

- Panelist at Kuwait Fintech, "**The Role of AI and Blockchain in Advancing Financial Services and Applications**" for exploring the applications and emerging challenges of AI in Kuwait's banking sector.

- Keynote on "**Blockchain- supported Federated Learning for Trustworthy 5G/6G Networks**", in IEEE 5G/6G Blockchain Cybersecurity Digital Trust Summit, Rabat, 2023.

***Upcoming***

- Demo Co-Chair, **IEEE International Conference on Blockchain and Cryptocurrency**, 27–31 May 2024, Dublin, Ireland
- Local Chair, **20th EAI International Conference on Security and Privacy in Communication Networks**, October 24-26, 2024, Dubai, UAE.

# SIG on ML and AI for Networking
## *Head: Melike Erol-Kantarci*

### *Recognition*

- Dr. Erol-Kantarci, her students and collaborators won two Best Paper Awards from IEEE ICC'23, one in Communication Software & Multimedia Symposium and another one from Next generation Networking and Internet Symposium

- Featured in IEEE ComSoc collection of videos celebrating the achievements of female members highlighting the incredible talent and technical achievements of these women from the ComSoc community https://www.youtube.com/watch?v=bsatW_IuXKI

### *Keynotes and panelist*

- Keynote on "Paving the AI-Native Way in B5G and 6G," IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom), Istanbul, Turkey, July 7th 2023.

- Panelist for "Getting RIS off the ground with AI and ML" Industry panel by Sparring Partners, October 2023.

### *Special Issues*

- Special Issue on "Data Sets for Machine Learning in Wireless Communications and Networks" (IEEE Communications Magazine 2023)

- Special Issue on "Open RAN: a New Paradigm for Open, Virtualized, Programmable, and Intelligent Cellular Networks" (IEEE JSAC 2023)

### *Conferences and workshops*

- General co- chair of IEEE International Conference on Machine Learning for Communication and Networking (ICMLCN) 2024

- Track chair, IEEE ICC, Selected Areas in Communications (SAC) - Machine Learning for Communications and Networking 2024

- Track chair, IEEE CCNC, AI/ML in Communications and Networking 2022, 2023, 2024

## SIG on Big Data and Communication Software
## *Head: Hassine Moungla*

***Conferences***

- The 44rd IEEE International Conference on Distributed Computing Systems (ICDCS 2024), July 2024 in Jersey City, New Jersey, USA.
- The 20th International Wireless Communications and Mobile Computing Conference,27–31 May 2024 | Ayia Napa | Adams Beach Hotel, Cyprus
- IEEE ICC 2024 and IEEE GC 2023, Track Chair.
- The Special Session in "Advances in the internet of biological and medical things", Within the IEEE 9th World Forum on Internet of Things, on the 12–27 October 2023 // Aveiro, Portugal,

***Journals Open Call***

- IEEE Transactions on Cognitive Communications and Networking - CFP Symbiotic Communication: When Backscatter Communications Meet Cognitive Radio in the Era of IoT – Paper Submission: 1 February 2024
- IEEE JSAC, Special Issue: Advances in Internet Routing and Addressing, 2024-2025 – Paper Submission: 31 May 2024

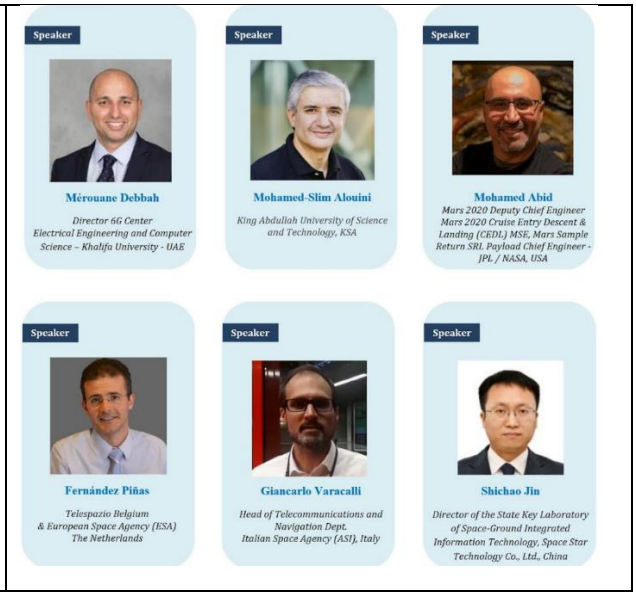
# Ongoing Research Project

- **A. Erbad** is the Lead Principal Investigator in the Academic Research Grant proposal (ARG01-0501-230053) titled "Building the Foundation for a Scalable and Secure Quantum Internet" that was awarded with budget $740,000 from Qatar Research, Development and Innovation (QRDI) Council QNRF programs. The project is a collaboration with Prof. Raj Jain (Washington University, St. Louis) and Prof. Ala Al-Fuqaha (Hamad Bin Khalifa University). If you are a PostDoc or a graduate student interested in this work, please approach us at aerbad@hbku.edu.qa
- **K. Dev** (Munster Technological University, Ireland) project under EU Funding with University of Johannesburg, South Africa on **"Carbon Neutralized 6G"** is accepted!

# Past Events

## Conferences and Workshops

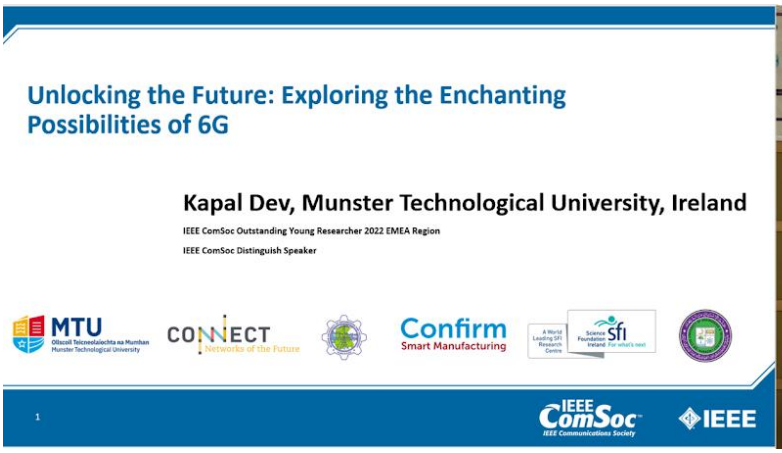
- **K. Dev** is serving as main track/Symposium Chair for "Symposiums on Spectrum Management in Future Networks" in conjunction with 2023 IEEE Future Networks World Forum. Deadline: **8 September 2023,** [Submissions are Open]
- **K. Dev** is serving as main track/Symposium Chair for "**Public Safety in Communication and Networking**" in conjunction with the The 2024 IEEE World Forum on Public Safety Technology (WF-PST).. **Deadline: 23 October 2023**.
- **K. Dev** is serving as main track/Symposium Chair for "Consumer Communications Networks and Connectivity (CCN)" in conjunction with the 42nd IEEE International Conference on Consumer Electronics (**ICCE 2024**). Deadline: **Aug. 15 2023.**
- **K. Dev** is serving as main track/Symposium Chair for "Wireless Networks" track in conjunction with "The 26th International Symposium On Wireless Personal Multimedia Communications"
- **K. Dev** is the workshop chair. [2023] "Call for Workshop Proposals" We invite you to submit workshop proposals for: The 2024 IEEE World Forum on Public Safety Technology (WF-PST). Deadline: 11 September 2023.
- **K. Dev** is the lead workshop chair at IEEE Globecom 2023 on 3rd Workshop on Sustainable and Resilient Industrial Networks
- **K. Dev** is the Workshop Co-Chair for **1st Workshop on "Pervasive AI and Network Intelligence for Metaverse Advancements (PANIMA'24)"** in conjunction with the IEEE PerCom 2024 conference. ***IEEE PerCom*** 2024 ***is ranked/rated "A" Conference.***
- **A. Erbad** is the General Chair for the 10th International Symposium on Networks, Computers and Communications (ISNCC'23) will be held at Doha, Qatar, from October 23 to 26, 2023. ISNCC 2023 is nominated by CommSoft TC. The conference attracted top keynote speakers and high quality papers.

- **A. Erbad** is the symposium chair of the "Smart and Cognitive Cities & Communities (SCCC) Symposium" in IWCMC 2023, Marrakesh, Morocco, June 2023.


# Talks

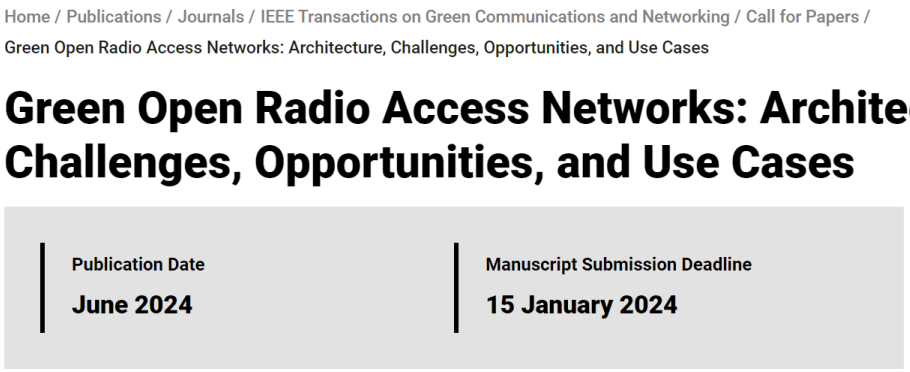
- **K. Dev** delivered an invited talk on **"Unlocking the Future: Exploring the Enchanting Possibilities of 6G"** under IEEE ComSoc Distinguish Speaker Program at MUET, Jamshoro, Pakistan.



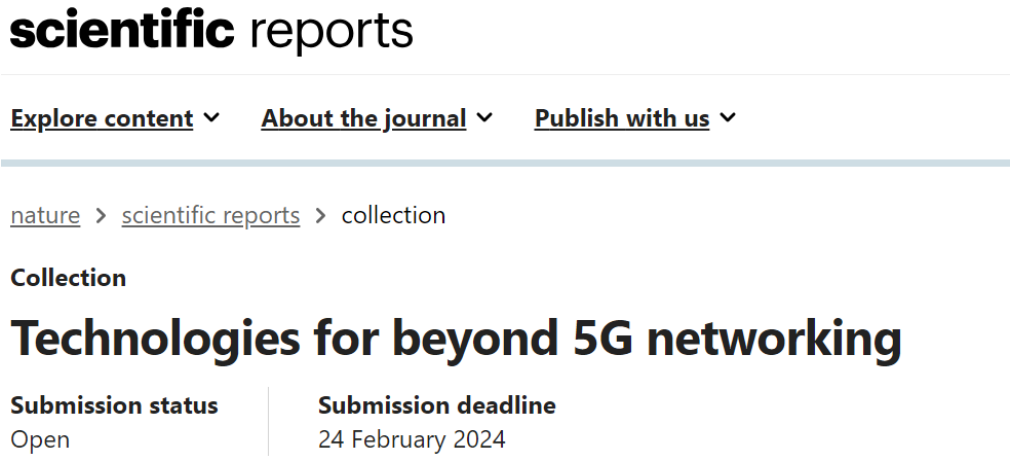

# Special Issues

- **K. Dev** is the Lead Guest editor in special issue titled "Green Open Radio Access Networks: Architecture, Challenges, Opportunities, and Use Cases" in IEEE Transactions on Green Communications and Networking. Submission is open!

  **Deadline:** 15 Jan 2024 | **Website:** https://www.comsoc.org/publications/journals/ieee-tgcn/cfp/green-open-radio-access-networks-architecture-challenges-0




- **K. Dev** is the Guest editor in special issue titled "**Technologies for beyond 5G networking**" in Scientific Reports".
  **Deadline:** 24 Feb 2024 | **Website:** **https://www.nature.com/collections/ighhaddjbi**



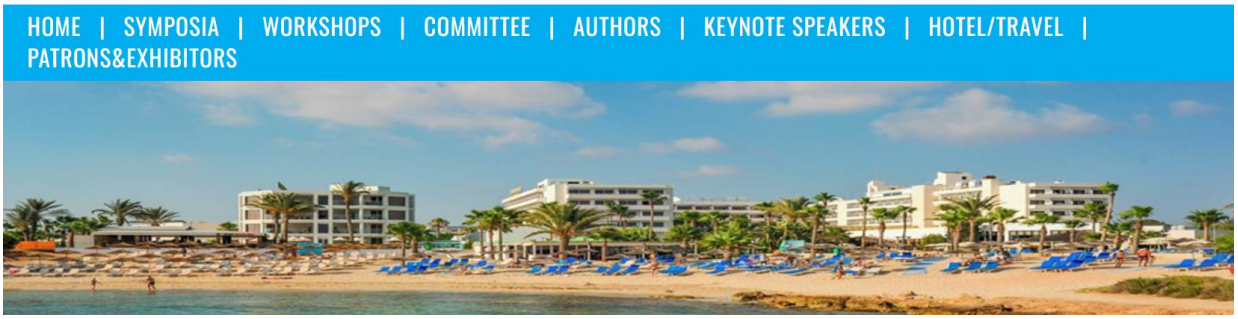

- **Abd-Elhamid M. Taha** was the guest editor in IEEE Communications Magazine for a Special Issue on "Affective Computing and Communications Research, Technologies, Management, and Applications" along with M. Fátima Domingues, Ajjen Joshi, and Mehmet Ulema.

  The special issues was published on Oct 2023 and you can read the guest editorial in the following link https://ieeexplore.ieee.org/document/10298061 and the highlights at the end of the report.

# Upcoming Events

## Conferences and Workshops

- **A. Erbad** is the Chair of the Smart and Cognitive Cities and Communities (SCCC) Symposium @ IWCMC 2024 in Cyprus.
  **When:** May 2024 | **Website**: https://iwcmc.net/2024/index.php


- **A. Erbad** is the Industrial Forum and Exhibition Chair in ISNCC 2024 organized in Washington DC, USA.

  **When**: Oct 2024 | **Website**: https://www.isncc-conf.org/home

# Highlights

## The 31st International Conference on Software, Telecommunications and Computer Networks (SoftCOM 2023)

## Tradition in connectiong academy and industry

*by Dinko Begusic, Josko Radic, Matko Saric, Katarina Rados, Marta Brkic, Croatia; Sinisa Krajnovic, McKinsey & Company, Pascal Lorenz, France; Joel J. P. C. Rodrigues, Portugal*

The 31st International Conference on Software, Telecommunications and Computer Networks - SoftCOM 2023 was held in Amphora hotel Split, Croatia, 21 to 23 September, 2023. The Conference has been technically co-sponsored by the IEEE Communications Society (ComSoc) with the support of the Technical Committee on Communications Software (CommSoft) and the IEEE Croatian Section. The Conference was organized by the University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB) and Croatian Communications and Information Society (CCIS) under the auspices of the Croatian Academy of Engineering.

31st SoftCOM conference extends the tradition of gathering academy and industry to joint the efforts in order to advance the science, technology and education in the area of ICT. A number of academic and industrial partners, as well as public institutions joined the collaboration and took parti in this endeavour. Attractive ambiance of the city of Split and Adriatic sea coast has been a perfect location for such a meeting.

The technical program featured seventeen conference sessions, including eight special sessions dedicated to: QoS in Wired and Wireless Networks, Ad Hoc & Sensor Networks, and Internet of Things, Green Networking and Computing, Security and Digital Forensics, Smart Environments and IoT, Advances in Data Analytics, Robotics and ICT Assisted Wellbeing, Environmental Electromagnetic Compatibility, and Advanced Educational Technologies. Three half day tutorials in the area of electromagnetics have been held by recognized experts. The interdicsiplinary Symposium on Information Security and Intellectual Property has been organized in collaboration with the University of Split, Faculty of law, and the University of Zagreb Faculty of electrical engineering and computing. The authors of selected papers have been invited to extend their papers and submit the for publication in the Journal of Communications Software and Systems (JCOMSS).

The keynote talk titled: "Server Selection in the Internet Continuum" was given by professor emeritus Marco Ajmone Marsan, MDEA Networks Institute, Spain / Politecnico di Torino, Italy, The speaker shared his perspective and experiences on the strategies for the selection of the server in the edge computing environment taking into account a set of relevant parameters. The invited talk titled "High-Baudrate SiP and InP Modulators for Data Center Interconnects" was presented by Oskars Ozolins, Research Institutes of Sweden (RISE AB), Sweden, Riga Technical University, University of Riga, Latvia. The speaker presented the recent research on the fast modulators technologies aimed to increase the speed of data tramsmission in data centers and thus enable more efficient overall design.
At the beginning of the plenary session a minute of silence for the deceased professor emeritus Nikola Rozic, one of the founders of the SoftCOM conference, has been held. As a part of the opening ceremony the audience has been addressed by prof. Branimir Lela, Dean of the Faculty of electrical engineering, mechanical engineering and naval architecture (FESB), prof. Pascal Lorenz, University of Upper Alsace, France, prof. Mario Kusek, IEEE Croatia Section Conference Coordinator, Faculty of electrical engineering and computing, University of Zagreb, Milan Zivkovic, Director, Strategy and Business Development, Ericsson Nikola Tesla company. The accompanying SoftCOM 2023 Business Forum featured professional workshops, project presentations and panel discussions with participation of experts and institution representatives. 29th Workshop on ICT featured a set of presentations of professional papers and posters in the area of ICT.

Panel discussion ”Digital Transformation – the Rise of EDIHs” was coordinated by professor Nedjeljko Perić, University of Zagreb and moderated by Ivana Vuka, Head of the Technology transfer office of the University of Split with participation of the representatives of European Digital Innovation Hubs (EDIHs). The panel discussion was endorsed of the Ministry economy and sustainable development of the Republic of Croatia. Panel discussion ”AI From University to Local IT” was moderated by Damir Brčić, Head of the Digital Dalmatia, County of Splitsko and Dalmatia. The panel discussion was focused on the collaboration between the academic institutions and the local community in AI education.

Workshop on Development of Optical Communication Networks was moderated by Damir Breškovic, PhD, Access network strategy and Planning Department, Croatian Telekom. The workshop has been endorsed by HAKOM (Croatian Regulatory Authority for Network Industries).

The presentation of the project VITA (Virtual Telemedicine Assistance) was organized by profesor Mladen Russo, FESB Split. The project is aimed to development of the collaborative telemedicine platform and it is cosponsored by European Regional Development Fund - the Competitiveness and Cohesion Operational Program.

A special part of the program was aimed to master level students. Ericsson Nikola Tesla Summer Camp 2023 Workshop featured the presentatiosn of seven students projects completed within the summer camp. The 12th Workshop on Software Engineering in Practice included ten students presentations of software development technologies. The workshops have been moderated by Darko Huljenić, PhD, Ericsson Nikola Tesla, Croatia.
More information about the SoftCOM 2023 conference may be found at the address https://2023.softcom.fesb.unist.hr/

*The plenary session was chaired by prof. Dinko Begusic,University of Split, prof. Maja Matijasevic, University of Zagreb, and prof. Pascal Lorenz, Universite de Haute Alsace, France.*

*The welcome party was organized in the City of Split Port – visiting sailing club Labud.. The conference trip included a guided tour of Olive museum and the storytelling walk around the historic fortress of Klis.*

# TinyML for Cybersecurity: From Theory to Case Study

Fatemeh Dehrouyeh, Li Yang, and Abdallah Shami
Electrical and Computer Engineering
Western University
Ontario, Canada

# TinyML for Cybersecurity: From Theory to Case Study

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**Abstract.** The escalating complexity of cyber threats in the Internet of Things (IoT) landscape necessitates robust security solutions. This paper explores the role of TinyML in enhancing the cybersecurity of IoT systems, particularly focusing on its application in Electric Vehicle Charging Stations (EVCS). The paper introduces TinyML as a transformative approach for implementing machine learning on edge devices, offering a comprehensive analysis of its advantages in terms of reduced latency, lower bandwidth and energy usage, enhanced security, and cost-effectiveness.

## 1 Introduction

The growing complexity of cyber threats poses significant challenges in maintaining the security of the Internet of Things (IoT) systems. Intrusions, defined as unauthorized activities that harm these systems, threaten the confidentiality, integrity, and availability of information. These activities encompass any that impairs the responsiveness of computer services to legitimate users [1].

To counteract these threats, Intrusion Detection Systems (IDS) are developed to defend against threats that compromise system security. IDSs are generally divided into two categories: Signature-based Intrusion Detection Systems (SIDS) and Anomaly-based Intrusion Detection Systems (AIDS) [1].

SIDS rely on pattern matching to identify known attacks, functioning through the comparison of intrusion signatures against a pre-existing database. When a match is found, an alarm is triggered [1]. SIDSs although often incorporate supervised Machine Learning (ML) algorithms to enhance their predictive capabilities, they fail to recognize new threats, thereby leaving systems vulnerable to emerging malicious activities. This approach also demands considerable resources for maintaining a large database and processing incoming data, which can strain computational resources and affect system performance [2]. Additionally, the centralized nature of traditional cybersecurity systems, often employed in SIDS, introduces vulnerabilities such as a single point of failure and privacy concerns. This centralization can compromise the entire network if breached and limits system flexibility and adaptability [3].

In contrast, AIDS leverage ML and statistical methods to establish a baseline of normal system behavior. Deviations from this baseline are flagged as potential intrusions [1]. ML models contribute to the creation of sophisticated frameworks capable of detecting malware, classifying spam, and identifying intrusions and anomalies. These models typically operate in powerful servers and employ substantial computational resources to analyze large datasets for identifying vulnerabilities [4].

Although ML models emerge as a potent solution in countering cyber attacks, relying solely on traditional ML approaches may not be sufficient due to the inherent limitations, especially in IoT data analytics [5]. Traditional ML models often suffer from issues of size, computational complexity, and high energy consumption, making them unsuitable for efficient deployment on resource-constrained edge devices, which are widely used in IoT systems. [4].

In response, TinyML has emerged as a distinct discipline dedicated to optimizing ML models specifically for edge devices with limited resources and capabilities [6].

## 2 TinyML Background

TinyML is an innovative technology that facilitates the deployment of various ML models and intelligent tasks on edge IoT devices, including battery-less low-power devices with limited resources. This advancement empowers devices to perform data processing and analysis at the extreme edge, paving the way for novel IoT applications [7].

Through the integration of ML models into compact IoT devices, each of these devices becomes capable of processing data and making decisions locally, thus eliminating the need for cloud data transmission [7]. Consequently, TinyML reduces dependence on cloud services, resulting in lower transmission requirements and potentially reducing bandwidth usage [8].

Reducing the reliance on external communication addresses the issue of latency [9]. By limiting the need to transfer data to cloud servers, TinyML enhances the ability for real-time decision-making, thereby reducing delays [10].

The cost advantage of TinyML is evident due to the simplicity and hardware constraints of IoT devices [11]. Additionally, reducing data traffic and bandwidth requirements through TinyML leads to cost efficiencies [6, 12].

Processing tasks demand significantly less energy compared to wireless transmissions [11]. Therefore, performing computations locally on devices requires less energy than transmitting data wirelessly, making energy efficiency a key benefit of implementing TinyML on Microcontroller Units (MCUs) [11, 13].

By limiting data flow through networks, TinyML significantly improves both security and privacy. This inherent protection arises because there is less data available for potential interception or manipulation, reducing vulnerability to cyber threats [13, 10]

Moreover, reduced connectivity dependency leads to enhanced availability and responsiveness as additional benefits of TinyML [14].

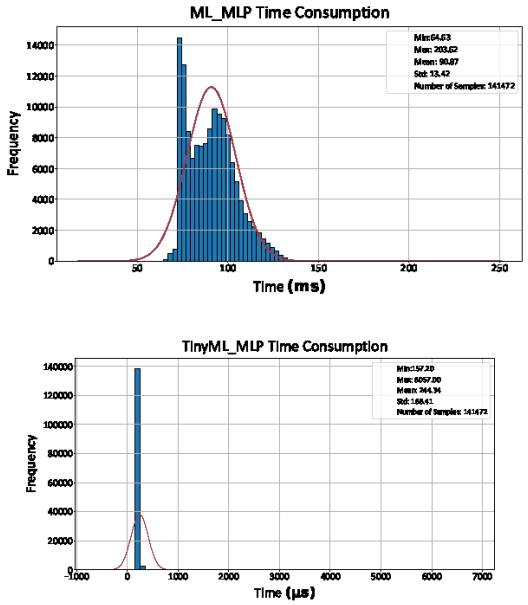


Figure 1: Histogram representation of per-sample memory usage during prediction

## 3 Use Case Scenario

Electric Vehicle Charging Stations (EVCS) are a crucial component of Intelligent Transportation Systems (ITS), representing a significant IoT application in the transportation sector. EVCSs are vulnerable to various cybersecurity threats due to their interconnected nature and the sensitive data they handle, such as payment information and real-time energy usage statistics. These attacks can take various forms, such as manipulating charging operations via WiFi connections, bypassing authentication mechanisms, injecting malicious software, and disabling the charger [15].

Specifically, an adversary can compromise an EVCS to create a traffic bottleneck by tampering with the charging schedules of Electric Vehicles (EVs) [16]. In such scenarios, the attacker causes disturbances at the grid level by orchestrating sudden surges in power demand or reverse power flows from EVs to the grid. To address these challenges, installing a TinyML microcontroller in the EVCS is an effective solution.

For the simulation, the CICIDS2017 dataset, including a diverse range of common cyber-attacks, serves as a foundational resource for our study on TinyML [17, 18]. Two distinct scenarios are considered for our intrusion detection system. Initially, a Multi-Layer Perceptron (MLP) model, referred to as ML_MLP, is implemented. This model, originating from TensorFlow Keras, is a sequential neural network consisting of four dense layers, each with 32 units. Subsequently, the model undergoes conversion into its resource-optimized TinyML model via TensorFlow Lite (TFLite), utilizing default optimizations. This optimized version is referred to as TinyML_MLP.

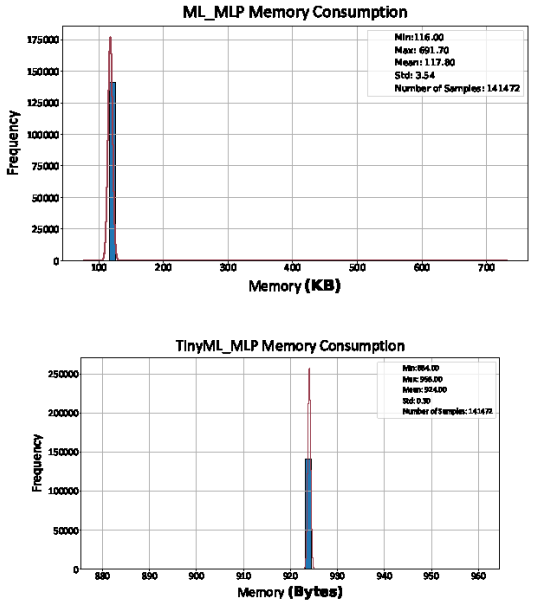


Figure 2: Histogram representation of per-sample memory usage during prediction

Histogram plots are provided for comprehension of the prediction phase's behavior. Figure 1 displays the time usage for each method, while Figure 2 provides insight into their memory usage. The TinyML model exhibits a substantial reduction in both prediction time and memory usage. It operates approximately 372 times faster and requires around 130 times less memory than its ML_MLP counterpart. Remarkably, the resource optimizations in TinyML have little to no impact on its predictive performance. TinyML_MLP matches its ML_MLP counterpart in all evaluated metrics, including accuracy, precision, recall, and F1 score, with each metric exceeding 99%.

## 4 Conclusion

In conclusion, the evolution of TinyML marks a significant advancement in addressing cybersecurity challenges. By enabling local data processing and decision-making on IoT devices, TinyML achieves reduced latency, lower bandwidth and energy usage, and enhances security, privacy, and cost-effectiveness. Moreover, simulation results on the CICIDS2017 dataset demonstrate that TinyML models can achieve similar performance to traditional ML models while significantly reducing time and memory consumption.

## References


[1] A. Khraisat, I. Gondal, P. Vamplew, and J. Kamruzzaman, "Survey of intrusion detection systems: techniques, datasets and challenges," *Cybersecurity*, vol. 2, no. 1, pp. 1–22, 2019.

[2] Q. Abd-Alhussain hadi al zubaidy, A. S. Alfoudi, and A. M. Mahdi, "Iot cybersecurity threats and detection mechanisms: A review," *Wasit Journal for Pure sciences*, vol. 2, no. 2, pp. 231–250, 2023.

[3] Z. Pourmirza, "Cybersecurity in centralised vs decentralised energy systems," 2023.

[4] A. Albanese, M. Nardello, G. Fiacco, and D. Brunelli, "Tiny machine learning for high accuracy product quality inspection," *IEEE Sensors Journal*, vol. 23, no. 2, pp. 1575–1583, 2023.

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# IEEE ComSoc Distinguished Lecturer Program (DLP) Tours by Tamer ElBatt in 2023

Prof. Tamer was nominated by CommSoft TC as IEEE ComSoc Distinguished Lecturer. In his capacity as a ComSoc Distinguished Lecturer, Prof. Tamer ElBatt had three tours in 2023 spanning two continents and three countries, namely Malaysia, Kenya and the United Arab Emirates.

In August 2023, he had his first DLP tour hosted by the IEEE Malaysia Communications Society & Vehicular Technology Society (ComSoc/VTS) joint Chapter. The tour included three major institutions. On Aug. 21st, he visited Universiti Putra Malaysia (UPM) and gave a talk entitled “Machine Learning and Edge Intelligence: Key Enablers for xG Wireless and IoT”. On Aug. 22nd, he visited Universiti Teknikal Melaka (UTeM) and gave a talk entitled “Edge Computing and Communications: Fundamental Limits and Applications in Wireless Caching and IoT”. On the last day of the tour, Aug. 23rd, Prof. ElBatt visited Universiti Teknologi Malaysia (UTM) and gave a talk entitled “Green Wireless: Optimization of Wireless Networks with RF Energy Harvesting”. The tour also included networking and social events hosted by the organizers. All talks were well-attended, physically and online.

In Sept. 2023, and in parallel with a sponsored visit for the Afretec Annual Conference organized by the University of Nairobi, Prof. ElBatt was hosted by the IEEE Kenya ComSoc Chapter, IEEE Kenya Section and the IEEE University of Nairobi Student Branch and gave a DLP talk at the University of Nairobi, entitled “Machine Learning and Edge Intelligence: Key Enablers for xG Wireless and IoT”. The talk was offered in a hybrid mode and was well-attended onsite.

In Nov. 2023, and in parallel with his visit to the UAE for his students’ senior project selection to participate in the “Prototypes for Humanity” Exhibition in Dubai (synced with COP28), he had a tour hosted by the IEEE UAE ComSoc Chapter and the IEEE UAE Section. The tour included two major universities in the UAE as part of the ComSoc Distinguished Speaker Program (DSP). On Nov. 28th, he visited the University of Dubai and gave a talk entitled “Green Wireless: Optimization of Wireless Networks with RF Energy Harvesting”. On Nov. 29th, he visited the American University of Sharjah (AUS) and gave a talk entitled “Machine Learning and Edge Intelligence: Key Enablers for xG Wireless and IoT”. Both talks were well-attended. The tour also involved a networking and a social event hosted by the organizers.

# Affective Computing and Communications Research, Technologies, Management, and Applications

GUEST EDITORIAL

# AFFECTIVE COMPUTING AND COMMUNICATIONS RESEARCH, TECHNOLOGIES, MANAGEMENT, AND APPLICATIONS


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Despite great advances in computer and communications technologies and applications, many nuances of face-to-face human interactions are still challenging to replicate digitally. While the introduction of emojis and the proliferation of video-based communications have enriched our interactions, there is still much to achieve in making communications and computing more pliable and accommodating.

A computer's ability to capture a human's emotion is called affective sensing, or emotion sensing, and more recently, emotional artificial intelligence (emotional AI). Since its introduction by Picard in the mid-1990s, affective sensing has evolved substantially and has found its role in various applications. These range from understanding a driver's affective state, distraction, and behavior; to automating the capture of the user's Quality of Experience (QoE) for a certain connection; to using emotions in crowd and traffic management; to relaying emotions to and from the metaverse.

This Feature Topic (FT) addresses affective computing and communications through research advances, technologies, applications, and management aspects that enable human-computer interaction, including emotion sensing. The goal is to report on the most up-to-date contributions in this area. Six papers were selected with the invaluable aid of reviewers.

The first article, "Catching Elusive Depression via Facial Micro-Expression Recognition," by Xiaohui Chen and Tie Luo, offers a key demonstration of the potential of affective sensing. In their work, they showcase the use of machine learning in identifying a category of depression called concealed depression — one where the subject's mental state is hidden, intentionally or otherwise. The recognition model is centered on facial micro-expression and is proposed as part of a solution that can be privately utilized at the subject's discretion.

Neurogames have recently gained attention as a gaming evolution that overcomes traditional human-to-computer interfaces. Rather, players connect to the gaming context through neurosensory artifacts, e.g., brain-to-computer interface. As such, serious neurogames have grown to show potential beyond entertainment, impacting the areas of communication, education, and healthcare. Within this scope, the second article, "Multisensed Emotions as Adaptation Controllers in Human-to-Serious NeuroGames Communication," by Sofia B. Dias, Herbert F. Jelinek, and Leontios J. Hadjileontiadis, explores a multi-modal (or a multi-sensory) emotion capture that can be used in emotion-adapting serious neurogames. In addition to an instructive framework elaborating on how such applications can be built, including the finer details of emotion recognition and classification, the work identifies the challenges ahead as we move towards more immersive and enriched communication environments.

The third article is "When Smart Metaverse Meets Affective Computing: Opportunities and Design Guidelines," by Rodolfo W. L. Coutinho and Azzedine Boukerche. The article focuses on the overlay between the metaverse and affective computing. The criticality of the metaverse over the next few decades cannot be underscored enough, especially as it embodies a key step in the evolution of communications and computing. Readily, deliberations on the infrastructure supporting the metaverse requirements have exponentially progressed over the last two years. The unique contribution of this work is that it identifies the necessity of affective sensing in refining virtual representations and interfacing in the metaverse and the challenges faced in realizing tactile and haptic experiences.

And against the increasing complexity of managing communication networks, intelligent automation presents itself as a capable solution. In particular, QoE has long been relied upon to validate network provisioning and operation aspects. The challenge, however, is that QoE measures rely on offline, bias-prone measures, notwithstanding standardization. The fourth article in this FT, "New Approach for an Affective Computing-Driven Quality of Experience (QoE) Prediction," by Joshua Bègue, Mohamed Aymen Labiod, and Abdelhamid Mellouk, presents a vision-based emotion recognition. The model is validated through a multi-sensory setup, allowing further possibilities in automating QoE estimation.

In the fifth article, entitled "Affective Surveillance Management in Virtual Emotion-Based Smart Complex Infrastructure," the authors Sooeon Lee, Seungheyon Lee, Yumin Choi, Jalel Ben-Othman, Lynda Mokdad, Kyungkoo Jun, and Hyunbum Kim lay out an infrastructure for affective surveillance management for an extensive Internet of Things (IoT) setup. A notable aspect of such infrastructure is the possibility of expanded energy expenditures. The authors discuss how such expenditures can be mitigated and offer a basis for designing future instances, including ones with mobile elements.

The sixth and final article is "Emotion-Aware Takeover Performance Prediction System in Semi-autonomous Driving" by Yantong Wang, Yu Gu, and Fuji Ren. The authors propose a general takeover safety framework consisting of three stages: sensing, predicting, and responding. The article describes the proposed framework's implementation, including software and hardware requirements for in-vehicle affect capture and how it can predict takeover safety.

We hope that the articles selected for this FT will provide greater insight into the area of affective computing and communication and instigate further work in the applications of this extremely interesting field.

We extend our gratitude to all authors who considered this FT as a venue for their work. We also deeply appreciate the expertise, time, effort, and patience of our reviewers, without whom this FT would not have come to fruition. We would also like to recognize the exceptional support the Communications Magazine personnel provided, especially Tammy Remington, the Magazine's Editorial Assistant. The guidance of Alberto Perotti, the Magazine's Associate Editor-in-Chief, and the support of the FT's liaison editor, Vyasa Sai, is also genuinely appreciated.

## Biographies

Abd-Elhamid M. Taha [SM] received his B.Sc. (Honors) and M.Sc. from Kuwait University in 1999 and 2002, and his Ph.D. from Queen's University, Canada in 2007. He currently serves as an associate professor in electrical engineering at Alfaisal University and holds an adjunct post at the School of Computing at Queen's. His general research interest is in computer networks and communications, with a specific focus on Internet of Things (IoT) services, as well as connected cyber-physical systems. More recently, he has started exploring the combined applications of affective sensing, AI, and IoT. He currently serves as an associate editor in the *IEEE Communications Magazine* and an Area Editor in the *IEEE Canadian Journal of Electrical and Computer Engineering*.

M. Fátima Domingues [SM], received her PhD in Physics Engineering in 2014, from University of Aveiro, Portugal. In 2015 M. Fátima Domingues started a Research Fellow position at the Instituto de Telecomunicações – Aveiro; and the Consejo Superior de Investigaciones Científicas (CSIC)-Madrid, Spain. At present, M. Fátima Domingues is an Assistant Professor at the Department of Biomedical Engineering and a researcher at Healthcare Engineering Innovation Center (HEIC), Khalifa University, Abu Dhabi, United Arab Emirates and a Researcher at Instituto de Telecomunicações, Aveiro. Her current research interests embrace new solutions of photonic based sensors and their application in e-Health scenarios, with a focus in physical rehabilitation architectures. He authored and co-authored more than 100 journal and conference papers, several book chapters and 5 books.

Ajjen Joshi received his Ph.D. in Computer Science from Boston University in 2018. He is currently Lead Computer Vision Scientist at SmartEye in Boston, USA. His research interests lie in the intersectional disciplines of computer vision, machine learning, and human computer interaction, where his focus is on the personalized analysis of spatiotemporal human signals, generated by eye-gaze, facial expressions and body gestures, in order to facilitate a computational understanding of human behavior and enable intelligent interaction with the computer. He has authored and co-authored more than 20 peer-reviewed papers and served as a reviewer for multiple journals and conferences.

Mehmet Ulema [LSM] received the B.S. and M.S. degrees from Istanbul Technical University, and the M.S. and Ph.D. degrees in computer science from Polytechnic University (currently, the New York University Tandon School of Engineering). He is a Professor of Computer Information Systems at Manhattan College, Riverdale, NY, USA. Previously, he held management and technical positions in AT&T Bell Laboratories, Bellcore, and Daewoo Telecom. He has been on the editorial board of several journals. He is also the Co-Editor of the IEEE Press-Wiley book series on Network and Service Management. He has authored a book titled Fundamentals of Public Safety Networks and Critical Communications (Wiley). He was actively involved in standardization in ITU, TIA, ATIS, and IEEE. He has received several awards, including the IEEE SA Standards Medallion Award and the IEEE ComSoc Harold Sobol Award. He is currently a member of the IEEE Standards Association Board of Governors. He is also a Co-Chair of the IEEE Public Safety Technology Initiative. He had leading roles in numerous IEEE ComSoc conferences, including IEEE ICC and IEEE GLOBECOM. He is the Co-Founder of the IEEE BlackSeaCom conference series.