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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: SECURITY AND TRUSTED COMPUTING FOR INDUSTRIAL INTERNET OF THINGS: RESEARCH CHALLENGES AND OPPORTUNITIES

Industrial IoT (IIoT) interconnects critical devices and sensors in critical infrastructure sectors with existing Internet of Things (IoT) devices and applications. Generally, IIoT deployment allows organizations and users to gain invaluable insights into industrial processes and achieve high-productivity gains while reducing cost. Their role will be increasingly important as we move toward Industry 5.0. Hence, it is also crucial to understand and address any security and privacy risks that may arise, including those discussed in the articles accepted in this Special Section.

A typical IIoT system has up to tens of thousands of interconnected devices and sensors, where information/data are exchanged in real-time. Analysis and mining of such (rich) data allow organizations and governments to gain situational awareness and invaluable insights into industrial processes, which in turn informs policy-making and strategy formulation. There are, however, underpinning security and privacy risks since these interconnected devices and sensors are now potential attack vectors that can be exploited (i.e., a significantly expanded attack base).

The objective of this Special Section is to report existing research efforts dedicated to strengthening the security foundations of IIoT systems, and the broader ecosystems where they are deployed (e.g., smart cities). Specifically, a total of 80 high-quality submissions were received and each manuscript was critically reviewed by at least two independent reviewers. The manuscripts were evaluated for their rigor and quality, as well as their relevance to the theme proposed in this Special Section. After a rigorous review process, 26 high-quality articles were accepted to be included in this Special Section (i.e., acceptance rate of 32.5%).

We will now briefly introduce the accepted articles.

In the article titled ''MIAEC: Missing data imputation based on the evidence chain,'' Xu *et al.* developed a missing value imputation algorithm based on evidence chain, namely, MIAEC, in order to facilitate security investigations in an IIoT environment.

In the article titled ''Malware threats and detection for industrial mobile-IoT networks,'' Sharmeen *et al.* focused on malware targeting devices deployed in an IIoT environment, where they analyzed approaches based on static, dynamic, and hybrid detection.

In the article titled ''A user-friendly privacy framework for users to achieve consents with nearby BLE devices,'' Cha *et al.* proposed a privacy preference expression framework for low-energy Bluetooth applications. Specifically, they defined specifications and guidelines for users and operators in order to achieve mutual agreement on privacy practices.

In the article titled ''Sensitivity analysis of an Attack-pattern discovery based trusted routing scheme for mobile Ad-Hoc networks in industrial IoT,'' Jhaveri *et al.* investigated a trusted routing scheme with pattern discovery (TRS-PD) for values of different parameters in IIoT scenarios.

In the article titled ''An effective high threating alarm mining method for cloud security management,'' Meng *et al.* proposed a self-adapting threat degree calculation method to qualify the threat degree of the alarms in an IIoT environment.

In the article titled ''Secrecy outage performance analysis for energy harvesting sensor networks with a jammer using relay selection strategy,'' Vo Nhan *et al*. attempted to enhance the secrecy of the IIoT systems. Specifically, they developed a near-optimal energy-harvesting time algorithm.

In the article titled ''A DDoS attack detection and mitigation with software-defined Internet of Things framework,'' Yin *et al.* proposed a general framework for software-defined IoT, which consists of a controller pool software-defined-IoT controllers, switches, and IoT devices.

In the article titled ''A reliable and lightweight trust computing mechanism for IoT edge devices based on multi-source feedback information fusion,'' Yuan *et al.* proposed a reliable lightweight trust mechanism for IoT edge devices, based on multi-source feedback information fusion.

Data encryption is a relatively mature research area but it is still of ongoing interest in IIoT, as evidenced by the article titled ''A novel efficient pairing-free CP-ABE based on elliptic curve cryptography for IoT.'' Specifically, Ding *et al.* proposed a pairing-free data access control scheme based on the ciphertext-policy attribute-based encryption (CP-ABE) using elliptic curve cryptography.

In the article titled "Secure APIT localization scheme against sybil attacks in distributed wireless sensor networks," Yuan *et al.* developed a lightweight Sybil-free algorithm, which is designed to mitigate Sybil attacks in approximate point in triangular test (APIT) algorithm.

In the article titled "An integrated method for anomaly detection from massive system logs," Liu *et al.* proposed an integrated method using K-prototype clustering and kNN classification algorithms to facilitate anomaly detection unentitled massive logs.

In the article titled "A new threat intelligence scheme for safeguarding industry 4.0 systems," Moustafa *et al.* addressed the challenges in Industry 4.0 and proposed a threat intelligence technique based on beta mixture-hidden Markov models (MHMMs) for discovering anomalous activities against both physical and network systems.

In the article titled "Oblivious transfer based on NTRUencrypt," Mi *et al.* investigated the fastest known 1-out-of-n oblivious transfer protocol and proposed a one-round postquantum secure OT_n^1 protocol using NTRUEncrypt.

In the article titled "Analyzing Android app privacy with GP-PP model," Kesswani *et al.* investigated app privacy issues over mobile devices by categorizing app permissions into privacy-invasive and generic permissions, and validating the classification using a Naïve Bayes classifier.

In the article titled "AES-128 based secure low power communication for LoRaWAN IoT environments," Tsai *et al.* developed a high-security, but low-power consumption communication solution using AES-128.

In the article titled "A novel collaborative task offloading scheme for secure and sustainable mobile cloudlet networks," Yang *et al.* proposed a collaborative task offloading method (CTOM) to mitigate DDoS attacks for secure mobile cloudlet networks.

In the article titled "Performance and security evaluations of identity- and pairing-based digital signature algorithms on Windows, Android, and Linux Platforms: Revisiting the algorithms of Cha and Cheon, Hess, Barreto, Libert, McCullagh and Quisquater, and Paterson and Schuldt," Zhong *et al.* examined the security performance trade-off for four existing digital signature algorithms.

Yang, *et al.* proposed a data integrity solution that can be implemented at the application layer of IIoT. The solution presented in the article titled "Compact hardware implementation of a SHA-3 core for wireless body sensor networks" is based on SHA3 for wireless body sensor networks.

In the article titled "Revocable identity-based encryption scheme under LWE assumption in the standard model," Zhang *et al.* proposed a revocable identity-based encryption scheme under learning with error (LWE) assumption from the lattice, which is shown to be secure against adaptive-ID attacks.

In the article titled "Behaviour and vulnerability assessment of drones-enabled Industrial Internet of Things (IIoT)," Sharma *et al.* proposed an N-layer hierarchical context-ware aspect-oriented Petri network model to evaluate the behavior of drones and assess the potential vulnerabilities under security policies.

In the article titled "Reliable resource provisioning using Bankers' Deadlock avoidance algorithm in MEC for Industrial IoT," Ugwuanyi *et al.* focused on a resource-constrained environment and proposed a deadlock-avoidance provisioning algorithm for IIoT. This allows one to ensure the reliability of network interactions in IIoT.

In the article titled "Data transfusion: Pairing wearable devices and its implication on security for Internet of Things," Lee *et al.* studied privacy issues relating to smartwatches and demonstrated how one can perform data extraction from such devices.

In the article titled "A secured data management scheme for smart societies in Industrial Internet of Things environment," Babar *et al.* proposed a centralized approach to achieve demand-side management over a smart-home case.

In the article titled "Privacy-aware data publishing and integration for collaborative service recommendation," Yan *et al.* improved the traditional, item-based collaborative filtering (ICF) approach by integrating the locality-sensitive hashing techniques.

In the article titled "A graph based security framework for securing Industrial IoT networks from vulnerability exploitations," George *et al.* proposed a graphical model to address the relations between vulnerability in the IIoT and a use-case was used to demonstrate the effectiveness of the proposed model.

In the article titled "A master attack methodology for an AI-based automated attack planner for smart cities," Falco *et al.* investigated the security and privacy issues in critical infrastructures, and proposed an example of automated attack generation method against cyberattacks targeting such critical infrastructures.

In this Special Section, the breadth of the topics reported demonstrates the ongoing interests of the community in ensuring the security of IIoT devices and systems. We hope that this Special Section will stimulate and encourage further research in security and related issues for IIoT.

In conclusion, we thank all researchers for submitting their work to this Special Section, and the reviewers for volunteering their time and expertise to critique and contribute to the submitted articles. We would also like to thank IEEE Access Editor-in-Chief and all staff members for their continuous support and guidance.

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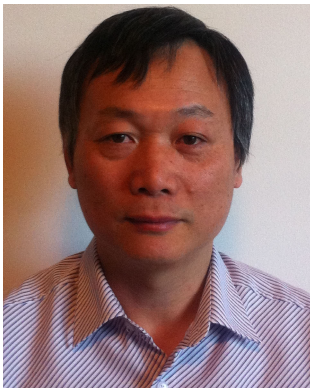

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