Guest Editorial
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RADIO Frequency Identification (RFID) is a generic term for a variety of active and passive RF technologies that wirelessly convey object identification information. RFID technologies encompass multiple frequency bands and different mechanisms of information transfer: Low Frequency (LF) and High Frequency (HF) RFID tags typically use inductive coupling, Ultra-High Frequency (UHF) and microwave RFID typically use electromagnetic wave propagation although they often operate in near-field application scenarios as well. RFID transponders have varying degrees of sophistication and their design is often a tradeoff between functionality and cost. At one end of the spectrum, there are active RFID tags that offer on-board battery and memory, sensor integration, active RF transmitter and hence communication range up to kilometers albeit at increased costs. At the other end, passive RFID tags rely on a simple load modulation to backscatter ID back to the reader. The tiny ICs of those passive tags are very complex: they contain more transistors than the Intel 80386 processor in the 1985 IBM PC-AT (that processor had about 275,000 transistors) but have lower power consumption than a honeybee's brain (which consumes about 10 microwatts) and thus can be RF-powered. These tags are range limited to the order of several meters but, at a price point of several cents per tag, are well suited for large-scale, low-cost automatic identification.

In the passive RFID domain, the last two decades have seen a coordinated effort in areas such as open standards development for networked RFID, low-cost, mass-manufacturing techniques for transponder hardware and energy efficient chip design. An estimated 16 billion passive RFID tags (LF, HF, and UHF) have been sold in 2018 to a wide range of industries and businesses including consumer goods tracking, apparel tagging, security, access, healthcare, construction, airlines, and aerospace (for example, NASA has been using passive RFID tags to tag and track items on board the International Space Station). As a result, passive RFID is well positioned as a core technology for connecting everyday objects of the physical world to the Internet of Things, giving them their digital twin identities. Industry alliances such as the NFC forum and the RAIN RFID alliance have been formed to motivate and promote these efforts.

As the demand for low-cost, edge devices to bridge the physical-digital divide grows, so has the scope of RFID research. Besides object identification, researchers have examined the possibility of using RFID tags for low-power wireless sensing, localization, access control and security. In the last 5 years alone there have been about 1600 issued U.S. patents and 3500 IEEE journal and conference publications (all with the term "RFID" in their titles), which serve to underline the rapid growth of the field.

In 2017, IEEE launched a new IEEE JOURNAL OF RADIO FREQUENCY IDENTIFICATION (JRFID). Each year, the journal features a special issue that presents a collection of extended papers from that year's IEEE RFID conference. Papers in this special issue are extended versions of paper and poster presentations that were featured in IEEE RFID 2018, a highly competitive premier technical conference on RFID that took place in Orlando, FL on April 10-12, 2018. The four papers presented in this issue are written by researchers from three countries: Germany, India and the USA. The topics of this paper include crowd size estimation, antenna design for near and far field applications, high accuracy temperature sensing and power efficient design of mm wave retrodirective antennas.

Gupta *et al.* illustrate how a set of 4 reference tags, attached to one side of a corridor, and 4 reader antennas, attached to the other side of the corridor, can be used to accurately count people as they traverse the corridor. Their algorithm utilizes RSSI time domain fluctuations from the 4 tags at each of the 4 antennas as features to estimate the passage of people in the corridor. They have demonstrated that their algorithm can reliably count up to 75 people passing through the corridor simultaneously with 90% accuracy. Furthermore, their algorithm is capable of differentiating between subgroups of up to 10 clustered people with $\pm$ 1 accuracy. The algorithm is also practical as it does not require the deployment of tags on the passing people in order to work.

Gupta *et al.* also present the design of a modified loop antenna capable of good performance in an application requiring both near field coupling and far field wave propagation. The authors compare and contrast the performance of their antenna with representative near and far field antenna designs in the literature. They demonstrate that, when used in this application, their dual mode antenna performs as well or superior to these representative antennas. Their approach has good potential to reduce the heterogeneity of hardware needed in such applications.

Alhassoun *et al.* present the design of a mm wave retrodirective RFID tag that makes use of a single chip, rat race coupler to achieve retrodirectivity. They demonstrate that their tag achieves at least 6dB improvement in radar cross section over comparable single antenna tags. The single chip design reduces the power consumption of the tag, the rat race design exhibits improved signal robustness and bandwidth over alternative designs in the literature. Furthermore, the compatibility of the coupler with low-power, high gain devices like

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tunnel diodes further improves the range and power consumption performance of this design, which has great potential for low-power IoT applications.

Tan *et al.* present the design of a system on chip HF RFID temperature sensor that is capable of reporting temperatures between 0 and 125°C with an accuracy of ±0.4°C. The chip has a footprint of 5.06 mm^2. The on-board temperature sensor consumes 3.5μW and has a fast-digital conversion speed of 1.48 ms. The design and testing of the chip has been covered in detail for researchers wishing to replicate the study. A fair comparison of this sensor in terms of cost, power consumption, speed and accuracy has been conducted with comparable work in the literature.

These papers represent a small sampling of the diversity of many active research topics in the field of RFID: antennas and propagation, sensors, localization, IC and reader design, system analysis, protocol improvements, etc. Undoubtedly, the field of RFID will continue to grow and encompass multidisciplinary fields of study and pose new challenges to researchers in industry and academia.

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