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Technical Session 1

Chair: Javier Vales-Alonso

Enabling IoT through Gen2 RFID: PHY/MAC Research Opportunities

Petar Šolić (University of Split & FESB, Croatia); Zoran Blažević and Maja Škiljo (University of Split, Croatia); Toni Perkovic (University of Split, FESB, Croatia)

Radio Frequency Identification (RFID) technologies were considered as the main enabler for the Internet of Things (IoT) vision due to its almost zero energy consumption and efficient price/performance ratio. Small and cost effective devices called tags can report their memory content from NLOS distances and therefore represent true replacement for old-fashioned barcodes. RFIDs are still advancing, and as already shown in the literature, there is some work to be done in order to improve overall system performances. To deal with this, research efforts made so far are concentrating on particular details of the protocol stack, while neglecting the influences that appear from the other layers. When looked integrally, to be optimal, these should be properly compensated. In this paper an overview of these influences is given while discussing open research questions and opportunities that remain to be investigated both in PHY and MAC layer.

Ring resonator based signal and power transfer at UHF frequencies

Julia Stöttner (Technical University of Munich, Germany); Norbert Seliger (FH Rosenheim, Germany)

We present low-cost, high-efficient electromagnetic coupling between open ring geometry and a so-called butterfly structure on standard printed circuit boards (FR4) for the purpose of short range wireless data and power transfer at an UHF resonance frequency of 868MHz. The components of the transfer system are characterized by simulation and experiments in terms of associated scattering parameters. Characterizing the efficiency of the coupled resonators, RF signal power transmission is examined for high power transfer as well as for low power DC supply utilizing a voltage doubler rectifier. With an enhanced butterfly structure coupler, unmodulated RF power transmission of 17.3W is achieved with an efficiency of more than 95%. Furthermore, signal transmission of Pulse-Width- Modulated (PWM) signals with frequencies up to 5MHz is demonstrated.

Effect of mobility on RFID reader-to-reader interference

Renato Ferrero and Filippo Gandino (Politecnico di Torino, Italy)

In an RFID network, the signal transmitted by a reader to query tags may interfere with the communication of other surrounding readers. As a consequence, the readers are not able to detect the weak reply from tags. The reader-to-reader interference affects readers located within a given distance, called interference range. This phenomenon can be estimated when deploying an RFID system, because the initial positions of the readers are known. It is also possible to completely avoid it by placing the readers far enough each other. However, if the readers are mobile, the distances among readers change and the probability of reader-to-reader interference dramatically increases. A theoretical analysis is conducted in this paper in order to estimate the probability of interference among static and mobile readers. The random waypoint model, one of the most common mobility models, is adopted to describe the movements of the readers. The theoretical results are validated with simulations.

Technical Session 2

Chair: Maurizio Rebaudengo

Comprehensive Measurement of Complex-valued Delta Radar Cross-section

Daniel Neunteufel; Florian Galler and Holger Arthaber (Vienna University of Technology, Austria)

While the magnitude of the delta radar cross-section (DRCS) is sufficient to characterize narrowband UHF radio frequency identification (RFID) systems, new broadband localization approaches require knowledge of the frequency dependent complex-valued DRCS. In this paper, a calibrated measurement method of the complex-valued DRCS in an anechoic chamber is introduced. Furthermore, a practical implementation based on a vector signal analyzer (VSA) and standard lab components is shown. This comprehensive setup is capable of determining the complex-valued DRCS in different frequency bands, for different power levels, and for different incident angles of the electromagnetic waves. To demonstrate this new method, measurement results of an off-the-shelf UHF EPC Class-1 Gen2 tag are shown and discussed.

ElectroMagnetic Attack Test Platform for Validating RFID Tag Architectures

Yassine Naija and Vincent Beroulle (University of Grenoble INP, France); Machhout Mohsen (Electronics and Micro-Electronics Laboratory, Tunisia)

Radio Frequency Identification (RFID) is more and more used in our daily life. Secure RFID communication is a mandatory factor in many sectors such as banking and ticketing. However, passive attacks as ElectroMagnetic Attacks (EMA) represent a serious threat for RFID tags. In this article, we propose an EMA test platform based on FPGA that allows validating RFID tag digital architectures and evaluating their security against EMA. First, we propose a tag architecture that respects the ISO/IEC 14443 type A and implements the Mifare Desfire authentication protocol. It requires 2713 LUTs (Look-Up Table) and consumes about 2 mW. Then, the EMA is performed against the block cipher embedded in this architecture with 3000 electromagnetic traces. Finally, in order to mitigate this attack, we propose a countermeasure based on a data-masking scheme (+128 LUTs) that prevents attacker to emulate the tag using a fake reader. This countermeasure hides the data input of the block cipher without modifying neither the encryption algorithm operations nor the authentication protocol as done in previous works.

Conditions for rate stability in constrained RFID networks

Javier Vales-Alonso (Universidad Politécnica de Cartagena, Spain); Pablo Lopez-Matencio (Technical University of Cartagena, Spain); Juan Jose Alcaraz (Universidad Politécnica de Cartagena, Spain); Francisco J. González-Castaño (Universidad de Vigo, Spain)

RFID networks are subject to constraints derived from the interference caused by concurrent readers operation. In this paper we discuss a general approach to decide whether a given system load produces stable operation, that is, if queue backlogs do not grow indefinitely. We assume that the RFID network operates in a time-slotted fashion, where traffic arrives as tag batches to RFID cells. The service rate (necessary to determine stability regions) of a RFID cell, given the batch size distribution and any arbitrary FSA policy is computed by simulation. This framework is illustrated with several examples.

Tachnical Session 3

Chair: Markus Rupp

Experimental Validation of Anti-Collision Protocols for RFID Sensor Networks

Laura Arjona; Hugo Landaluce and Asier Perallos (University of Deusto, Spain); Joshua R. Smith (University of Washington, USA)

Currently, there is an increasing interest on the use of RFID systems with passive or battery-less tags with sensors incorporated, also known as computational RFID (CR- FID) systems. These passive tags use the reader signal to power up their microcontroller and an attached sensor. Following the current standard EPC C1G2, the reader must identify the tag (receive the tag EPC) prior to receive data from its sensor. In a typical RFID scenario, several sensor tags share the reader interrogation zone, and during their identification process, their responses often collide, increasing their identification time. Therefore, RFID application developers must be mindful of tag anti-collision protocols when dealing with CRFID tags in dense RFID sensor networks. So far, significant effort has been invested in simulation-based analysis of the performance of anti-collision protocols regarding the tags identification time. However, no one has explored the experimental performance of anti-collision protocols in an RFID sensor network using CRFID. This paper: (i) demonstrates that the impact of one tag identification time over the total time required to read one sensor data from that same tag is very significant, and (ii) presents an UHF-SDR RFID system which validates the improvement of FuzzyQ, a fast anti- collision protocol, in relation to the protocol used in the current RFID standard.

A dense RFID network for flexible Thermal Monitoring

Edoardo Giusto, Filippo Gandino, Maurizio Rebaudengo, Bartolomeo Montrucchio and Michele Luigi Greco (Politecnico di Torino, Italy)

Indoor climate control is a key feature for smart homes. Automatic systems exploit data collected by temperature sensors for managing heating, ventilation, and air conditioning. A dense deployment of sensors would be beneficial for improving the quality of the control. This requires the adoption of a pervasive technology for thermal monitoring. This paper investigates the adoption of RFID technology for this task. This kind of technology simplifies the quick development of monitoring systems thanks to its flexibility and ease of integration. By leveraging a long transmission range, multiple sensors can easily be deployed in different environments without the hassle of cable handling and avoiding conflicts among readers. A case study with field test shows that the RFID network is suitable for thermal monitoring, and that a high level of sensor density provides useful data to tune the climate control.

A simulation-based comprehensive study of the LBT mechanism in RFID networks

Pablo Lopez-Matencio and Javier Vales-Alonso (Technical University of Cartagena, Spain)

Radiofrequency Identification (RFID) installations with passive tags pose the interference problem among readers. Tags require a minimal power-up signal strength sent by the reader to operate and therefore the system is very sensitivity to interferences. To face this issue, two mechanisms are used: (a) an anti-collision protocol, which serves to solve tags' collisions, and (b) a network coordination protocol, which coordinates readers operation to avoid them transmitting at the same time (and thus interfering each other). In this paper we address a thorough study of the standardized coordination protocol Listen Before Talk (LBT), which has been issued by the European regulation ETSI 302 208. The goal is describing the network operation in

terms of the achievable throughput, by carefully detailing all the critical settings of a real facility: (a) a physical model for the channel which involves precise computations of powers and gains, sensitivities and channel fading, (b) modeling the anti-collision mechanism ISO 18000-6C (Framed Slotted Aloha), (c) precise operation of the LBT according to the ETSI regulation, (d) realistic traffic modeling (batch works), and (e) accurately computing the precise operation among readers. A variety of results is provided, which are mainly in these categories: throughput versus traffic, versus cell layout, versus network layout, versus reader and anti-collision protocol setup. They can be employed by practitioners in real-world application to understand the performance of RFID networks.