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Authors	Title	Keywords	Abstract (initial)
Sushim Mukul Roy*, Isaac Balbin, Nemaï Chandra Karmakar	Novel N - way Power Divider and Array Configuration for RFID Readers operating at 5.8 GHz	Building Block System Components; Reader Antenna Designs	A novel N - way power divider has been designed to be used in arrays for the development of readers in RFID systems. In contrast with the conventional power dividers, this power divider can accommodate any number of power division starting from 1 to 16 and higher from one central circular microstrip patch acting like a hub. Like other conventional power dividers, this power divider can also be put in cascade. The power divider is broadband in nature and greatly reduces space used by arrays compared to the conventional designs. Additionally, the scope of this power divider to be used in RFID systems is huge opening an entire new approach to tracking electronics.
Gregory Durgin*, Anil Rohatgi	Multi-Antenna RF Tag Measurement System Using Back-Scattered Spread Spectrum	Channel Measurements and Modeling; Tag Antenna Theory and Designs; Reader Antenna Designs	This paper presents the design, construction, and operation of a unique measurement system capable of recording simultaneous antenna measurements in a backscatter radio configuration with genuine mutual coupling effects. The system allows rapid-fire design and testing of the increasingly important multi-antenna RF tag designs as well as low-level physical-layer experiments involving anticollision (numerous RF tags communicating with one another in a common field of view), RF tag shadowing, and multi-antenna fading experiments.
Shi-Cho Cha*, Kuan-Ju Huang, Hsiang-Meng Chang	An Efficient and Flexible Way to Protect Privacy in RFID Environment with Licenses	Data Access and Privacy Issues; System Security Solutions	To release the tension between the convenience and the privacy risk brought by RFID systems, organizations are requested to disclose their policies about RFID activities, to obtain a customer's consent, and to adopt appropriate mechanisms to enforce the policies. However, current researches on RFID typically focus on the enforcement part - to protect personal data stored in RFID tags and to prevent organizations from tracking a person through the information emitted by specified RFID tags. There is a missing piece for customers to achieve agreements with organizations efficiently and to limit organizations' RFID activities flexibly. This paper proposes a new technical and legal approach for responding to concerns about the privacy of personal data in RFID systems by extending the framework of Online Personal Data Licensing (OPDL) and applying the framework to RFID environment. In our proposed approach, organizations must obtain licenses before collecting a person's data via RFID technologies. The digitalized and standard licenses can further be checked automatically to ensure that the collection and use of a person's data is strictly under the the person's consent. While individuals can control who have licenses and the content of the licenses easily, the framework can hopefully provide an efficient and flexible way to overcome the deficiency of current privacy protection technologies for RFID system.
Darmindra Arumugam*, Daniel Engels	Characterization of RF Propagation in Helical and Toroidal Metal Pipes for Passive RFID Systems	EMC/RF Radiation; Interoperability	In this paper we extend the theory of radio frequency (RF) propagation within helical and toroidal metal pipes. This work is motivated by the need to understand the operation of UHF radio frequency identification (RFID) systems when the tags are placed within toroidal metal pipes. The field components inside a helical metal pipe are derived to obtain the propagation and attenuation constants and the different transverse electric and transverse magnetic modes. The cutoff frequencies, attenuation and angle of deployment are used within the theory to identify operating limitations of passive RFID systems in hollow helical metal pipes. The helical model is then simplified to describe the case of a toroidal metal pipe. This theory extends existing theories of propagation within cylindrical metal pipes to form a comprehensive general theory. Analytical evaluations are used to visualize the tags within the metal pipes and to validate the theory presented in this paper. This

			evaluation presents the propagation of RF waves within toroidal, bent and cylindrical metal pipes. The general theory is shown to predict, and simulations are revealed to confirm that UHF RFID tags can be read under certain conditions within narrow pipes whose cutoff is below UHF frequencies.
Dilek Dagdelen Uysal*, Jean-Pierre Emond, Daniel Engels	Evaluation of RFID Performance for a Pharmaceutical Distribution Chain: HF vs. UHF	Frequency; Testing	In this paper, we investigate and compare the use of passive HF and UHF RFID systems for the item level identification of pharmaceutical products throughout their supply chains. We compare the overall identification performances of both types of RFID systems on individual products and on totes filled with tagged products. Scenarios representative of all aspects of the pharmaceutical distribution chain from the manufacturer to the retailer are considered. We conclude that the tested passive UHF RFID system provides significantly superior identification performance than do passive HF RFID systems.
Geoffroy Gosset*	Very High Efficiency 13.56 MHz RFID Input Stage Voltage Multipliers Based On Ultra Low Power MOS Diodes	Low-power Design; Energy Harvesting; Building Block System Components	This paper presents an ULP (Ultra-Low-Power) diode based voltage multiplier which is used to convert RF input signal to DC supply voltage. This uses an input signal of 1V peak to peak and 13.56MHz frequency and reaches 3V at its output with 10 diodes. The IC is implemented in a 2 $\mu$ m-multiple threshold voltage- SOI CMOS technology. The IC outperforms classical MOS diodes based voltage multiplier, implemented on the same technology, from the point of view of efficiency (minimum RF input power for given output specifications) and impedance.
Ibon Zalbide*, Julia Vicario, Igone Velez	Power and energy optimization of the digital core of a Gen2 long range full passive RFID sensor tag	Low-power Design; Integrated Sensors; Building Block System Components	The communication range of a passive RFID is severely limited by the total power consumption of the tag. Even more if a sensor is implemented within the tag. This paper studies the energetic behavior of an EPC Gen2 compliant RFID sensor tag and presents a power optimized architecture in order to maximize the communication range. Moreover, a criteria to select the optimum value of the supply capacitor is presented. Results are obtained for the 0.35 $\mu$ m technology of X-FAB (XL035). The proposed techniques make it possible to achieve a significant power consumption reduction and thus, double the communication range.
Carlo Mutti*, Christian Floerkemeier	CDMA-based RFID Systems in Dense Scenarios: Concepts and Challenges	Modulation and Detection; Reader System Architecture	We identify the requirements and challenges of radio frequency identification (RFID) systems in dense scenarios, i.e. when the number of tags is very large. Current systems can only read one tag at one time, and if multiple tags respond together a collision is detected, and no data is read. An increasing number of applications require to efficiently read a large number of tags in a short time. Solutions to this problem which involve multiple tags being read simultaneously are very attractive as they increase the system efficiency, and have the potential to reduce the reading identification time. The paper assesses the performance gain of a spread-spectrum multiple-access scheme for RFID systems, in particular comparing the system efficiency and the identification time, with current systems used in dense environments.
Daniel Yeager*, Pauline Powledge, Richa Prasad, David Wetherall, Joshua Smith	Wirelessly-Charged UHF Tags for Sensor Data Collection	Non-silicon-based Structures; Low-power Design; Integrated Sensors	We present the WISP Passive Data Logger (PDL), an RFID sensor data logging platform that relies on a new, wirelessly-charged power model. A PDL has no battery yet (unlike a passive sensor tag) is able to collect data while away from an RFID reader. A PDL senses and logs data using energy stored in a capacitor; the capacitor can be wirelessly recharged (unlike active tags), and data can be uploaded whenever the PDL is near a reader. Standard EPC Generation 2 readers are used for WISP-PDL charging, ID-reading, and sensor data transfer. This allows WISP-PDLs to operate using commercial RFID readers as the only support infrastructure (for both data and power), and allows WISP-PDLs to co-exist with standard RFID tags. We describe the design and implementation of a prototype WISP-PDL, and report results from a short demonstration study that shows it can monitor the temperature and fullness of a milk carton as it is used over the course of a day.
Christian Klappf*, Albert Missoni, Wolfgang Pribyl, Günter Hofer, Gerald Holweg,	Improvements in Operational Distance in passive HF RFID Transponder Systems	Novel System Designs for Tags; Building Block System Components;	This paper introduces new transponder-design concepts which aim to enhance the working range in passive HF RFID systems. Sideband theory, system architecture, chip design, verification and interdependencies will be discussed. Testchip measurements show a decrease of 40% in field strength requirements for operation. The working range enhancement compared to products currently available on the market is at least 20% depending on the reader unit setup.

Walter Kargl		Modulation and Detection	
Nilo Rivera*, Rosemary Mountain, Lia Assumpcao, Allen. A. Williams, Cooper A. B., Douglas L. Lewis, Richard C. Benson, Joseph A. Miragliotta, Michael Marohn, Taylor Russell H.	ASSIST - Automated System for Surgical Instrument and Sponge Tracking	Novel System Designs for Tags; Issues in Patient Safety	Every surgical item used during surgery (e.g., sponges) must be accounted for after surgery to ensure that none of these items is left inside the patient. Despite the numerous precautions in place, in approximately 1 in 1500 cases, something gets left behind inside the patient's body. This paper presents ASSIST, an automated system for surgical instrument and sponge tracking that increases the safety of surgical procedures. ASSIST utilizes RFID (Radio Frequency Identification Detection) technology to aid in accounting for all items used during surgery. The design takes into account safety, simplicity, ease of deployment, and ease of use. An initial evaluation utilizing RFID-tagged sponges demonstrates that ASSIST can reliably track surgical sponges with minimal impact to current operating room procedures. The end result is two-fold: The risk of error is decreased, and the operational cost is reduced, for each intervention.
Alex Janek*, Christian Steger, Josef Preishuber-Pflugl, Markus Pistauer, Reinhold Weiss	Functional Verification of Future Higher Class UHF RFID Tag Architectures based on Cosimulation	Novel System Designs for Tags; Low-power Design; Energy Harvesting	Today's applications for UHF RFID tags require a high operating distance and communication performance, sensing and monitoring capabilities to allow tracking of environmental parameters, autonomous data processing, alarm handling and large memory areas. and drive them to become embedded systems of increased complexity and high energy consumption. %The development of such complex embedded system requires functional verification of the various system components. This work proposes a novel tag architecture satisfying today's and future requirements on higher class UHF RFID systems with mentioned functionality and incorporating energy harvesting devices as additional tag power supply. A novel simulation concept for the functional verification of the architecture is presented, which is based on a cosimulation approach. It combines system level models of the UHF RFID system with hardware level descriptions of performance and components defining th energy consumption of the tag. To prove the proposed simulation concept, a part of the entire system model is presented at the end of the paper together with related simulation results showing the benefits of the implementation.
Raj Bridgelall*	Introducing a Micro-Wireless Architecture for Business Activity Sensing	Novel System Designs for Tags; Ranging and Localization; System-on-a-chip	RFID performance deficiencies discovered in recent high profile applications have highlighted the danger of selecting only passive tags for an application because of their lowest cost relative to other types of RFID tags. Consequentially, battery-based RFID technologies are being considered to fill those performance gaps. A mix of both passive and battery-based RFID technologies can provide a more cost effective and robust solution than a homogeneous RFID deployment. However, it is easy to choose the wrong battery-based RFID technology given the confusing array of choices currently available. This paper explores the performance deficiencies of both passive and battery-based RFID technologies. A new micro-wireless technology that resolves these performance deficiencies is then introduced. Finally an application example is presented that demonstrates how the new technology can also seamlessly roam between passive and battery-based RFID infrastructures at the lowest possible cost to bridge their respective performance gaps.
Nicolas Pillin*, Norbert Joehl, Catherine Dehollain, Michel Declercq	High Data-Rate RFID Tag/Reader Architecture Using Wireless Voltage Regulation	Novel System Designs for Tags; Reader System Architecture; Modulation and Detection	This paper discusses a novel tag/reader system, based on the passive, far-field RFID principle, with megabits per second read capability at operating ranges of several centimeters. The system operates in the ISM band at 2.45 GHz. A maximum data rate of 4 Mbps was demonstrated, at a tag/reader distance of 5.5 cm. The tag is entirely realized in a standard CMOS process for minimum costs. The described system also uses wireless voltage regulation, an innovative technique that allows to improve the overall efficiency of wireless power transmission and to save power on reader side. According to the measurement results, it is shown that the efficiency was improved by a factor larger than four in the best case.
Stevan	A Novel Chipless RFID	Novel System	RFID is taking the world by storm but lowering the price of the tag is a necessity in order to completely replace

Preradovic*, Isaac Balbin, Nemai Chandra Karmakar, Gerry Swiegers	System Based on Planar Multiresonators for Barcode Replacement	Designs for Tags; Tag Antenna Theory and Designs; Spectral Management	barcode systems with RFID systems. Researchers around the world have been working on chipless RFID systems. In this paper we present a novel chipless RFID system for barcode replacement. The system can be effectively used in conveyor belt applications. It uses spectral signatures to encoded data and hence provide a unique ID for every tagged object., The chipless tag is fully passive and planar.
Vladimir Kulyukin, Aliasgar Kutiyanawala*, Edmund LoPresti, Judith Matthews, Richard Simpson	iWalker: Toward a Rollator-Mounted Wayfinding System for the Elderly	Ranging and Localization; Integrated Sensors	Research on intelligent walkers aims at helping elderly individuals to maintain their independence in familiar and unfamiliar environments. Several walkers have been developed by researchers at the Carnegie Mellon University and the University of Pittsburgh. This article contributes to this research venue by describing the design and initial evaluations of iWalker, a multi-sensor rollator-mounted wayfinding system for the elderly. The primary difference of the proposed navigation aid from other intelligent walkers is that iWalker emphasizes a smart world (SW) perspective. A SW is a physical space equipped with embedded sensors, e.g. passive RFID tags. By integrating inexpensive sensors into the environment, the cost and complexity of the walker itself can be reduced.
Po Yang*, Wenyan Wu	SLAM Algorithm for 2D Object Trajectory Tracking based on RFID Passive Tags	Ranging and Localization; Novel System Designs for Tags	Tracking the physical location of nodes in a 2D environment is critical in many applications such as camera tracking in virtual studio, indoor mobile objects tracking. RFID technique poses an interesting solution to localizing the nodes because the passive RFID tags could store the position unit information according to unique tag ID. Based on tags pattern, algebraic approach could solve the 2D trajectory tracking problem. However, the tracking accuracy of this approach is highly related to the tags position distribution and position unit. It would be inaccurate for some erratic trajectory tracking. Thus, we would try to apply and evaluate the probabilistic approaches, such as SLAM (Simultaneous Localization and Mapping), into RFID tag based trajectory tracking. In this paper, we propose an RFID tag based SLAM algorithm for 2D trajectory tracking. Also a technique called Map adjustment is proposed to increase the efficiency of the algorithm. The simulation results show that the approach could improve the accuracy for some parts of trajectory tracking compared to RFID algebraic approach. The limitation and future work are given in the conclusion.
Andreas Löffler*, Uwe Wissendheit, Dina Kuznetsova	GIDS - A system for combining RFID based site information and web based data for virtually displaying the location on handheld devices	Ranging and Localization; Reader System Architecture	This paper describes a system which combines RFID and mapping of location based coordinates. A RFID transponder which contains the location of itself and optional information e.g. about the location, building, history, etc. is read out by a developed RFID HF reader. This reader processes the information and forwards it to a computer which is connected to a database/intranet or the Internet. On this computer a LabVIEW based application is running. This application is responsible for processing the data from the transponder and for mapping the location of the RFID transponder on a graphical output, which is based on the Google Maps environment shown in a web browser plugin, by using LLA1 information from Google Maps. This is done by applying certain scripts (realized in JavaScript) to the program which uses the Google Maps API to create standard and special-made maps. Also a first step is done by porting this system to a mobile platform by using the Nokia 6131 NFC mobile phone as RFID reader.
Nemai Chandra Karmakar*, Sushim Mukul Roy, Muhammad Saqib Ikram	A Compact Low Cost Planar Smart Antenna for RFID Reader at 900 MHz	Reader Antenna Designs	Radio Frequency Identification (RFID) systems have many important applications in the 900 MHz frequency band. A 3x2-element planar smart antenna for RFID readers in a low cost compact package is developed. The smart antenna covers 860-960 MHz frequency band with more than 10 dB input return loss, 12 dBi broadside gain and up to 40° elevation beam scanning with a 4-bit reflection type phase shifter array. Once implemented in the mass market, RFID smart antennas will contribute tremendously in the areas of RFID tag reading rates, collision mitigation, location finding of items and capacity improvement of the RFID system
Jeong-Jin Kang, Dong-Joon Lee*, Chia-Chu Chen,	Compact Mobile RFID Antenna Design and Analysis Using Photonic-	Reader Antenna Designs;	We present the design and analysis of a small planar loop antenna for applications in mobile RFID readers within the cell phone band. In the design of the antennas for mobile handsets, size reduction is one of the crucial factors and the compactness of the loop antenna is realized by bending a folded-dipole in a circular fashion.

John F. Whitaker, Edward J. Rothwell	assisted Vector Near-field Characterization	Testing; EMC/RF Radiation	Furthermore, a capacitive loading, through a parasitic patch, is created inside the loop antenna and has an effect of increasing the electrical length of the structure. This enhanced length provides the tunability of the resonance frequencies and a secondary dominant radiation port in the center of the antenna. A short planar dipole is transformed to a twice folded dipole and a loop antenna to produce a larger input resistance. We also analyze the performance of the RFID antenna by exploring the current-induced near field radiation patterns using a non-invasive photonic-assisted dielectric field mapping system. The evolution from the near to the far field is also discussed.
Christian Floerkemeier*	Integrating RFID Readers in the Enterprise IT - Overview of Intra-organizational RFID System Services and Architectures	Reader Deployment and Operation; Scalable Deployment Technologies; Reader System Architecture	RFID system deployments require the configuration, monitoring and data management of RFID readers. This paper provides an overview of different services deployed in intra-organizational RFID systems. The paper also analyzes different system architectures implemented today. Our analysis distinguishes a centralized architecture, where a controller device or a software component on an application server locally controls the RFID readers, and an autonomous architecture, where the RFID readers execute application logic and are managed by enterprise IT management systems. The paper also discusses how emerging standards developed by EPCglobal relate to these architecture types.
Sudhanshu Gakhar*, Joseph Feldkamp, Mark Perkins, Rensheng Sun, C. J Reddy	Engineering RFID systems through Electromagnetic Modeling	Reader Deployment and Operation; Tag Antenna Theory and Designs; Ranging and Localization	RFID technology provides a more granular visibility for industrial assets and inventory thereby offering a strategic advantage to the business. This paper introduces a methodology for deploying RFID systems and engineering solutions based on fundamental electromagnetic understanding of the deployed scenarios. A virtual database comprising of RFID tags, antennae and experimental setup was first created and verified. Experiments were then conducted to develop trends both in lab-based and virtual environments. These trends were then validated against each other to show feasibility of using electromagnetic models to simulate and engineer RFID systems.
Cheng-Hao Quan, Jin-Chul Choi*, Gil-Young Choi, Chae-Woo Lee	The Slotted-LBT: A RFID Reader Medium Access Scheme in Dense Reader Environments	Reader Synchronization and Regulatory Compliance; Reader System Architecture; Ranging and Localization	RFID technology as a core technology for realizing ubiquitous environment is emerged. Although it was developed rapidly in the past a few years, the read rate is still concerned in the RFID technology adoption. At the same time it is also a technical issue which must be resolved. In order to increase the read rate, a number of researches have focused on the air protocol method and the medium access method. In this paper, we propose a distributed Slotted-LBT method to increase the numbers of readers which can read tags at the same time and to provide stable channel access time and to reduce the interference among readers by using the channel zone. From the results in this research, compared with the existing normal LBT method, the proposed Slotted-LBT method shows that the coefficient of variation for the channel access time is reduced from 96% to 38% and the effect of interference is reduced by 28.48%. Besides, since each channel can be controlled separately, we can use the categorized channels according to demanding feature of manifold applications.
Pekka Pursula*, Heikki Seppä	Hybrid Transformer Based Adaptive RF Front End for UHF RFID Mobile Phone Readers	Reader System Architecture; Low-power Design	We introduce hybrid transformer based adaptive RF front end for UHF RFID readers. Small, narrow band antennas with high radiation efficiency can be utilized with an adaptive tuning of the antenna. The adaptivity also increases immunity to environmental changes, like detuning of the antenna by user hand. The hybrid transformer based electronics provides high isolation from TX to RX and eliminates the need for a cumbersome and expensive circulator. The small size of the module including the antenna enables integration to mobile phones.
Seon Mi Yeo*, Bu Won Jeon, Jae Hyun Bae, Young joo Moon, Hyoung Hwan Roh, Park	Analysis of Interference Effects on UHF RFID service Environment	Reader System Architecture; Modulation and Detection; Reader	UHF (Ultra High Frequency) RFID (Radio Frequency IDentification) has been known to be the one of key technologies. Due to its numerous advantages compared to other identification systems pre-existing with trends of electronic devices, RFID systems are now beginning to conquer those new mass markets. Particularly on UHF band passive RFID; it has drawn a great deal of attention since it enables recognition from a distance. Several major supply chain corporations such as Wal-Mart and Tesco have planned to mandate the use of UHF

Jun Seok, Seong Yeong Rak, Oh Ha Ryoung		Deployment and Operation	RFID in their product lines, which operates at 860-960MHz. However, since RFID networks basically consists of radio communication components, various environmental effects which causes adverse results are now being issued. Different types of readers neighboring in shorten interrogation range and comparatively narrow band of frequency will correlated each other, and thus the coupling effects can be occur. In case of dense reader environments, such issues are now being the most critical factor to be considered for establishing local standards. In this paper, from the fundamental difficulties through the modern trends, a new channel utilization scheme for UHF RFID dense reader environment will be presented.
Laurent Simon, Poompat Saengudomlert*, Urachada Ketprom	Speed Adjustment Algorithm for an RFID Reader and Conveyor Belt System Performing Dynamic Framed Slotted Aloha	Reader System Architecture; Novel System Designs for Tags; Modulation and Detection	Dynamic environments pose a challenge to the read performances of current RFID systems. Moving tags on a conveyor belt affects the read performance of a static reader. This paper attempts to evaluate a static reader identifying moving tags on a conveyor belt. We propose an algorithm enabling the conveyor belt to dynamically adjust its speed for the RFID reader to reliably identify tags without prior knowledge of how tags are distributed on the conveyor belt. We show by simulations that our algorithm yields more than 99% of tags being successfully identified, along with trying to maximize the average speed of the conveyor belt. In addition, the algorithm can be applied for different reader's ranges.
Christian Floerkemeier*, Ravikanth Pappu	Evaluation of physical and logical layer RFID Simulation Engine	Reader System Architecture; Reader Deployment and Operation; Testing	Radiofrequency identification poses a number of research challenges, such as interference mitigation, throughput optimization and security over the RF channel. In this paper we investigate to what extent the physical and logical layer simulation engine RFIDSim can be used to evaluate RFID system performance. Our analysis compares simulation results against measurements with RFID equipment. We investigate timing, medium access, capture, and fading behaviour.
Jae Sung Choi*, Hyun Lee, Daniel Engels, Ramez Elmasri	Robust and Dynamic Bin Slotted Anti-Collision Algorithms in RFID System	Reliability	In this paper, we present the Dynamic Bin Slotted memoryless anti-collision algorithm (DBS) and the Robust Dynamic Bin Slotted memoryless anti-collision algorithm (RDBS) (which is a countermeasure of strong and weak tag problems). These algorithms are based upon a bin slot tree algorithm. Both of these algorithms combine deterministic and probabilistic approaches for efficiency of the algorithms. We suggest a simple estimator to estimate the number of tags in an interrogation zone that is optimized for bin-slot tree algorithms. Our performance evaluation shows that DBS and RDBS surpass other existing bin slotted algorithms. According to our simulation results, the total identification time of the DBS algorithm for all tags is reduced by 59.71% for 500 tags compared to the conventional Bin Slotted Algorithm (BSA). Moreover, under the strong-weak tag problem, the RDBS algorithm increases the identification rate by more than 9.2% over the Bin-slotted Hybrid Search Algorithm which is the best reported variation of BSA.
Zang Li, Chao-Hsien Chu*, Wen Yao	SIP-RLTS: An RFID Location Tracking System Based on SIP	Scalable Deployment Technologies; Ranging and Localization; Interoperability	RFID (Radio Frequency Identification) has recently being favorably considered as a cost-effective alternative for indoor location tracking. However, most implementations use active tags, which are more expensive and may not work with other pervasive devices such as IP Multimedia systems or cell phones. In this paper, we propose an RFID-enabled location tracking system, SIP-RLTS, based on SIP (Session Initiation Protocol). Our proposed solution can be used for both Push and Pull location tracking modes and can be used with either active or passive tags. The use of SIP infrastructure, coupled with the proposed location- oriented middleware extension, Ontology infrastructure and semantic integration, making SIP-RLTS a more cost-effective solution for the next generation communication services.
Mithu Bhattacharya, Chao-Hsien Chu, Tracy Mullen*	A Comparative Analysis of RFID Adoption in Retail and Manufacturing Industries	Scalable Deployment Technologies; Social Implications of RFID	Radio Frequency Identification (RFID) technology mandates by large retailers and various government agencies have driven compliance requirements for many organizations implementing the technology. In this paper, we use content analysis methodology and examine open literature, news releases, and industry white papers to identify and compare current implementation status, adoption drivers, potential benefits, supply chain locations, applicable tasks, and challenges of implementing RFID in the retail and manufacturing industries. Our analysis concluded that whereas RFID applicable tasks for retail and manufacturing industries are significantly different,

		Technology; Testing	the adoption drivers, benefits, supply chain locations, and challenges are similar.
Tatsuya Inaba*	Value of Sparse RFID Traceability Information in Asset Tracking during Migration Period	Social Implications of RFID Technology; Ranging and Localization; Interoperability	We present a model to infer the location of assets in a supply chain network by using sparse traceability information and evaluate the model by a numerical study. The sparseness of the traceability information is a typical problem when an existing supply chain is migrating to an RFID-enabled one, and the lack of models that quantitatively show the value of sparse information delays this migration process. Our model is a solution to this situation. The target industry we focus on in this study is the returnable transport item rental service industry, in which RFID deployment has been already started. This model in conjunction with a simulator used to evaluate the model will be used as a tool to accelerate the deployment.
Shuihua Han*	Tamper Detection in RFID-enabled supply chains Using Fragile Watermarking	System Security Solutions	This paper highlights potential security threats especially data tampering in RFID-enabled supply chains and how they might be addressed using fragile watermarking technologies. We first survey RFID system and its security attacks, and then explain the importance of fragile watermarking schemes for RFID system and possible application using fragile watermarking to detect and locate any modifications in RFID. Finally we suggest possible solutions using fragile watermarking for RFID-enabled supply chain
Xuefei Leng*, Keith Mayes, Konstantinos Markantonakis	HB-MP+ Protocol: An Improvement on the HB-MP Protocol	System Security Solutions; Data Access and Privacy Issues	This paper reviews a new lightweight protocol in the HB-family of protocols for RFID. We show an effective man-in-the-middle attack against the HB-MP protocol since the rotation of a secret key is predictable to the attacker. An enhanced version of the HB-MP protocol is proposed to randomise the rotation of the secret key and resist the man-in-the-middle attack. The paper proposes the use of round keys that may be produced by rotation or more generally by a non-linear function. A general form of this HB-MP <sup>+</sup> protocol is proposed at the end of this paper.
Rainer Falk, Florian Kohlmayer, Andreas Koepf, Mingyan Li*	High-Assurance Avionics Multi-Domain RFID Processing System	System Security Solutions; Software Defined Radio	Distributed processing of RFID information enables new RFID applications where tags, readers and processing systems belong to different administrative domains and where multiple RFID applications are realized using a common reader and processing infrastructure. A novel distributed RFID processing architecture supporting various future eEnabled airplane applications based on RFID technology is described. In a particularly challenging application environment, RFID readers are installed on-board of airplanes and connected dynamically by wireless communication with various ground system at airports and during maintenance. The airplane RFID reader infrastructure has to be dynamically integrated with different ground systems. The security requirements caused by this temporal integration within different administrative domains and corresponding solution approaches are described.
Benjamin Braaten*	A Printed Rampart-Line Antenna with a Dielectric Superstrate for UHF RFID Applications	Tag Antenna Theory and Designs	A novel printed Rampart line antenna with a dielectric superstrate for passive RFID tags is presented. A design process is outlined to determine the number of elements used in the Rampart line antenna to achieve the required gain for the desired read range. An inductive loop is then added to the port to match the antenna with the passive tag circuitry. It is shown that a passive tag with a printed Rampart line antenna and a dielectric superstrate can achieve comparable read ranges to commercially available passive RFID tags.
Frank Deicke*, Hagen Grätz, Wolf-Joachim Fischer	Combined System Analysis and Automated Design of RFID Transponder Systems	Tag Antenna Theory and Designs; Reader Antenna Designs; Channel Measurements and Modeling	RFID transponder systems including ID and sensor functionality conquer more and more new application areas. Especially passive transponders with integrated sensors represent miniaturised and autonomous functionalities. That can be used in industry for process monitoring or automation. Just as well complex and implantable diagnostic systems are available in e.g. medical engineering using that technology. Until now, simple approximated or closed formulas are often used for system design. Considering the numerous applications with different specifications introduced above, that method does not meet the requirements of accuracy for most cases. On the other hand numerical tools using e.g. FEM are well known. But automated system optimisation can only be done partly and with big efforts. Considering that, this paper focuses on methods for a combined system analysis and an automated design of RFID transponder systems to open up that bottleneck. The most important goal of the presented methods is a high efficiency and a sufficient accuracy. That is necessary to

			consider field models and electrical circuit models concurrently and to find an optimal solution within an adequate amount of time. The methods are brought together in a new software tool called TransCal. It could be an interesting approach to design the transmission channel, to optimise the antennas and to integrate it into the whole system.
Pavel Nikitin*, KVS Rao	Antennas and Propagation Issues in UHF RFID Systems	Tag Antenna Theory and Designs; Reader Antenna Designs; Channel Measurements and Modeling	In this paper, we discuss various antenna and propagation issues in passive UHF RFID systems such as front end antenna configurations for readers, forward and reverse link limitations, multi-path effect on tag range, etc. We support our discussion with experimental measurements and provide a comprehensive literature review.
Huafei Zhu	Aggregating Symmetric/Asymmetric Attestations	Tag Features for Security	The computation complexity and communication complexity are two prime factors related to energy consumptions of an RFID system. Since the larger bits of communication and computation need higher energy consumption, it is certainly welcome if the computation complexity and communication complexity of an RFID system are low while security and privacy of the system are achieved in a desired level. This leaves an interesting research problem when an RFID is used for identifying tags: given $\sigma_i = (m_i, id_i, f(k_i, m_i, id_i))$ , where $f$ is a cryptographic primitive (say, a message authentication code, or a digital signature scheme), and $k_i$ is a secret key shared between tag $\mathcal{T}_i$ and a processor $\mathcal{P}$ ( $i=1, \dots, l$ ), we ask whether there exists an efficient polynomial time algorithm $g$ such that on input $f(k_i, m_i)$ , it outputs an aggregate of message authentication codes (or signatures) $T$ ( $T \stackrel{\triangle}{=} g(f(k_1, m_1), \dots, f(k_l, m_l))$ ) such that the size of $T$ is independent of $l$ while the computation complexity of $g$ is as lower as possible; furthermore, the validity of individual attestation can be checked efficiently given $T$ ? $\text{\textbackslash medskip}$ $\text{\textbackslash noindent}$ Since an attestation can be produced by a message authentication scheme or a digital signature scheme, we consider the following two cases separately: $\text{\textbackslash noindent}$ - Aggregating symmetric attestations (or message authentication codes): we define $g(f(k_1, m_1), \dots, f(k_l, m_l)) = f(k_1, m_1) \otimes \dots \otimes f(k_l, m_l)$ , where $f$ is any secure message authentication algorithm and $\otimes$ is a simple operator suitable for software implementation (e.g., XORing, modulo addition and multiplication). $\text{\textbackslash noindent}$ - Aggregating asymmetric attestations (or digital signatures): we define a function $g$ for aggregating asymmetric attestations that is admissible to the algebraic structure of underlying one-way functions and $\otimes$ is a simple operator suitable for software implementation (e.g., XORing, modulo addition and multiplication). $\text{\textbackslash medskip}$ $\text{\textbackslash noindent}$ We show that 1) assuming the existence of a cryptographically secure message authentication
Akira Yamamoto*, Shigeya Suzuki, Hisakazu Hada, Jin Mitsugi, Fumio Teraoka, Osamu Nakamura	A Tamper Detection Method for RFID Tag Data	Tag Features for Security; Novel System Designs for Tags; System Security Solutions	Recently, system designer, especially in the field of product life-cycle management system start considering use of user memory bank of UHF RFID tags. By storing most useful life-cycle data onto a tag, user can access to data even without access to back-end databases. One of the major issues to make use of the user memory bank is detection of tampering by third parties. Although technology vendors start introducing better functionalities such as fine grained locking along with high capacity user memory, these tags with newer functionalities require new non-standardized air protocol to operate -- require modified version of reader/writer. Also, these tags are usually more expensive. In this paper, we introduce a novel approach to this problem: "Tag Memory Cloaking," with tag side write journaling mechanism. Cloaked memory region is only readable and not writable from external devices to tag such as reader/writer, but writable by tag itself. Also, modified tag user memory write logic add journal entry -- offset and length of write -- into the cloaked memory region on each write

			request. Later, user can check existence of overlapped write to user memory by checking journal records. Since we have not modified any of tag air protocol, standard compliant read/writer can fully capable of all of our proposed operations: write to the tag, read, then detect unusual modification to user memory area. We have implemented the functionality to Programmable Battery Assisted Passive tag (BAP), then validated the functionalities with several standard compliant reader/writers.
Yong Ki Lee*, Lejla Batina, Ingrid Verbauwhede	EC-RAC (ECDLP Based Randomized Access Control): Provably Secure RFID authentication protocol	Tag Features for Security; System Security Solutions	Operational and security requirements for the RFID systems such as the system scalability, the anonymity and the anti-cloning are difficult to obtain due to the constraints in area, memory, etc. Due to the scarceness of resources most of the proposed protocols were designed using symmetric key cryptographic algorithms. However, it has been shown that it is inevitable to use public key cryptographic algorithms to satisfy these requirements. Moreover, general public key cryptography based authentication protocols are vulnerable in terms of anonymity, which is shown in this paper. Accordingly, we design a new authentication protocol named EC-RAC using EC (elliptic curve) cryptography. EC-RAC can be proved for its security in the generic group model and is carefully designed to minimize its computational workload. Moreover, we present the implementation results of EC-RAC to show its feasibility for the RFID systems.
Srinivas Devadas*, Edward Suh, Ziola Thomas, Vivek Khandelwal	Design and Implementation of "Unclonable" RFID ICs for Anti-Counterfeiting and Security Applications	Tag Features for Security; System Security Solutions	Physical Unclonable Functions (PUFs) exploit the physical characteristics of the silicon and the IC manufacturing process variations to uniquely characterize each and every silicon chip. Since it is practically impossible to model, copy or control the IC manufacturing process variations, PUFs not only make these chips unique, but also "unclonable." Additionally, PUFs also provide a secure, robust, low cost mechanism to authenticate each and every silicon chip. This makes PUFs attractive for RFID ICs where cost and security are the key requirements. In this paper we present the design and implementation of PUF enabled "unclonable" RFIDs, summary of extensive testing done at Pufco. We also highlight the advantages of PUF based RFIDs in anti-counterfeiting and security applications.
Byung Youn Song*, Arunabh Chattopadhyay, Jae Yeol Lee, Rajit Gadh, Junghoon Lee	Feasibility Study of Surface Acoustic Wave RFID for Information Processing Asset Management	Testing; EMC/RF Radiation; Non- silicon-based Structures	Business-to-business (B2B) market of information processing devices such as printers, copier, fax, database servers, data storage arrays and laptops is growing seamlessly and rapidly, especially in developing country. Radio Frequency Identification (RFID) system can be the most promising system for information technology (IT) asset management because of its well-developed level of technology, worldwide standards and its lower price than other wireless protocol such as WiFi, WiMAX, Bluetooth and so forth. However, RFID system for IT asset management in B2B environment is limited by several constraints. So, Surface Acoustic Wave based RFID at 2.4GHz and UHF passive RFID at 900MHz are discussed as a candidate of it. By analyzing objective data, estimating their future performance, and measuring the readability of SAW RFID system in the standard office, we concluded that the most hopeful candidate for B2B information processing device asset management is Surface Acoustic Wave technology based RFID because of its batteryless passive RFID characteristic, relatively long readable range and its potential, and inherent sensor capability and its expandability as well.
Peter J. Hawrylak*, Ajay Ogirala, J. T. Cain, Marlin Mickle	Automated Test System for ISO 18000-7 – Active RFID	Testing; Interoperability; Co-existence of Rfid Systems	When testing a system for compliance to a standard or interoperability with other systems compliant with a standard, the quality and repeatability of the testing methods is critical. This is especially true when the results are used to make a purchasing decision. The ideal test procedure will expose every device that is tested to the exact same stimuli, record the same measurements and evaluate those measurements using the same method. To this end the University of Pittsburgh RFID Center of Excellence has developed an automated test suite for testing compliance to and interoperability under ISO 18000-7, a leading active RFID standard. This automated system provides consistent input stimuli to all device and ensures that all results are calculated using the same method.
Edmund Chan*	Shortest Distance to Obtain Full Reads of Least RFID Friendly	Testing; Reliability; Reader	The least RF friendly stacking configuration to achieve full reads was done to meet readability required from random stacking of cartons on pallets during operations. Design of Experiments (DOE) was done to obtain the least area for full reads possible from different factor settings of top antennas, side antennas and pallet push

	Cartons Stacking Configuration on Pallet Using Advance Design of Experiments Techniques and Gage Reproducibility and Repeatability	Deployment and Operation	speeds. An understanding of the interactions between the factors will help the experimenter select settings for full reads in the shortest distance possible even with varying pallet push speeds. Steepest slope ascent to further minimize read distance was attempted. A gage repeatability and reproducibility (Gage R&R) is also done to ascertain the reads obtained are due to factor settings and not the measurement system. The results should encourage experimenters to make use of advance DOE techniques to obtain robust reads and optimize read distances.
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