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Role of RFID Technology in Engineering Applications

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Abstract

This paper provides an extensive overview of Radio Frequency Identification technology (RFID) and its applications across different industries, rather than focusing on recent developments alone. Due to the multidisciplinary nature of RFID, proficiency in various engineering fields is necessary to fully comprehend this technology. As the use of RFID continues to expand in various industries, it is imperative to educate engineers and professionals to better understand this technology. An RFID system typically consists of tags, readers, antennae, and software, and various factors such as reading range, frequency range, and environmental considerations must be taken into account when designing such a system. Security must also be a key consideration in the development of an RFID system. To incorporate RFID technology into traditional engineering curricula, this study proposes emphasizing its connection to traditional fields such as electrical, computer, and artificial engineering.

Keywords: Data transfer; data privacy; electromagnetic waves Issues with security; identification; programmable logic controllers; software engineering.

1. Introduction

RFID stands for Radio-frequency Identification. It's a way of using wireless communication to store information about things. This information might include things like a serial number, location, colour, or date of purchase. RFID markers are used to store this information, and they communicate with RFID readers using electromagnetic waves. Compared to older identification technologies like barcodes, RFID is more precise. With RFID, you can give each item its own unique identification code, which makes it easier to keep track of things in a logistical or industrial setting.

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Lots of different groups have shown interest in using RFID, from businesses to healthcare providers to the military[19]. As RFID technology becomes more popular, it's also becoming more standardized. New communication protocols, like Ultra High-Frequency Generation 2, are making it easier to use RFID in different contexts. This article presents a collection of academic papers on RFID technology. The papers are organized around three main themes: Context, Capture, and Control. Finally, Radiofrequency identification (RFID) technology has been widely adopted in various engineering fields, including electronic engineering, industrial engineering, and computer science engineering, due to its numerous applications and potential benefits. In this paper, we aim to explore the uses of RFID technology in these fields and investigate its impact on manufacturing processes [14]. Specifically, we focus on how RFID technology can improve inventory management, enhance supply chain efficiency, and enable real-time monitoring of production processes. By analyzing case studies and experimental results, we aim to provide insights into the ways in which RFID technology can be used to improve the performance and flexibility of modern manufacturing systems.

2. Rfid system components

RFID integration into any process is often accomplished from three perspectives: environment, capture, and control. On the environmental front, one must investigate the operational environment of the RFID integration process by researching the ambient parameters under which RFID markers will operate. It is necessary to identify the information to acquire from the process and link communication limits and hurdles imposed by the process landscape (such as hindrance, reflection, and other communication obstacles). The capture aspect involves selecting RFID equipment (markers and readers) to ensure accurate data collection from the investigated process and terrain. Various variables must be considered at this point, including operating frequency, RFID marker reading range, RFID antenna locations, power regulation, data storage, and security challenges, for effective data capture and reliable RFID interrogation zone design [7]. The control aspect is heavily involved in real-time control of the RFID system (middleware connectivity to other corporate activities, EPC database, graphical user interfaces), as well as business intelligence rule enforcement (information processing, system response to RFID label triggered events, control rules, algorithms). In general, RFID middleware is designed based on environmental limits and capture perspectives. An introductory RFID system typically includes the following components:

- RFID markers that are fixed to realities using a unique electronic product law (EPC) per reality (wireless RFID network);
- RFID compendiums that are networked and Realtime databases • RFID antennas are used to exchange information between the marker's wireless network and middleware/control systems.

RFID markers are classified into two types: passive and active. An irresistible RFID label is propelled by electromagnetic radiation emitted by RFID anthology antennas and grounded by backscattering. An irresistible label cannot generate radio waves on its own, thus its information storage and computing capacity are restricted. It can only be read from a limited distance (0.6 to 3 measures). An active label is powered by an on-board long-life battery, which offers enough energy to allow autonomous communication within a limited range (roughly 90 measures). Antennas are required to establish connection between RFID markers and compendiums.

Antennas for active and non-resistant RFID systems include direct, indirect, broad band, narrow band, single, and binary focused antennas. Antennas are often called based on their ray range (for narrower or wider content) Because an indirect antenna has more inductance than a direct antenna, it produces distributed swells in several directions, resulting in a larger interrogation zone content. Figure 1 depicts the armature of an introductory RFID network. The right side presents RFID middleware features (stoner access, control interface, commerce with corporate database, and waiters), while the left side describes the ad-hoc wireless RFID network integrated into the physical process under supervision/control [5].

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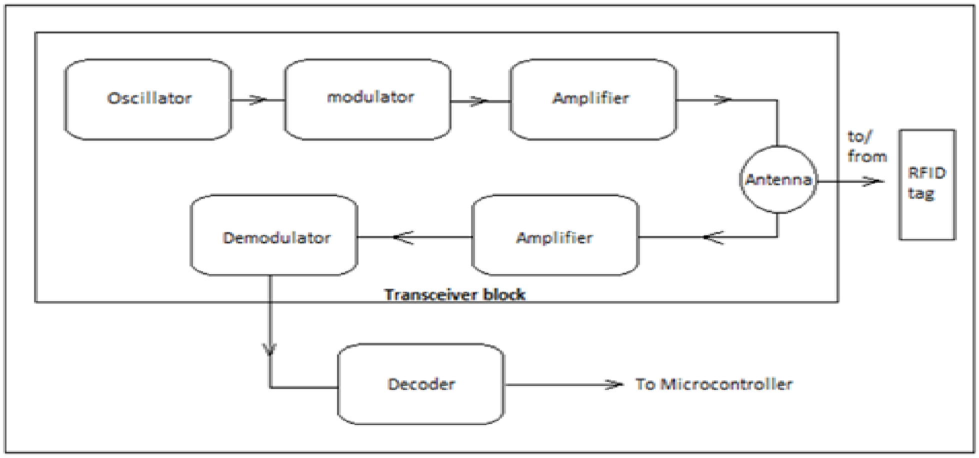

Figure 1: Generic architecture of a basic RFID system.

While some RFID middleware is tailored to specific applications, there is a growing trend towards providing technological flexibility that can work with various RFID equipment, as well as application flexibility to enable the rapid deployment of diverse applications. Additionally, RFID middleware is designed to provide access flexibility, allowing multiple users to concurrently and remotely access the system. This approach allows for greater versatility and customization of RFID technology to meet a variety of needs and applications.

3. Past developments in rfid

Despite the fact that some RFID middleware is application-specific, the tendency is to provide technological flexibility (compatibility with multiple RFID equipment), application flexibility (quick deployment of diverse applications), and access flexibility (multi-users, concurrent and remote access).

I. RFID System Design from The Past Five Years

- NFC-enabled RFID: Near-field communication (NFC) technology has been integrated into RFID systems to enable communication between RFID tags and mobile devices. NFC-enabled RFID tags are being used in various applications such as access control, payments, and marketing.

- RFID in Agriculture: RFID technology has been used in agriculture for tracking livestock, monitoring crop growth, and improving supply chain management. The use of RFID in agriculture has increased efficiency, reduced costs, and improved the quality of products.

- Hybrid RFID Systems: Hybrid RFID systems that combine multiple RFID technologies, such as UHF and HF, have become more prevalent in recent years. These systems provide a comprehensive solution for specific applications, improving accuracy and efficiency.
- Advanced Data Analytics: RFID data analytics have become more advanced, enabling real-time tracking of assets, predictive maintenance, and demand forecasting. These analytics provide valuable insights into business operations, improving efficiency and reducing costs.
- 5G and RFID: The rollout of 5G technology has enabled faster and more reliable communication between RFID devices, improving the accuracy and speed of data exchange. 5G technology has also enabled the development of new applications for RFID technology in areas such as smart cities and autonomous vehicles.

II. RFID System Applications From The Past Five Years

Some recent examples of RFID system applications

- Retail Inventory Management: In 2019, Zara, a Spanish clothing retailer, implemented an RFID-based inventory management system in its stores, which helped improve inventory accuracy and reduce out-of-stocks [4].
- Healthcare: In 2020, CenTrak, a provider of healthcare location and sensing services, introduced a new RFID-based asset tracking solution for hospitals that enables real-time tracking and management of medical equipment [6].
- Supply Chain Management: In 2018, IBM and Maersk announced the development of TradeLens, an RFID-based supply chain management platform that provides end-to-end visibility of cargo shipments [11].
- Asset Tracking: In 2018, Tive, a provider of supply chain visibility solutions, introduced a new RFID-based asset tracking system that enables real-time tracking of assets in transit.
- Smart Packaging: In 2019, Digimarc, a provider of digital identification solutions, announced the development of a new RFID-based smart packaging solution that enables automatic checkout of products without the need for traditional barcodes.
- Access Control: In 2017, HID Global, a provider of secure identity solutions, introduced a new RFID-based access control system that enables secure and convenient access to buildings and other facilities.

III. RFID System Threats and Regulation Issues

RFID systems are vulnerable to security threats during data transfer over the air interface. The interception of RFID label data by unauthorized third parties may result in security breaches and compromise the safety of individuals and assets within the reading range of the RFID system. Researchers are working to enhance security measures, including improving user authentication and data encryption techniques to secure RFID data transfer [16]. Additional issues such as RFID label cloning and denial of service attacks are also being investigated. Physical security measures, such as the use of Faraday cages, restricted range transmission, and on-demand RFID marker scanning, are being explored to secure interrogation zones [8]. Despite progress made in implementing EPC Global Inc. guidelines, vulnerabilities remain unresolved due to the absence of governing regulations on RFID usage

4. Rfid system components

As RFID technology becomes increasingly prevalent across a range of industries, engineers must be equipped with a comprehensive understanding of its concepts and integration challenges. To meet this demand, engineering disciplines such as industrial engineering, electrical engineering, and computer science engineering are well-suited to incorporate RFID engineering concepts into their respective fields. Drawing on the 3C framework, which emphasizes the intersection of these three disciplines, engineers can develop a deep understanding of how RFID technology can be leveraged to enhance productivity and efficiency in various engineering fields [17].

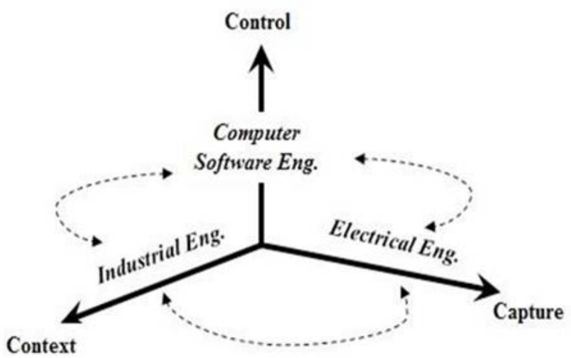

Figure 2: RFID engineering using the 3C methodology.

A. Industrial Engineering

Inventory Management:-RFID technology can be used to automate inventory management processes. RFID tags can be attached to products, and RFID readers can be installed at various locations in the warehouse or manufacturing plant. This allows real-time tracking of inventory levels, reducing the time and cost of manual inventory counts. Weights and measures should be expressed in either SI (MKS) or CGS as primary units. (SI units are encouraged [4].

Quality Control: RFID technology can be used to track and trace products throughout the manufacturing process. RFID tags can be used to store information such as the production date, batch number, and quality test results. This information can be used to ensure that products meet quality standards and to quickly identify and isolate any defective products.

Asset Tracking:- RFID technology can be used to track and manage assets such as equipment, tools, and vehicles. RFID tags can be attached to assets, and RFID readers can be installed at various locations in the facility. This allows real-time tracking of asset locations, reducing the time and cost of manual asset tracking.

Production Planning and Control:- RFID technology can be used to monitor and control the production process. RFID tags can be attached to work-in-progress products, and RFID readers can be installed at various locations in the production line. This allows real-time monitoring of the production process, enabling quick identification of bottlenecks or issues that may cause delays[10].

Maintenance Management:- RFID technology can be used to track and manage maintenance activities for equipment and machines. RFID tags can be attached to equipment, and RFID readers can be installed at various locations in the facility. This allows real-time tracking of maintenance activities, enabling proactive maintenance scheduling and reducing downtime.

In summary, RFID engineering can provide significant benefits in various applications within the field of Industrial Engineering, including inventory management, quality control, asset tracking, production planning and control, and maintenance management. By using RFID technology, businesses can improve their operational efficiency, reduce costs, and increase overall productivity.

B. Electrical Engineering

RFID technology has various applications in the field of electrical engineering. Here are some examples of previous work in this field:

Asset tracking: In the electrical engineering field, RFID tags can be used to track and manage assets such as tools, equipment, and machinery. By attaching an RFID tag to each asset, its location can be tracked in real time, helping to prevent loss and improve inventory management.

Smart grid management: RFID technology can be used to monitor and manage power grids, allowing engineers to remotely control and optimize the flow of electricity. This can help to improve the efficiency of the grid and reduce energy waste.

Maintenance tracking: RFID tags can be used to track maintenance records and schedules for electrical equipment, helping to ensure that regular maintenance is performed and reducing the risk of equipment failure.

Safety monitoring: RFID tags can be used to monitor safety equipment such as hard hats and safety glasses. By tracking when safety equipment is being worn, engineers can ensure that safety protocols are being followed and reduce the risk of accidents[12].

Anti-counterfeiting: In the electrical engineering field, RFID tags can be used to help prevent counterfeit products from entering the market. By attaching an RFID tag to each product, its authenticity can be verified, helping to ensure that customers receive genuine products.

Overall, RFID technology has many potential applications in the field of electrical engineering, and its use is likely to continue to expand in the future.

C. Computer and Software Engineering

RFID Middleware: RFID middleware is software that connects RFID readers and tags to business applications. Middleware provides a layer of abstraction between the RFID hardware and software systems, allowing for easier integration and management of RFID data. Computer and software engineers can develop and implement RFID middleware to facilitate the integration of RFID technology with business applications.

RFID Software Development: RFID software can be developed to manage and process RFID data. For example, RFID data can be used to track inventory levels, monitor the location of assets, and manage the production process. Computer and software engineers can develop customized software applications to meet the specific needs of a business, leveraging RFID technology to optimize business processes and increase efficiency.

RFID Data Analytics: RFID data can provide valuable insights into business processes and operations. Computer and software engineers can develop analytics software to analyze RFID data and generate reports on key performance indicators (KPIs). By analyzing RFID data, businesses can identify areas for improvement and optimize their operations.

RFID Cloud Services: Cloud services can be used to store and manage RFID data. Computer and software engineers can develop cloud-based applications that enable businesses to store and analyze RFID data in real-time. This allows for remote access to RFID data and enables businesses to leverage the scalability and cost-effectiveness of cloud computing.

In summary, RFID engineering can be used in various applications within the field of Computer and Software Engineering, including middleware development, software development, data analytics, and cloud services. By leveraging RFID technology, businesses can optimize their processes, improve efficiency, and increase profitability.

5. Rfid applications

Several businesses, including those in manufacturing, agriculture, hospitality, parking management, and transportation, have been more interested in RFID technology. These are a few of the most common RFID applications:

Healthcare Applications: Applications for RFID in healthcare could help save money that would then go into improving patient care. By promptly labelling medical items in the healthcare system, such as patient files and medical equipment, RFID applications could lower the number of errors[1,15]. By integrating medical objects used throughout the patient's treatment, RFID significantly enhances the scenario for patient care. The effectiveness and efficiency of paramedical staff would enhance thanks to RFID-based timely information regarding the locations of objects, improving patient experiences[1].

Baggage Applications: When luggage or shipments are lost or delivered late, the airline, package, and delivery businesses all suffer financial losses. It can be quite difficult to manage many parcels going in many different directions on different routes. In this situation, RFID technology offers the finest resource management, effective operation, and efficient package transfer. RFID assists in package identification and generates data that can inform the sector of potential areas for improvement[2]. Additionally, it keeps clients updated on their products

Toll Road Applications: Since cars and other vehicles cannot proceed through toll booths without stopping to pay, RFID applications improve toll collecting and charging while also improving traffic flow[18]. RFID is utilized to speed up transactions and automatically identify the account holder. Using data mining techniques, this application assists in maintaining smooth traffic flow and identifying traffic trends that can be used to inform administrative or decision-support systems. For instance, the data might be used to report on traffic conditions or extend and create future policies[18].

Libraries of RFID Labels: RFID can be used in libraries to manage their book collection. RFID uses a variety of components for this management, including tags, readers, self-checkout/in, book drop readers, middleware, etc. These elements enable it to control the book borrowing and return processes[3]. Whether borrowing a book or returning a book, RFID keeps track of the previous borrowings and returns.

6. Rfid security concerns

IoT offers tremendous benefits to consumers; yet, it also has certain drawbacks Scholars and legal professionals have been most concerned about IoT bias in terms of cybersecurity and fiscal risks. Numerous organisations and pots have had to deal with IoT concerns, which have been exacerbated by recent high-profile cyber-security incidents. Moreover, issues linked with obscurity and deception on the Internet pose challenges in the use of IoT. Some of the security concerns are as follows:

RFID Sniffing: One of the major security challenges associated with RFID technology is the risk of sniffing. RFID readers are designed to scan for tags to retrieve identification information. The reader then compares this information against data stored on a backend server. However, many RFID tags cannot differentiate between a legitimate request from a real RFID reader and a fraudulent request from a fake reader. As a result, an attacker could potentially scan the tags with their own RFID reader and exploit the information retrieved for their purposes.

Tracking: An attacker can potentially monitor the location and movement of an object or a person by reading information from an RFID tag. When a tag is affixed to an object and that object comes within the range of an RFID reader, the reader can identify and locate the object. As a result, it's important to recognize that if an RFID tag is attached to an object, there is a risk of it being tracked by an attacker, even if encrypted messaging is used to communicate between the tags and readers. An attacker could leverage mobile robots or other methods to trace the location of the object.

Denial of Service: When a reader requests information from an RFID tag, the tag's identifier is typically compared to the identifier stored in a database server. Unfortunately, both the reader and the backend server can be susceptible to denial of service (DoS) attacks. Such attacks can prevent tags from authenticating their identification with the reader, causing the service to become unavailable. To prevent this scenario, it is important to implement appropriate measures to protect both the reader and the database server from potential DoS attacks.

Spoofing: A spoofing attack is a type of security threat where an attacker pretends to be a genuine user of a system. This can involve impersonating a legitimate Object Naming Service or database user, for example. If the attacker can obtain unauthorized access to the system using forged credentials, they can potentially carry out a range of malicious actions concerning RFID data. This might include responding to fraudulent requests, altering RFID identifiers, disrupting normal operations, or even introducing harmful code into the system.

Repudiation: Repudiation is a situation where a user denies having performed a particular action, and there is no way to verify whether the denial is true or not. In the context of RFID technology, there are two main forms of repudiation. First, a sender or receiver can deny having sent an RFID request or performed some other activity, without any conclusive evidence to support or refute the claim. Second, the owner of an EPC number or a database may deny having any information about the tags associated with an object or a person.

Insert attacks occur when an attacker tries to inject system commands into the RFID system instead of sending standard data. This kind of attack involves using a tag that stores system commands in its memory, which can be used as an RFID insert attack.

Acknowledgements

This paper presents an overview of the history of RFID technology and its various applications in different industries. Building upon this knowledge, the article proposes a paradigm for integrating RFID technology into education and training curriculums. This framework is based on the 3C concept, which will be further discussed. This framework. is built on the 3C notion described below. Industrial, electrical, and computer engineering appear to give a bigger possibility of abilities to any RFID engineering programmed To summaries, RFID integration is frequently associated with large investments, extensive testing, and true process reengineering. We can conclude that RFID technology still has some security flaws, such as data manipulation, that attackers could exploit. RFID technology has numerous applications across various fields, including supply chain management, logistics, transportation, healthcare, and retail[13].

The technology offers many advantages, such as real-time tracking, inventory management, and enhanced security. However, the use of RFID technology also raises security concerns, as RFID systems can be vulnerable to data breaches and attacks[9]. RFID technology has the potential to significantly improve operational efficiency, reduce costs, and increase productivity in various industries.

Engineers from different disciplines have a crucial role in the development, implementation, and integration of RFID technology into their respective fields. By leveraging the 3C methodology framework and considering the challenges associated with RFID technology, businesses can effectively integrate RFID technology into their processes and reap its benefits.

References

[1] Adams, G. (2007). Pharmaceutical manufacturing: RFID reduces errors and labour. Filtration & Separation, 44(6), 17-19.

[2] Chow, H.K.H, Choy, K.L., Lee, W.B. and Lau, K.C. (2006). creating a case-based resource management system for warehouse operations using RFID. Expert Systems with Applications, 30, 561–576.

[3] K. Coyle (2005). Controlling RFID in libraries. Academic Librarianship Journal, 31(5), 486-489.

[4] G.Q. Huang, Y.F. Zhang, and P.Y. Jiang (2007). Real-time job shop WIP inventory management using RFID-based wireless manufacturing. Global Journal of Advanced Manufacturing Technology, 36(7), 752-764.

[5] L. Jongyoung and K. Naesoo (2006). Parameters, design, implementation, and features of a performance testing tool for RFID middleware. 8th International Conference on Advanced Communication Technologies Proceedings, Gangwon-do, Korea, February 20–22, 149–152, Global IT Research Institute, ISBN 89–5519–129-4.

[6] Ni, L.M., Lau, Y.C., Y. Liu, and A.P. Patil (2004). LANDMARC: Active RFID Indoor Location Sense. 10, 701–710, Wireless Networks

[7] The authors are K. Penttilä, M. Keskilammi, L. Sydänheimo, and M. Kivikoski (2006). Radiofrequency technology for controlling logistics and automated manufacturing. The use of RFID antennas in industrial applications is covered in Part 2. 31, 116–124, International Journal of Innovative Manufacturing Technologies

[8] R. Reid Sr (2007). ID cards with RFID. Is society sophisticated enough to handle smart cards? 23, 53–61 of the Computer Law & Security Report.

[9] Y. Rekik, E. Sahin, and Y. Dallery (2008). analysis of how the use of RFID technology has helped retail businesses make fewer mistakes with product placement. 112 (1), 264-278, International Journal of Production Economics.

[10] Gottschalk, S., Höhne, T., and Schuh, G. (2007). superior production management. The CIRP Annals, 56(1), 439-442.

[11] Wang S.J., Wang W.L., and Liu S.F. (2008). The TFT-LCD industry's pull-based inventory replenishment and the implications of an RFID-enabled supply chain. 112 (2), 570-586, International Journal of Production Economics.

[12] Wu, P.W.K., Wong, D.M.H., Chan, D.Y.K., Fung, L.C., and Leung, S.W. are among the authors (2006). RFI evaluation of the RFID system's human safety at Hong Kong International Airport. Singapore, Feb. 27–March 3, 108–111 in Proceeding of the IEEE 17th International Zurich Symposium on Electromagnetic Compatibility, published by EMC Zurich, ISBN 3-9522990-4-9.

[13] Asif Z, Mandviwalla M. Integrating the supply chain with RFID: A technical and business analysis. Communications of the Association for Information Systems. 2005;15(24):1-57. DOI: 10.17705/1CAIS.01524

[14] Zhu X, Mukhopadhyay SK, Kurata H. A review of RFID technology and its managerial applications in different industries. Journal of Engineering and Technology Management. 2012;29(1):152-167. DOI:

10.1016/j.jengtecman.2011.09.011

[15] Bansal D, Malla S, Gudala K, Tiwari P. Anti-counterfeit technologies: A pharmaceutical industry perspective. Scientia Pharmaceutica. 2013;81(1):1-13. DOI: 10.3797/scipharm.1202-03

[16] Lehtonen M, Staake T, Michahelles F, Fleisch E. From identification to authentication: A review of RFID product authentication techniques. In: Networked RFID Systems and Lightweight Cryptography, Part II. 2008. pp. 169-187. DOI: 10.1007/978-3-540-71641-9_9

[17] C. Fang, "Electrical system design of flexible production line for 3C products based on industrial robots," Journal of Shenzhen Vocational and Technical College, vol. 19, no. 1, p. 8, 2020.

[18] Zhang, X.D.; Yue, S.J.; Wang, W.M. The review of RFID applications in global postal and courier services. J. China Univ. Posts Telecommun. 2006, 13, 106–110.

[19] Haddara, M.; Staaby, A. RFID Applications and Adoptions in Healthcare: A Review on Patient Safety. In Proceedings of the International Conference on Health and Social Care Information Systems and Technologies (HCIST), Lisbon, Portugal, 21–23 November 2018; Elsevier: Amsterdam, The Netherlands, 2018; Volume 138, pp. 80–88.