

Application of Passive RFID Technology

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Abstract. Passive Internet of Things (IoT) is an emerging IoT technology that enables communication and data exchange between items through various sensors and devices. Sensor nodes do not require built-in batteries or other energy supply devices, but instead use external signals for operation. Radio Frequency Identification (RFID) technology is a simple and low-cost solution for the passive Internet of Things, suitable for scenarios that require simple tracking and monitoring of items. The sensor devices in this technology can be used for a long time interregional operation reduces maintenance costs and improves work efficiency. Therefore, it is a promising technology that can bring tremendous changes to various industries. In recent years, this technology has been widely applied in many fields, including logistics and supply chain management, industrial automation, intelligent agriculture, and health monitoring. This article elaborates on the practical application of the latest passive RFID technology, providing reference for more application scenarios in the future.

Keywords: Passive Internet of Things; Radio Frequency Identification; Application Scenario.

1. Introduction

Passive Internet of Things is a new type of wireless communication technology, where sensor nodes do not need to actively send signals and do not require batteries or other energy sources, but use the RF signal of the external environment to obtain the required energy, and use the backscatter method

Data transmission to achieve communication with other devices [1] [2]. This technology can greatly reduce the size and power consumption of sensor nodes, and improve the availability and reliability of IoT systems [3]. Compared with traditional IoT technologies, passive IoT has lower energy consumption and cost [4], and can also achieve a wider range of application scenarios [5] [6] [7], such as smart home, smart agriculture, and smart logistics and other fields. Therefore, passive IoT is an important direction for the future development of IoT [9].

Radio Frequency Identification (RFID) system is a key application in the passive Internet of Things [10] [11]. It utilizes the energy in electromagnetic fields to transmit and receive wireless signals, thereby achieving automatic identification and tracking of items. The system consists of three parts: a reader/writer, an antenna, and a tag [12]. The reader/writer activates the tag by emitting a certain frequency of electromagnetic waves, causing it to generate electrical energy and send information to the reader/writer; The antenna serves as the medium for data transmission, converting the electromagnetic signal sent by the reader into an RFID signal, and feeding back the label information to the reader; The tag contains a chip and an antenna, which stores information about the item and processes it after receiving the signal from the reader and returns the stored information to the reader in the form of an RFID signal. The tags in this system have the characteristics of low cost, long lifespan, small size, and easy deployment [14] [15], and are suitable for scenarios with high energy consumption and size requirements [16] [17] [18], such as logistics management, inventory management, retail industry, supply chain management, environmental monitoring, vehicle management, hospital equipment, industrial manufacturing, and smart home, as shown in Figure 1. In things

In terms of flow and supply chain management, this technology can be used to track the position and status of goods throughout the entire supply chain, thereby improving transportation efficiency [19]



[20]. In industrial automation, passive tags can be directly integrated into machines and equipment without the need for additional power sources, achieving more convenient installation and lower maintenance costs [21]. The efficient, precise, and flexible characteristics of RFID [22] not only improve the efficiency of business processes and supply chain management [23], but also improve the traceability and transparency of items [24], help enterprises achieve automation and intelligent management [25], improve production efficiency and accuracy [26], and reduce labor costs. This article focuses on the RFID technology of passive Internet of Things and elaborates on its practice and application in various fields.

2. Application of RFID Technology in Different Fields

With the development of RFID technology, it has been widely applied in many industries. This section mainly introduces the practical applications of systems designed by international companies and research institutes in areas such as inventory management, medical industry, environmental monitoring, and positioning

American eyeglass frame wholesaler FSG recently released a new inventory management system AIMS2.0, further improving management efficiency. In 2020, FSG introduced AIMS1.0 based on RFID technology to address issues such as low efficiency, high losses, and delayed restocking in store inventory manual management. Subsequently, FSG further explored the value of the data and optimized the process. The store sent prescription glasses to the lens processing factory, and sent consumer information about purchasing frames to the frame supplier. The supplier directly shipped the frames to the lens processing factory. By utilizing the new system, the ordering and processing information of each order is updated in real-time to the backend database, providing a decision-making basis for optimizing store display, product ordering, and supplier scheduling, and achieving full process tracking of materials and products. At the same time, the system can provide support for on-site sales of products such as beauty glasses and contact lenses in stores.

Stadium is one of the largest sports goods department stores in northern Europe, founded in 1987 with 180 stores. Before launching the RFID project, the company believed that its inventory accuracy was 99.5%. After launching a software statistics project within the company, it was confirmed that the inventory accuracy rate is only 70%. In 2019, the company selected two stores to pilot the RFID project, and after the pilot effect was confirmed by the board of directors, it quickly expanded in all stores. At present, RFID has covered over 90% of the products on sale, from leather skis to shoelaces.

GuardRFID is a company that provides real-time positioning systems, mainly serving the medical industry. The acquisition of the company by HID, which specializes in identity recognition and security technology, means that it will also receive widespread attention in the field of healthcare technology and provide customers with more comprehensive solutions, including infant safety, patient mobility management, employee security protection, medical guidance, process optimization, and asset management.

L-COM Corporation is a subsidiary of Infinite Electronics, a leading global electronic component supplier, and has recently released new environmental monitoring sensor products that support air quality monitoring and water leakage monitoring. The air quality sensor can monitor various pollutants, including alcohol, dust, formaldehyde, temperature, humidity, and smoke, and is suitable for commercial facilities, factory workshops, laboratories, and public toilets. Water leakage sensors are suitable for environments that are damaged by water leakage, such as computer rooms, equipment cabinets, data centers, warehouses, logistics centers, and other places. These sensors can help users monitor potential hazards in the environment and take necessary measures to prevent or mitigate losses caused by air pollution or water leakage.

Researchers at the Massachusetts Institute of Technology have designed an advanced system that integrates RFID readers and antennas into AR helmets, using SAR like technology to generate 3D maps and achieve 10cm accuracy in positioning and navigation. The system is already in operation

widely applied in fields such as industry and healthcare, and achieved good results. The non line of sight recognition advantage of RFID enables it to effectively compensate for the shortcomings of AR visual recognition, accurately locate and identify blocked items, items placed in packaging boxes, and similar items in appearance. This technology, which combines RFID and AR, is expected to be widely applied in multiple scenarios such as warehousing, industrial production lines, and home use in the future, providing more accurate and efficient logistics and management services for various industries.

3. Practical Application of RFID Awards

RFID Journal is a media website dedicated to RFID technology and applications. It regularly holds international awards such as RFID Awards to recognize individuals, companies, and organizations who have made outstanding contributions in the field of wireless radio frequency identification technology. The awards are divided into four categories, including the Practice Incentive Award, Best New Product Award, Best Printing/Labeling Application Award, and Best RFID Laboratory Award. This award has been held continuously for 18 years, attracting participants from all over the world. The winners can receive international recognition and promotion, and have the opportunity to communicate and cooperate with peers, providing more opportunities and innovative ideas for the industry, and jointly promoting the development of wireless radio frequency identification technology. This chapter mainly introduces some practical nominations for RFID awards and new product nominations with practical application value, which have a significant impact on our industrial production and daily life.

3.1. Best Practice Nomination

The RFID Best Practice Nomination is to recognize organizations that have successfully adopted RFID technology to solve business problems or have had a positive impact on certain social issues. The nominated companies will elaborate on the challenges they face, as well as the process and results of using RFID technology to address these challenges. Finally, the evaluation committee will select the final winner based on innovation, implementation effectiveness, and commercial value.

In terms of retail, German C&A Clothing Company has deployed RFID in all its stores in Europe, resulting in more accurate inventory data. Through transparent product availability information, it has optimized the user experience and achieved process simplification and standardization; The largest clothing chain in Brazil Lojas Renner has deployed RFID in warehouses and stores, improving the accuracy and frequency of inventory counting; Siman Group, the largest department store retailer in Central America, has utilized SML's solution to improve inventory accuracy to over 95%, significantly reducing the time employees spend searching for items in the warehouse management system.

In terms of medical care, AZ Saint Martin Hospital in Belgium uses RFID to improve the logistics management of medical equipment (including beds, wheelchairs, sphygmomanometer, etc.), which can locate medical supplies and equipment in real time, and synchronize data to hospital resources planning system; Gateshead Health Foundation hospitals in the UK use RFID to improve the utilization and traceability of existing equipment and avoid additional investment in equipment with low utilization; Einstein Israel Hospital has deployed multifunctional RFID facilities throughout the entire hospital area, allowing the same reader and writer to be used for multiple purposes, reducing future deployment costs.

In terms of manufacturing, Brazilian automotive glass manufacturing company Pilkington uses recyclable metal frames to supply automotive manufacturers. The company uses RFID to manage effective vehicles and the flow of vehicles between different customers, reducing vehicle loss and wear; Japan Shuishui Aviation Industry Company, located in the United States, uses RFID to track the transportation of disposable tools between two production lines, expands its deployment scope, improves operational efficiency, and promotes timely delivery of its products; Vestel deployment of Türkiye household appliance enterprise RFID is used to track various products, such as household

appliances, electronic products, and computers, to prevent unexpected production interruptions, and to evaluate their costs, productivity, and efficiency through real-time device tracking processes.

In terms of products and services, the largest drug wholesaler in the United States, Meiyuan Bergen, has utilized its position as a wholesaler and RFID technology provider to produce AB drug trays, which are pre labeled with products to reduce manual labeling by pharmacy personnel the need for materials while reducing third-party costs and complexity; The Halden City Hall in Norway attaches RFID tags to each trash can in the city, and the card reader on the garbage collection truck reads the tags to accurately record the number of empty trash cans, in order to issue invoices correctly and properly handle user complaints caused by missing trash cans; UPS achieves automatic scanning through wearable RFID technology, and other visual operations such as loading and customer pickup scanning are achieved through an onboard RFID reader.

In addition, the Avon and Somerset police in the UK have developed an IoT based solution based on their dementia protection plan, aimed at reducing the number of dementia patients who have lost their lives; CPC Petroleum and Natural Gas Company in Taiwan, China, China enters the filled oil drums implement automated management, recording the storage location of each drum and the weight of each drum and pallet; Enea Operator, the fourth largest energy group in Poland, has improved its warehouse management process through RFID based self-service counters, thereby improving the security, availability, convenience, and reliability of its facilities

3.2. Best New Product Nomination

The RFID Best New Product Award mainly selects RFID products with innovation and practicality, based on a comprehensive evaluation of innovation, practicality, product performance, cost-effectiveness, and market potential. The winning product will be widely recognized and promoted in the industry.

The WalletMate mobile wallet Near field Communication (NFC) card reader launched by Longjie Smart Card Co., Ltd. in Hong Kong, China has been certified by Apple and Google, allowing users to safely use the reader on iOS and Android devices without worrying about incompatibility with operating systems or applications, and providing consumers with additional trust guarantees. The NFC technology supported by this card reader allows users to use mobile wallets for payment, deposit, and transfer operations. In addition, its design is flexible, convenient to carry, and easy to use.

The AD TexTrace soft fabric label developed by Avery Dennison Smartrac in the United States integrates woven antennas and small loop inlays, and can be used on environmentally friendly textile substrates. This label can be easily integrated into textiles, such as clothing and other textiles, to provide tracking and recognition functions. Braided antenna is a special antenna design that can work in soft and stretchable materials, and can provide better performance and a larger reading range. Small loop inlay is an RFID tag that is typically used to work on non-metallic surfaces and can be combined with woven antennas for remote reading. This type of label can help manufacturers and brand companies better grasp their supply chain, improve operational efficiency, and provide better product traceability and counterfeit prevention functions. In addition, the label can also resist washing and dry cleaning, making it very suitable for daily necessities such as clothing, bed sheets, towels, etc. The HF550X RFID reader and writer launched by Bluebird, South Korea, looks similar to a mobile phone. The reader and writer supports high-frequency RFID and NFC reading and writing functions, and can read and write RFID tags and cards that comply with ISO 14443 and ISO 15693 standards. The reader uses the Android operating system and is equipped with a 5-inch high-definition touch screen, supporting wireless communication methods such as WiFi, Bluetooth, and 4G. It can be connected to cloud and backend systems to achieve data transmission and management, with high reliability and stability, and strong data processing capabilities. In addition, it also has certain waterproof, dustproof, and anti drop capabilities, suitable for various outdoor environments. This reader has a compact design, simple and convenient operation, and can be widely used in logistics, warehousing, retail, medical, transportation and other fields to improve business efficiency and accuracy.

The end-to-end inventory management, animal monitoring, and traceability solution provided by HerdX in the United States is a comprehensive management tool for the animal husbandry industry, including intelligent readers and software applications, which can achieve real-time monitoring, management, and traceability of livestock. It can easily connect multiple units and wirelessly transmit the read data through Bluetooth technology, and can also be customized according to specific needs. Using the HerdX solution, livestock owners can achieve real-time monitoring and management of livestock information, ensuring the stability and profitability of livestock production. In addition, adopting this solution can effectively improve the traceability of livestock quality and ensure the safety of consumer food.

Shanghai Orange Group Microelectronics Co., Ltd. has launched a low-power Bluetooth chip, NanoBeacon IN100, using a programming free and code free platform, aiming to achieve next-generation active RFID applications and wireless sensors. This chip has the characteristics of small size, high performance, low power consumption, and supports multiple Bluetooth protocols and RF standards, which can be widely used in various IoT devices; It can also be used as an active RFID tag to achieve tracking, monitoring, and positioning of items; It can also be used as a wireless sensor node to monitor and collect environmental parameters. At the same time, the chip can also remotely upgrade firmware through the cloud, making it easy for users to maintain. The chip has a wide range of applications, including smart homes, smart healthcare, intelligent logistics, intelligent manufacturing, and other fields, and is expected to provide more efficient and intelligent solutions for the development of these fields.

4. Conclusion

RFID technology is a wireless communication technology used to identify and track items, with advantages such as automation, efficiency, accuracy, and real-time. It is widely used in many industries, such as logistics management, asset management, inventory management, retail, healthcare, and so on. In addition, this technology can also be used in fields such as vehicle management, production line management, animal tracking, personnel positioning, and electronic payment. The widespread application of RFID technology in various fields can not only change people's lifestyles, but also effectively improve the operational efficiency and customer satisfaction of enterprises, and promote social development.

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