

**Working Paper 2025.2.1.19**

**- Vol. 2, No. 1**

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**HỆ THỐNG QUẢN LÝ KHO HÀNG SỐ ỨNG DỤNG RFID TRONG NGÀNH THƯƠNG MẠI ĐIỆN TỬ: NGHIÊN CỨU ĐIỂN HÌNH VỀ AMAZON VÀ BÀI HỌC CHO VIỆT NAM**

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**Tóm tắt**

Chuỗi cung ứng toàn cầu ngày càng trở nên phức tạp, cùng với kỳ vọng ngày càng cao của người tiêu dùng, đã thúc đẩy việc phát triển và áp dụng các công nghệ tiên tiến trong quản lý kho hàng. Trong số đó, công nghệ Nhận dạng tần số vô tuyến (RFID) đã nổi lên như một công cụ hữu ích giúp theo dõi hàng tồn kho theo thời gian thực, nâng cao hiệu suất vận hành và đảm bảo độ chính xác trong các quy trình kho bãi. Nghiên cứu này xem xét vai trò của RFID trong quản lý kho hàng thông qua nghiên cứu điển hình về Amazon, một tập đoàn hàng đầu trong lĩnh vực thương mại điện tử và logistics. Bài nghiên cứu phân tích những lợi ích của việc triển khai RFID, bao gồm tự động hóa, tối ưu hóa chi phí và quản lý hàng tồn kho hiệu quả; đồng thời đề cập đến các thách thức như chi phí đầu tư ban đầu cao và vấn đề bảo mật dữ liệu. Ngoài ra, nghiên cứu còn khám phá tiềm năng của việc ứng dụng RFID trên các nền tảng thương mại điện tử tại Việt Nam; từ đó xác định những rào cản và đề xuất các giải pháp chiến lược nhằm thúc đẩy quá trình triển khai công nghệ này. Kết quả nghiên cứu đóng góp vào cuộc thảo luận về chuyển đổi số trong quản lý chuỗi cung ứng, đồng thời cung

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cấp một khung tham chiếu cho các doanh nghiệp đang cân nhắc ứng dụng công nghệ RFID nhằm nâng cao hiệu quả hoạt động kho hàng.

**Từ khóa:** RFID, quản lý kho, thương mại điện tử, Amazon, hàng tồn kho

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## AN RFID-BASED DIGITAL WAREHOUSE MANAGEMENT SYSTEM IN ECOMMERCE INDUSTRY: A CASE STUDY OF AMAZON AND IMPLICATIONS FOR VIETNAM

### Abstract

The growing complexity of global supply chains, coupled with increasing consumer expectations, has led to the adoption of advanced technologies in warehouse management. Among these technologies, Radio Frequency Identification (RFID) has emerged as a critical tool for real-time inventory tracking, operational efficiency, and accuracy in warehouse processes. This study investigates the role of RFID in warehouse management through a case study of Amazon, a global leader in e-commerce logistics. The research examines the advantages of RFID implementation, including automation, cost efficiency, and inventory optimization, while also addressing challenges such as high initial investment costs and data security concerns. Furthermore, the study explores the potential for RFID adoption in Vietnamese e-commerce platforms, identifying key obstacles and proposing strategic solutions to facilitate implementation. The findings contribute to the ongoing discourse on digital transformation in supply chain management and provide a framework for businesses considering RFID technology to enhance warehouse operations.

**Keywords:** RFID, warehouse management, e-commerce, Amazon, inventory

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### 1. Introduction

The increasing complexity of global supply chains and rising consumer expectations have enhanced the adoption of advanced technologies in warehouse management. Among these, Radio Frequency Identification (RFID) has emerged as a key solution, offering real-time inventory tracking, improved operational efficiency, and boosted accuracy in warehouse processes. RFID technology has been widely adopted by major corporations to optimize logistics and supply chain operations, with Amazon serving as a notable case study in its successful implementation.

As one of the largest e-commerce platforms globally, Amazon has leveraged RFID to streamline warehouse operations, automate inventory management, and enhance fulfillment efficiency. By integrating RFID with cloud computing and automated systems, Amazon has significantly improved inventory visibility, reduced human errors, and optimized storage utilization. Understanding Amazon's approach to RFID implementation provides valuable insights for other businesses, particularly in emerging markets where technological adoption remains a challenge.

This study aims to examine the implications of RFID technology in warehouse management through a case study of Amazon. The research will explore:

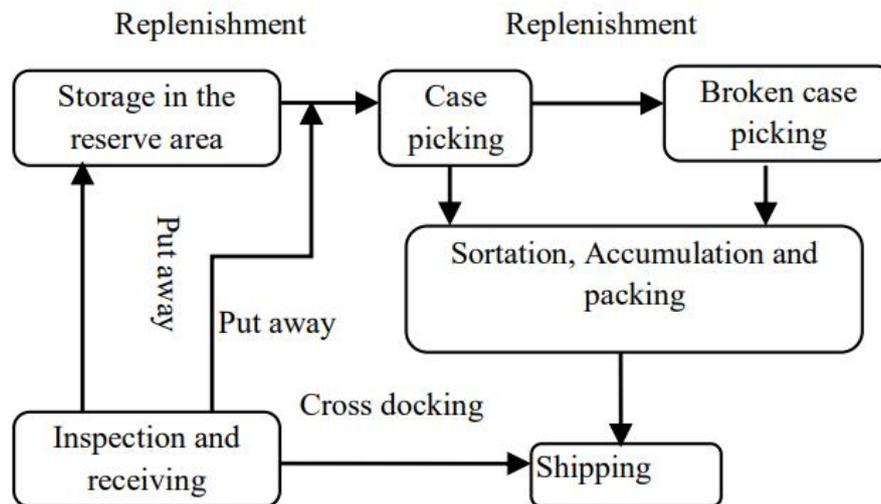
- (1) The role of RFID in Amazon's warehouse operations.
- (2) The key advantages and challenges associated with RFID implementation.
- (3) The potential applications of RFID in Vietnamese e-commerce platforms

## **2. Theoretical framework**

### ***2.1. Warehouse management***

A warehouse serves as a crucial part within the supply chain, primarily designed to consolidate products, thereby lowering the transportation cost, achieving economies of scale in manufacturing or purchasing. Warehouses are categorized into various types: production or distribution centres; based on their roles, they are further classified as raw materials warehouses, work-in-process warehouses or finished goods warehouses, fulfillment warehouses, local warehouses direct to customer demand, and value-added service warehouses. ([Ramaa et al., 2012](#)).

Ramaa et al. also states that despite differences in operations, warehouses typically follow a similar pattern of material flow, including: receiving, putaway, internal replenishment, order picking accumulating and sorting, packing, cross docking and shipping (Figure 1)



**Figure 1.** Typical Warehouse Functions and Flows

**Source:** Ramaa et al. (2012)

Warehouse management is defined as the integration of planning and control systems along with decision-making rules implemented in inbound flows, storage processes and outbound flows (Faber et al., 2013, p. 1232). At a high level, warehouse management involves picking and packing, inventory tracking, demand forecasting, storage optimization, enhancing security and improving overall supply chain efficiency (Hopstack, 2024).

The main objective of a warehouse management system or WMS is to “control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, put-away and picking” (Ramaa et al., 2012).

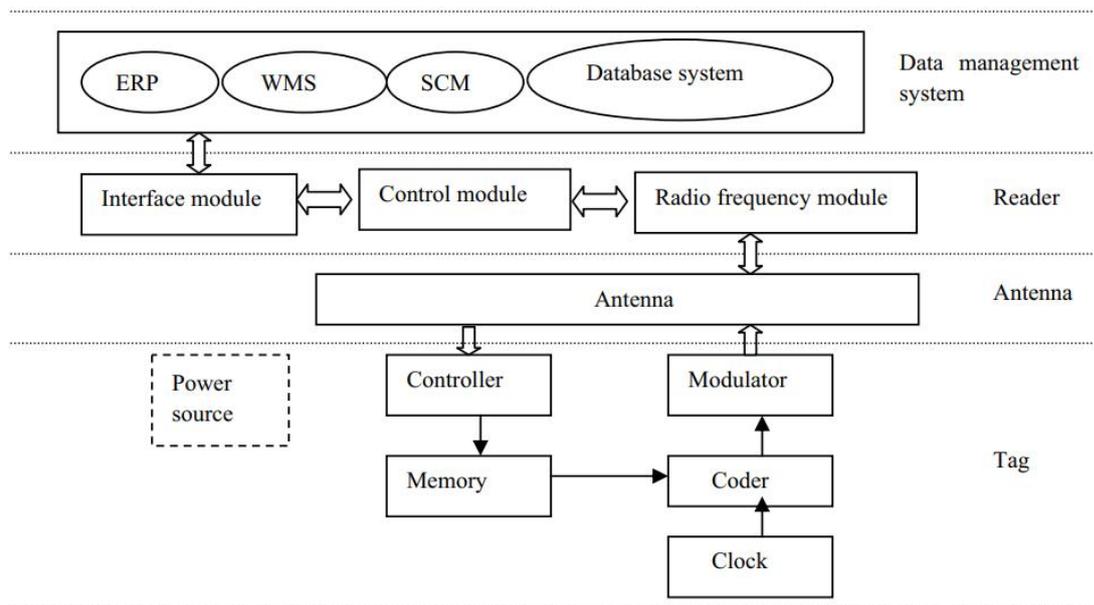
Meanwhile, a warehouse control system acts as an interface between the warehouse management system and daily operations to receive and forward information. Regarding the warehouse control system, Ramaa et al. divides warehouse management systems into 3 specific types:

- **Basic WMS** - is mainly used to support stock and location control by recording information and generating storing and picking instructions
- **Advanced WMS** - is capable of arranging resources and activities to be aligned with the movement of goods within the warehouse
- **Complex WMS** - is able to optimize the operation of the warehouse or a group of warehouses by offering additional functionality

## **2.2. RFID Technology**

Radio Frequency Identification (RFID) is a technology that enables wireless information transmission using radio frequency signals and space coupling (through an alternating magnetic or electromagnetic field) to identify and exchange information (Hui Tan, 2008). Basically, the RFID system includes four components, which are Reader, Tag (or Responder), Antenna and Application Software System.

- **Tag:** it serves as an important component of the RFID system. Normally, a tag consists of a tag antenna and a special tag chip. Each tag is assigned a specific electronic code, which is attached to the selected object. Its main function is to store information for later identifying and transmitting
- **Reader:** it is designed to read or write (decodes) information from the tag. A reader is able to solely process or collaborate with other computers or systems to perform processes involving the tag. Typically, a reader structure includes control module, radio frequency module, interface module and reader antenna as shown in Figure 2
- **Antenna:** The main function of Antenna is to provide space for transmitting radio frequency signals between the tag and the reader. It can be either placed inside the reader or connected to the reader through coaxial cable
- **Data management system:** it is primarily used for storing and managing the data and information, while also controlling the operations of the reader and the tag. It can be used as a database system or management system, depending on the users' intention.



**Figure 2.** Basic structure of the RFID technology

**Source:** Hui Tan (2008)

According to Hui Tan (2008), the workflow of a RFID system begins when the Reader transmits radio frequency signals through the antenna. This signal will trigger induced current to be produced in the tag of the target object as it reaches the Reader’s working area. The tag then uses the energy from the current to transmit product information stored in its chip. After receiving and decoding the signal from the tag, the Reader forwards the information to the data management system. The system will evaluate the validity of the tag based on predefined settings and control the operation of the actuator by sending out command signals.

Howard (2006) believed that RFID holds the potential to transform the way of exchanging goods and inventory which will benefit both customer and store. The use of RFID can determine the correct amount customers purchase and also estimate the exact amount of inventory in the store. Therefore, RFID can help prevent unexpected stock shortages and improve the accuracy of inventory audit. In contrast, [Asif \(2005\)](#) argued that RFID gives rise to a new set of problems and its implementation process is not straightforward. [Ygal et al. \(2007\)](#) shared the same idea that the limitation in adopting this technology is due to several factors such as high costs, security issues or lack of expertise.

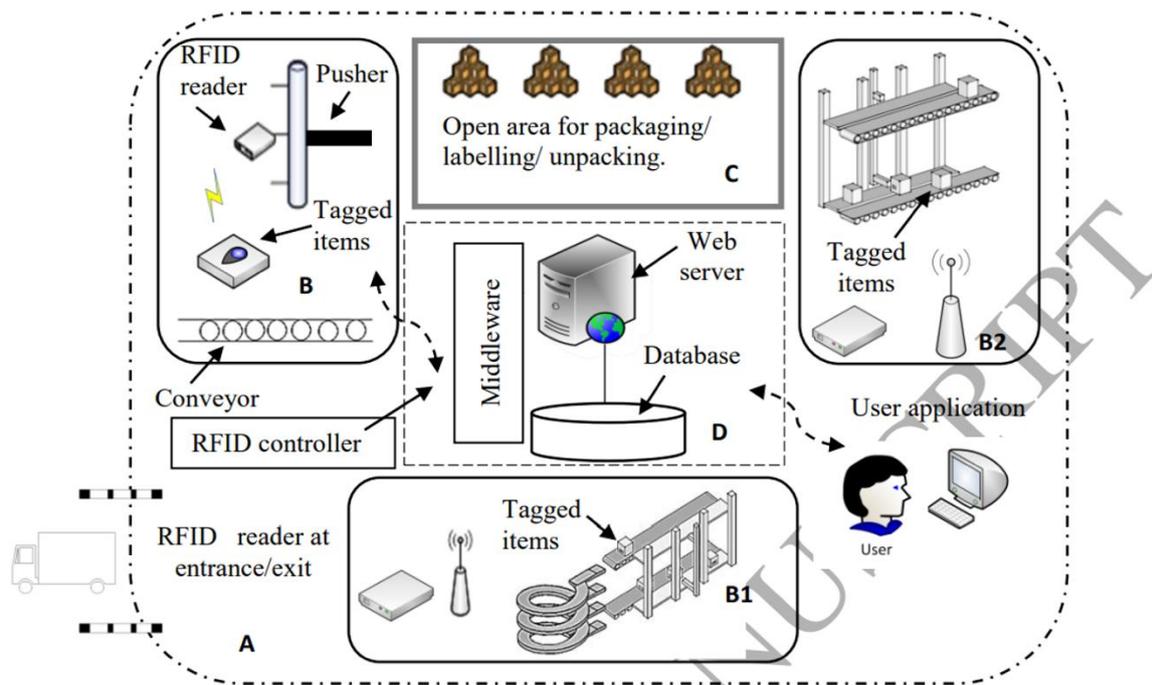
### ***2.3. RFID-based digital warehouse management system for Ecommerce industry***

In the ecommerce industry, warehouses are essential for connecting upstream suppliers with downstream customers. The increasing competition in this sector necessitates advanced warehouse management systems. As an innovative solution for inventory control and warehouse operations, WMS optimizes organizational processes and offers numerous benefits to retail businesses. This digital platform is designed to manage and streamline routine operations within the warehouse infrastructure ([Jenkins, 2020](#)). The advancements in RFID technology are evident across various supply chain sectors, including warehouse management, transportation management, production scheduling, order management, inventory management, and asset management systems ([Banks et al, 2007](#)). Within supply chain management, RFID systems can capture a wide range of product information, such as instance data (e.g., manufacture and expiration dates), historical data (e.g., departure and arrival times), product group data (e.g., descriptions, dimensions, and selling units), and commercial entity data (e.g., addresses and telephone numbers) ([Tajima, 2007](#)).

[Banks et al. \(2007\)](#) conducted a comprehensive evaluation of the integration of RFID technology within various warehouse management and distribution activities. Their findings highlight how RFID significantly enhances operational efficiency and accuracy across multiple processes. In the receiving process, RFID automates the scanning of incoming goods, reducing time consumption and minimizing human error. This technology is particularly beneficial for cross-docking, where it ensures that goods move directly from receiving to shipping docks, thereby reducing inventory costs and lead times. During the putaway process, RFID helps ensure that goods are stored in the correct environment by verifying tags against storage specifications, and forklifts equipped with RFID readers can identify optimal storage locations. For inventory control and stock location management, RFID provides continuous monitoring of inventory levels and storage locations, reducing the need for physical counts and manual recording, and minimizing ineffective use of storage space.

Various studies have applied RFID technology within the context of warehouse management systems (WMS), yielding consistently positive results that align with the findings of Banks and his group. [Wamba et al. \(2008\)](#) examined the use of RFID in the picking and shipping processes of a third-party logistics company's warehouse, demonstrating that RFID can support business process redesign, enhance data quality, enable real-time data collection, and improve synchronization and information sharing among stakeholders. [Poon et al. \(2009\)](#) developed WMSs to manage warehouse resources and monitor operations,

utilizing RFID technology to facilitate data collection and sharing within the warehouse. [Wang et al. \(2010\)](#) highlighted the benefits of an RFID-based digital WMS in improving operational efficiency, warehouse capacity utilization, and inventory accuracy, while also reducing manpower and loading time. [Kumar and Chan \(2010\)](#) found that RFID application not only enhanced the utilization of warehouse resources but also increased system work efficiency. Additionally, [Wang et al. \(2010\)](#) demonstrated that RFID techniques could improve the accuracy of object tracking and reduce lead times for preparing robotic arm tooling, thereby effectively enhancing manufacturing processes.



A. RFID reader. B. Storage area. C. Open area for packaging/labelling/unpacking. D. Data center.

**Figure 3.** Application and integration of an RFID-enabled warehousing management system

**Source:** Naz (2024)

Figure 3 illustrates the key components of an RFID-based warehouse management system. At the warehouse entrance/exit gate (A), an RFID reader collects data from RFID-tagged goods on incoming or outgoing lorries. After unloading and unpacking, items are placed in totes and moved to storage racks (B1) via a conveyor. When an item is needed, it is automatically transferred from the storage rack to an output conveyor (B2) by a pusher device (B), which also contains an RFID reader to receive signals from the tagged items. Inventory data is instantly updated in the warehouse management system through a controller that transmits the data via middleware (D), the software layer between the RFID reader and the

management system. The system's database contains records of each item's identification, availability, and other information. When an item is ordered, the RFID-based system automatically checks the database, and a programmable logic controller (PLC) activates a pusher to move the item onto the output conveyor. The item is then transported along an RFID-guided route to a packaging area (C). The inventory database is updated as the item leaves the warehouse, ensuring the entire process is automated, except for unpacking, labeling, and packing operations.

### **3. Analysis of RFID-based digital warehouse management activities**

#### ***3.1. Overview of Amazon***

##### *3.1.1. General information of Amazon*

Amazon, founded in 1994 by Jeff Bezos ([Wikipedia, 2025](#)), initially began as an online bookstore. However, it rapidly expanded its operations and diversified its business model to become one of the largest and most influential e-commerce platforms globally, offering a vast range of products and services. Over the years, Amazon has introduced innovative technologies such as Alexa, its AI-powered virtual assistant, and Amazon Go, a cashier-less shopping experience that leverages advanced sensors and machine learning. Its technological strengths will be thoroughly examined in the subsequent sections of the paper.

In recent years, Amazon has consistently ranked among the five most valuable companies worldwide, with a market capitalization approximately \$2.375 trillion, as in January 2025 (Companiesmarketcap, 2025). The company has significantly shaped the evolution of e-commerce, serving billions of consumers and enabling millions of businesses to reach a global audience through its platform (Britannica, 2025). Additionally, Amazon has pioneered advancements in cloud computing through its subsidiary, Amazon Web Services (AWS), which has become a cornerstone of its diversified portfolio and a leader in the technology sector (Britannica, 2025). As a result of these achievements, Jeff Bezos, the company's founder, has frequently been recognized as one of the wealthiest individuals globally (Britannica, 2025).

##### *3.1.2. Technological development at Amazon*

#### **Foundation and Emergence of the E-Commerce Platform (1994–2001)**

Amazon began its journey in 1994 as an online bookstore, gradually expanding to include a variety of products such as DVDs, electronics, toys, and more by 2001. During this

period, the company introduced notable features like "1-Click Shopping," which streamlined the purchasing process, and the Associates Program, allowing third-party websites to promote Amazon products in exchange for a commission. A significant milestone was the acquisition of Junglee Corp., which facilitated Amazon's transformation into a retail platform by enabling third-party sellers to list their products. These early initiatives were pivotal in establishing Amazon as a versatile and scalable marketplace, effectively connecting customers, sellers, and partners.

### **Technological Diversification and IT Integration (2002–2006)**

Between 2002 and 2006, Amazon diversified its technological capabilities, focusing on expanding its product offerings and integrating advanced IT services. Innovations such as the "Search Inside the Book" feature enhanced customer interaction, while the launch of Amazon Web Services (AWS) in 2006 marked a significant move into cloud computing. Strategic acquisitions during this period, including Mobipocket for e-books and CustomFlix for on-demand DVDs, laid the groundwork for Amazon's entry into digital content production and distribution. Additionally, Amazon began offering its e-commerce tools to developers and website owners, signaling a shift towards becoming a comprehensive provider of IT services alongside its retail operations.

### **Expansion of Ecosystems and Digital Innovation (2007–2013)**

The period from 2007 to 2013 saw Amazon solidify its role as a leader in e-commerce and digital technology through ecosystem development and innovation. The launch of the Kindle in 2007 transformed the e-book industry and established Amazon's presence in the consumer electronics market. AWS expanded to include new services such as CloudFront and Elastic Beanstalk, further enhancing its cloud infrastructure. Acquisitions, such as Audible for audiobooks and LoveFilm for video streaming, strengthened Amazon's digital media portfolio. Meanwhile, initiatives like Fulfillment by Amazon (FBA) and Amazon Webstore enabled third-party sellers to utilize Amazon's logistics and e-commerce capabilities. Collectively, these advancements allowed Amazon to create a cohesive ecosystem that supported its growth across multiple sectors.

### **Advancements in Technology and Operational Efficiency (2013–Present)**

Since 2013, Amazon has prioritized technological advancements to optimize its operations and enhance customer service. A key development has been the integration of RFID (Radio Frequency Identification) technology in its warehouses, enabling real-time

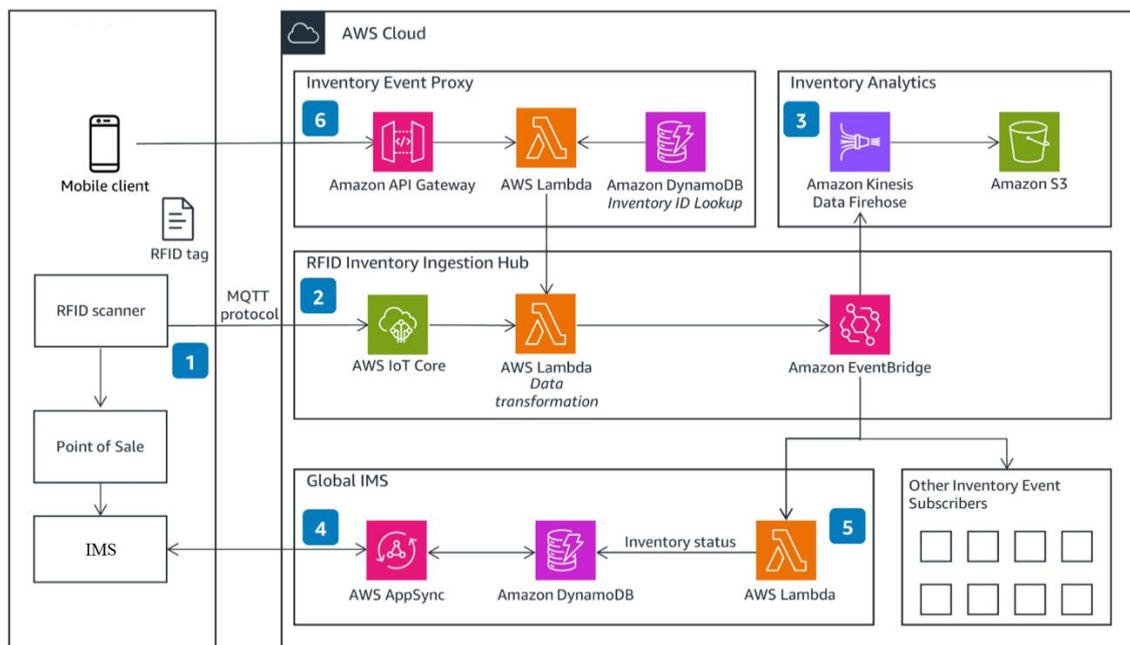
inventory tracking, reducing errors, and streamlining order fulfillment. Additionally, Amazon Web Services (AWS) supports IoT platforms that facilitate seamless integration of RFID and robotics across fulfillment centers. Complementing this, Amazon has expanded its use of robotics, following the 2012 acquisition of Kiva Systems, deploying over 750,000 robots by 2023 to improve efficiency in picking, packing, and sorting processes.

### 3.2. RFID application in digital-warehouse management of Amazon

Within the overall logistics chain, RFID technology has been widely applied in inventory management (Hellström & Wiberg, 2010) due to its ability to enhance inventory accuracy through real-time tracking and discrepancy reduction. The application of RFID in Amazon's warehouse management primarily focuses on controlling inbound and outbound inventory, ensuring systematic organization and minimizing errors. In the scope of this study, the authors will analyze the application of RFID technology in inventory identification, management, and auditing processes within Amazon's warehouses and customer fulfillment centers.

#### 3.2.1. Managing Warehouse Inventory

Amazon utilizes Radio Frequency Identification (RFID) technology to optimize warehouse inventory management by improving efficiency in tracking, monitoring, and automating operations. Unlike traditional barcode scanning, RFID enables real-time data visibility, reduces manual effort, and increases operational speed.



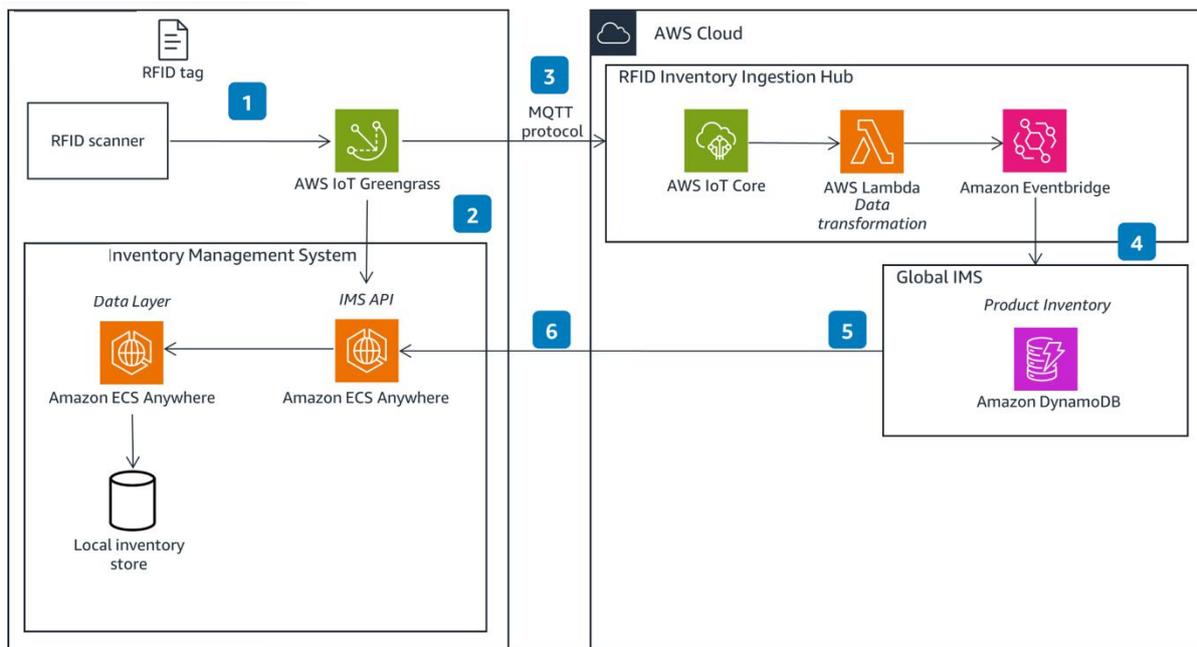
**Figure 4.** RFID system architecture in managing Amazon warehouse inventory

**Source:** Amazon solutions library

Each product is equipped with an RFID tag, which communicates with RFID readers to transmit data to AWS IoT Core. The Inventory Ingestion Hub processes inventory scan events, with AWS IoT Core utilizes AWS Lambda to perform data transformation tasks. This system facilitates instant stock updates, minimizes human error, and eliminates the need for manual scanning. With real-time inventory visibility, warehouse managers can make data-driven decisions to optimize stock control and improve operational efficiency.

To mitigate risks associated with stockouts and overstocking, Amazon employs AI-driven demand forecasting and AWS analytics tools. These systems analyze purchasing patterns and predict demand fluctuations, enabling automated reordering and optimized inventory distribution. AWS Lambda processes stock updates, while Amazon DynamoDB securely stores inventory data for real-time access.

### 3.2.2. Counting Warehouse Inventory



**Figure 5.** RFID system architecture in counting Amazon warehouse inventory

**Source:** Amazon solutions library

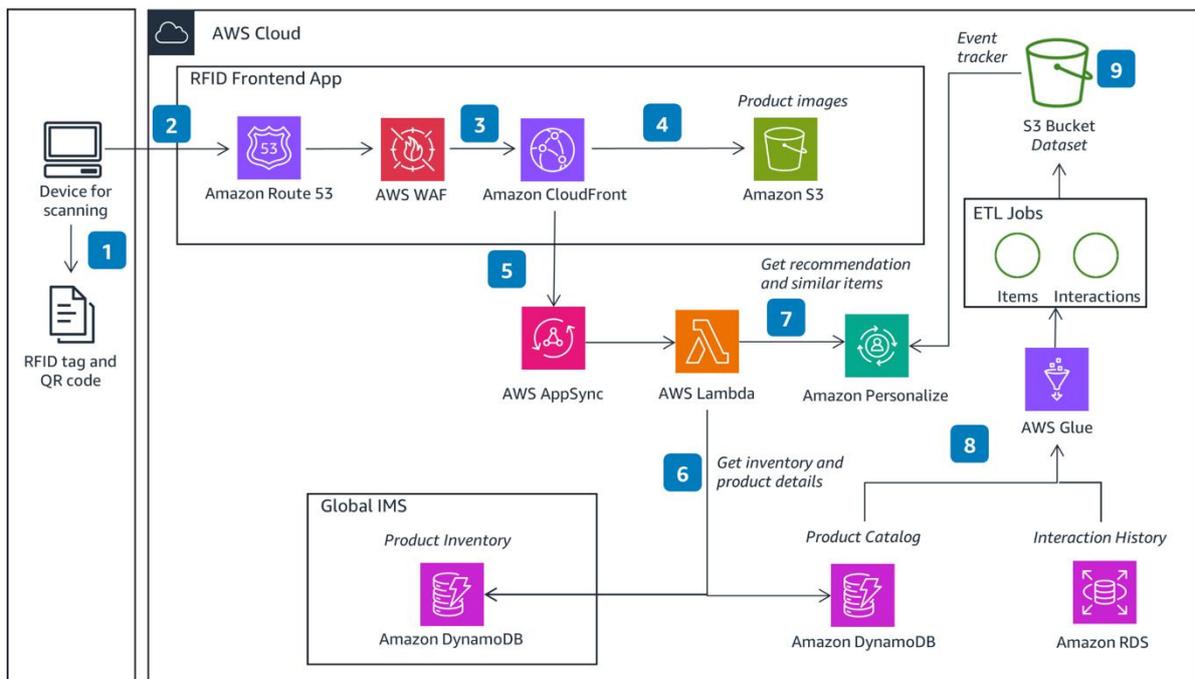
Amazon employs RFID technology to enhance the accuracy and efficiency of inventory audits, reducing reliance on manual counting methods that are often labor-intensive and error-prone. The implementation of RFID scanners enables rapid scanning of inventory

stored on shelves and racks. These scanned data points are transmitted to AWS IoT Greengrass, where they undergo pre-processing and de-duplication through AWS Lambda before being published to EventBridge for further analysis.

Following data processing, AWS IoT Greengrass communicates with the In-Store Inventory Management System (IMS), which operates on Amazon ECS Anywhere, facilitating centralized inventory management. The scanned inventory data, including item identification and store location, is then relayed to the Inventory Ingestion Hub, where the Global IMS reconciles any discrepancies and updates inventory records stored in Amazon DynamoDB. Upon completion of the audit, the Global IMS synchronizes inventory data with the In-Store IMS, ensuring consistency across the system.

Beyond audit automation, RFID technology contributes to shrinkage reduction and loss prevention by integrating with AWS security solutions, which generate alerts for unauthorized inventory movements. Additionally, AI-driven predictive analytics improve inventory forecasting, allowing for more precise stock level management and replenishment strategies.

### 3.2.3. Identifying Warehouse Inventory



**Figure 6.** RFID system architecture in identifying Amazon warehouse inventory

Source: Amazon solutions library

When a product's RFID tag or QR code is scanned, this request is routed through Amazon Route 53 for domain translation, secured by AWS WAF (Web Application Firewall), and processed by Amazon CloudFront to ensure efficient data retrieval. Product details, including specifications and images, are then accessed from Amazon S3.

Inventory data is further managed through AWS AppSync, which facilitates query processing, while AWS Lambda retrieves product information, including stock availability and characteristics, from Amazon DynamoDB. Additionally, Amazon Personalize generates product recommendations based on purchasing patterns, supported by data extraction and transformation processes conducted through AWS Glue. This structured data is stored in Amazon S3 to improve future recommendation models through machine learning.

RFID technology utilization in identifying inventory helps enhance order accuracy, streamline warehouse operations, and improve supply chain efficiency. RFID-tagged inventory allows workers to use handheld scanners and wearable technology integrated with AWS to verify items against customer orders in real time, significantly reducing picking errors.

In addition, RFID-enabled smart shelving systems provide real-time location tracking, minimizing search time and increasing fulfillment speed. RFID authentication systems also validate the authenticity of high-value products by cross-referencing product data with manufacturer databases, ensuring only genuine items enter the supply chain.

### ***3.3. Evaluation of RFID in Amazon's Warehouse Management***

#### ***3.3.1. Managing Warehouse Inventory***

RFID technology plays a pivotal role in enhancing the management of warehouse inventory at Amazon by improving tracking accuracy, boosting automation, and reducing operational inefficiencies. By integrating RFID with AWS cloud services, Amazon achieves real-time inventory visibility, ensuring continuous monitoring and updating of stock levels. This automation minimizes reliance on manual tracking, thereby reducing human errors and optimizing stock replenishment strategies. Tan (2008) highlights that RFID enhances tracking efficiency and facilitates automatic storage and retrieval assignments, reducing misplacements and improving order accuracy. Moreover, the implementation of RFID helps prevent stockouts and overstocking by leveraging AI-driven predictive analytics to analyze sales trends and demand fluctuations. The integration of RFID with robotic picking systems

further enhances warehouse efficiency, enabling automated systems to swiftly retrieve items, thus reducing processing time and improving fulfillment speed.

Despite these benefits, challenges persist in warehouse inventory management with RFID. The initial investment in RFID infrastructure—including tags, scanners, and cloud-based tracking systems—requires substantial financial resources. Additionally, signal interference caused by environmental factors, such as metallic shelving or liquids, may affect RFID accuracy, necessitating advanced calibration techniques to maintain optimal performance.

### *3.3.2. Identifying Warehouse Inventory*

The accurate identification of warehouse inventory is crucial to Amazon’s logistics operations, where RFID technology is utilized to streamline order accuracy and reduce picking errors. RFID-enabled scanners and smart shelving systems ensure precise location and retrieval of items, thereby enhancing the efficiency of order fulfillment. The use of RFID in product authentication and counterfeit prevention is particularly valuable for high-value products, as RFID tags store unique product data that can be cross-referenced with manufacturer databases to verify authenticity.

In addition to improving order picking accuracy, RFID enhances supply chain visibility by enabling seamless tracking from suppliers to fulfillment centers. This capability ensures real-time monitoring of inventory movements, reducing the likelihood of misplaced or lost items. However, integrating RFID with legacy warehouse management systems can present challenges, requiring significant system upgrades and compatibility adjustments. Moreover, maintaining the security of RFID-generated data remains a priority, as unauthorized access to tracking information could pose risks to inventory management operations.

### *3.3.3. Counting Warehouse Inventory*

Traditional inventory audits are labor-intensive and time-consuming, often necessitating manual stock verification. Amazon addresses these inefficiencies by deploying RFID-based automated inventory audits, enabling rapid and accurate cycle counts without disrupting warehouse operations. RFID scanners integrated with AWS machine learning services streamline inventory reconciliation, ensuring precise recording of stock levels and prompt addressing of discrepancies. The implementation of RFID for inventory counting

reduces shrinkage caused by theft, misplacement, or administrative errors, thereby enhancing security and accountability within warehouse operations.

Despite its advantages, RFID-based inventory counting systems must overcome several challenges. The cost of deploying automated RFID audit systems remains a significant barrier, particularly for companies operating on a smaller scale. Additionally, the ability of RFID scanners to read multiple tags simultaneously can sometimes lead to data overlap or misreads, necessitating sophisticated filtering algorithms to ensure accuracy. To mitigate these challenges, Amazon continually invests in refining RFID technology and integrating it with AI-driven anomaly detection systems to enhance inventory verification processes.

## **4. Implications for RFID applications in warehouse management of Vietnamese e-commerce platforms**

### ***4.1. Challenges***

#### *4.1.1. Lack of sufficient RFID system structures*

Amazon's successful implementation of RFID hinges significantly on its robust IT infrastructure, especially its cloud-native, scalable, and integrated system architecture. Through services like AWS Lambda, DynamoDB, IoT Core, and AppSync, Amazon achieves seamless real-time data flow from RFID readers to back-end systems for inventory management, audit, and product identification. Vietnamese e-commerce platforms, however, often lack such an advanced and unified system that can efficiently process the massive volumes of real-time data generated by RFID. Most platforms rely on fragmented legacy systems, which leads to poor data integration, processing delays, and scalability limitations. RFID systems generate vast amounts of real-time data, and managing these large datasets poses a challenge. The system must be able to store, process, and analyze this data efficiently to provide actionable insights for warehouse management, including real-time inventory tracking, order fulfillment, and stock replenishment. Moreover, as e-commerce platforms expand, the scalability of the RFID system becomes a critical issue. Inadequate scalability can lead to slow response times, reduced system performance, and delays in order processing, affecting overall warehouse efficiency.

#### *4.1.2. Threats from cybersecurity*

The use of RFID technology also raises concerns regarding the security and privacy of the data transmitted between tags, readers, and central systems. While Amazon possesses

their own database and cloud for information gathering and control, Vietnamese enterprises do not have sufficient resources for them, and often outsource data storing by a third party platform. The real-time tracking of goods, while enhancing inventory management, also increases the risk of unauthorized access or data breaches. Given the increasing importance of cybersecurity in e-commerce, Vietnamese platforms must address these risks to ensure the safe transmission of sensitive data related to product movements and inventory levels.

#### *4.1.3. High expenditure*

Another challenge in RFID implementation is the prohibitive cost associated with the technology, particularly the RFID tags themselves. The tag is attached to the product, and due to the high cost of RFID tags, customers cannot take the tags with them when the product is shipped. This creates a significant issue for operations that require the tag to remain with the product throughout its lifecycle, especially in last-mile delivery where efficient stock management is critical. The high cost of implementing RFID across the entire supply chain also presents a substantial barrier. Deploying RFID technology widely—from warehousing to final delivery—may lead to excessive expenses that are not justifiable by the benefits, prompting companies to seek alternative methods in non-critical stages. Additionally, reverse logistics introduces another layer of complexity and cost. Retrieving RFID tags from products once they are returned or recycled can incur extra expenses, further challenging the cost-effectiveness of a full-scale RFID deployment. While RFID can be highly effective in managing stocks during last-mile delivery, its application in every stage of the process is often seen as wasteful. This has led many companies to adopt a more targeted approach, leveraging RFID only where it provides the most significant value.

## **4.2. Recommendations**

### *4.2.1. Enhancing RFID Infrastructure through Scalable and Modular Systems*

To overcome the limitations in system infrastructure, Vietnamese e-commerce platforms should adopt a modular and scalable approach to RFID implementation. Instead of attempting to replicate Amazon's comprehensive in-house system, businesses can begin with cloud-based services that offer flexibility in data storage and processing. Utilizing platforms such as Amazon Web Services (AWS), Microsoft Azure, or domestic cloud service providers enables enterprises to process real-time RFID data without requiring extensive investment in physical infrastructure.

In addition, integrating RFID with existing Enterprise Resource Planning (ERP) or Warehouse Management Systems (WMS) through standardized APIs can help ensure smoother data flow and system compatibility. The adoption of microservices architecture is also recommended to allow for independent deployment and scaling of core RFID functions such as inventory tracking or order picking. Strategic collaboration with local technology providers or research institutions can further support the development of tailored RFID applications, while keeping development costs manageable.

#### *4.2.2. Addressing Cybersecurity Risks in RFID Deployment*

As RFID systems collect and transmit large volumes of sensitive, real-time data, Vietnamese e-commerce enterprises must pay careful attention to cybersecurity concerns. Unlike Amazon, which operates its own secure cloud infrastructure, many local firms rely on third-party platforms for data storage and processing. This reliance increases the risk of unauthorized access and data breaches if proper safeguards are not in place.

To mitigate these risks, firms should implement robust encryption protocols, user authentication mechanisms, and regular system audits. Collaborations with cybersecurity specialists or certified vendors may be necessary to ensure the security of both hardware and software components within the RFID system. Furthermore, training programs aimed at improving employees' awareness of cybersecurity practices should be integrated into the transition to RFID-based operations. Compliance with national data protection laws and international standards will also be essential in protecting business continuity and consumer trust.

#### *4.2.3. Reducing RFID Implementation Costs through Strategic Planning*

The high cost of RFID tags and supporting infrastructure remains a significant barrier for many Vietnamese enterprises. Rather than deploying RFID across the entire supply chain, it is advisable to implement the technology selectively in areas where it offers the highest value, such as managing stocks in last-mile delivery and critical inventory management points, or quality assurance for returns.

Incorporating a hybrid model—where RFID is used selectively alongside traditional barcode systems—can also help reduce initial investment. Additionally, the use of reusable RFID tags within warehouse operations or controlled environments can lower long-term costs. Enterprises may also benefit from negotiating bulk purchasing agreements with RFID suppliers or participating in joint procurement initiatives.

Finally, businesses should explore opportunities for financial support through government programs that encourage digital transformation. Initiatives that incentivize the return or recycling of RFID tags from customers can further improve cost efficiency while promoting sustainability.

## **5. Conclusion**

In recent years, as the ecommerce industry in Vietnam is growing rapidly, it is essential to enhance the efficiency of the warehouse management system to ensure a fast and seamless supply chain. By examining Amazon's implementation of RFID in the warehouse management system, the research aims to provide valuable insights into how Vietnamese firms can leverage this technology.

The findings from this research aims to clarify both benefits and challenges of integrating RFID into warehouse management. From the experience of a giant ecommerce business like Amazon, Vietnamese firms can gain practical lessons to ensure successful implementation of RFID in the future. The adoption of RFID can significantly improve operational accuracy, data recording and accelerate order fulfillment. Meanwhile, the technology presents certain disadvantages such as high initial investment as well as challenges in the reverse logistics process. By carefully evaluating the application of RFID, businesses can maximize its benefits while mitigating potential risks, ensuring a more effective warehousing process.

Despite some disadvantages, RFID remains as a promising solution for the warehouse management system in Vietnam's ecommerce sector. RFID adoption can be a strategic move for enterprises to further enhance their ability to identify, track and manage inventory in real time.

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