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DIGITALIZING INVENTORY MANAGEMENT USING UNMANNED AERIAL VEHICLE (UAV'S) AND RFID TECHNOLOGY

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ABSTRACT

Radio Frequency Identification (RFID) allows a business to identify individual products and components, and to track them throughout the supply chain from production to point-of-sale. Connecting RFID reader to the aerial drones to read RFID tags tens of meters away, the readers can identify, track and monitor the objects attached with tags globally, automatically, and in real time, if needed using Internet Of things .The equipped drone system has the potential to be used in large warehouses in order to prevent inventory mismatches and locate individual items. This paper introduces the technologies of RFID and UAV's, discusses the applications and challenges of RFID technology and drones used for inventory management.

Keywords: *RFID technology; Drones ; Inventory management*.

I. INTRODUCTION

Radio frequency identification system (RFID) is an automatic technology whereby digital data encoded in RFID tags or smart labels and captured by a reader via radio waves .The RFID technology was first appeared in 1945, as an surveillance tool for the Soviet Union, which retransmitted incident radio waves with audio information RFID is similar to bar-coding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line-of-sight, whereas barcodes must be aligned with an optical scanner.RFID tags are an improvement over bar codes because the tags have read and write capabilities. Data stored on RFID tags can be changed, updated and locked. With the Advancement in technology many retailer companies have begun using RFID tags and have found that the technology offers a better way to track merchandise for stocking and marketing purposes.

A typically RFID systems consist of three components: an RFID tag or smart label, an RFID reader, and an antenna. RFID tags contain an integrated circuit and an antenna, which are used to transmit data to the RFID reader. The reader then converts the radio waves to a more usable form of data. Information collected from the tags is then transferred through a communications interface to a host computer system, where the data can be stored in a database and analyzed at a later time.

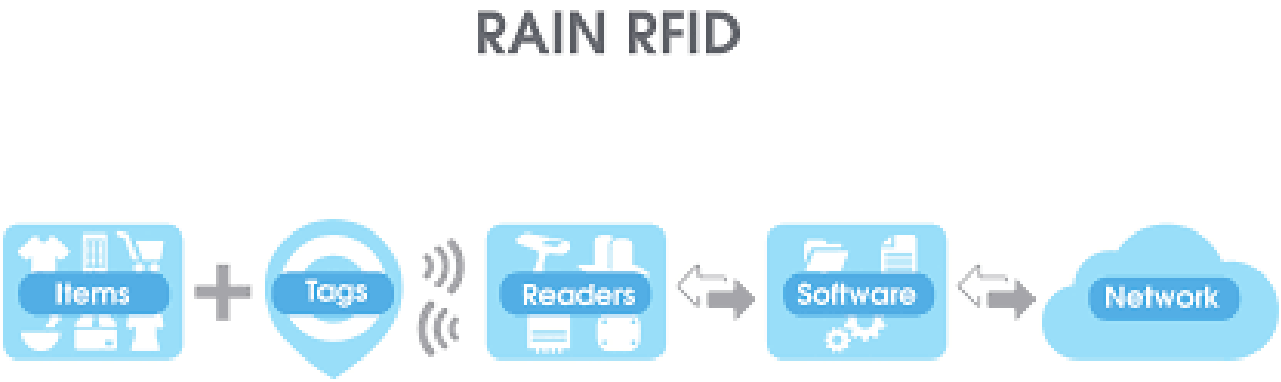
RFID is one of the big opportunities in information technology, which will change the world broadly and deeply. Although RFID tags were intended to revolutionize supply chain management, in practice these battery-free tags, which receive power wirelessly from scanners to broadcast identifying numbers, have often proved unreliable. This leads to errors with supply chain inventory management. To help overcome this, drones can access the tags in different locales more effectively than a person wandering around with a hand-held scanner.

II. RFID TECHNOLOGY

RAIN RFID

RFID is a generic term that encompasses different frequencies and standards which include both NFC (Near Field Communication)and RAIN technologies which are supported by industry alliances. RAIN RFID is a passive

(battery-free) wireless technology system that connects billions of everyday items to the Internet, enabling businesses and consumers to identify, locate, authenticate and engage each item. RAIN RFID is used in a wide variety of applications, including inventory management, patient safety, asset tracking and item authentication.



Taking inventory with a RAIN RFID Drone reader is 25X faster than with a barcode reader

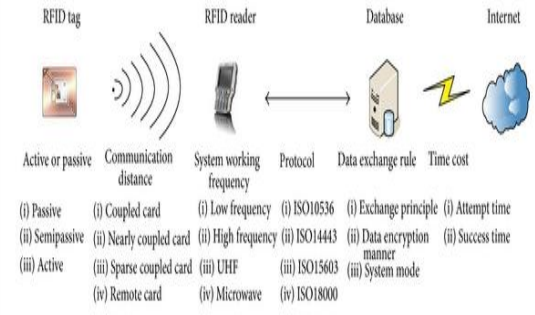
RAIN RFID has the capacity to both greatly enhance and protect the lives of consumers, while revolutionizing the way companies do business. It is a flexible, low-cost solution, making its use appealing to a wide range of industries—from retail to healthcare, manufacturing, entertainment and hospitality.

RAIN RFID can tell you what an object is, where it is, and even its condition. With this information, businesses around the world are able to increase sales, drive operational efficiencies, and improve customer experience **RAIN RFID*System***

RFID System include three main elements:

Endpoints

A RAIN RFID tag is comprised of a tag chip (IC) attached to an antenna that has been printed, etched, stamped or vapor-deposited onto a mount which is often a paper substrate or Polyethylene Therephtalate (PET).which is then converted or sandwiched between a printed label and its adhesive backing or inserted into a more durable structure. Finished tags are available in a wide variety of shapes and sizes including labels or stickers, apparel hang tags, security tags, and industrial asset tags used on pallets and heavy machinery. Advancements in RAIN RFID have made it possible to tag liquids and metals. The type of tag needed depends on the item being tagged and where and

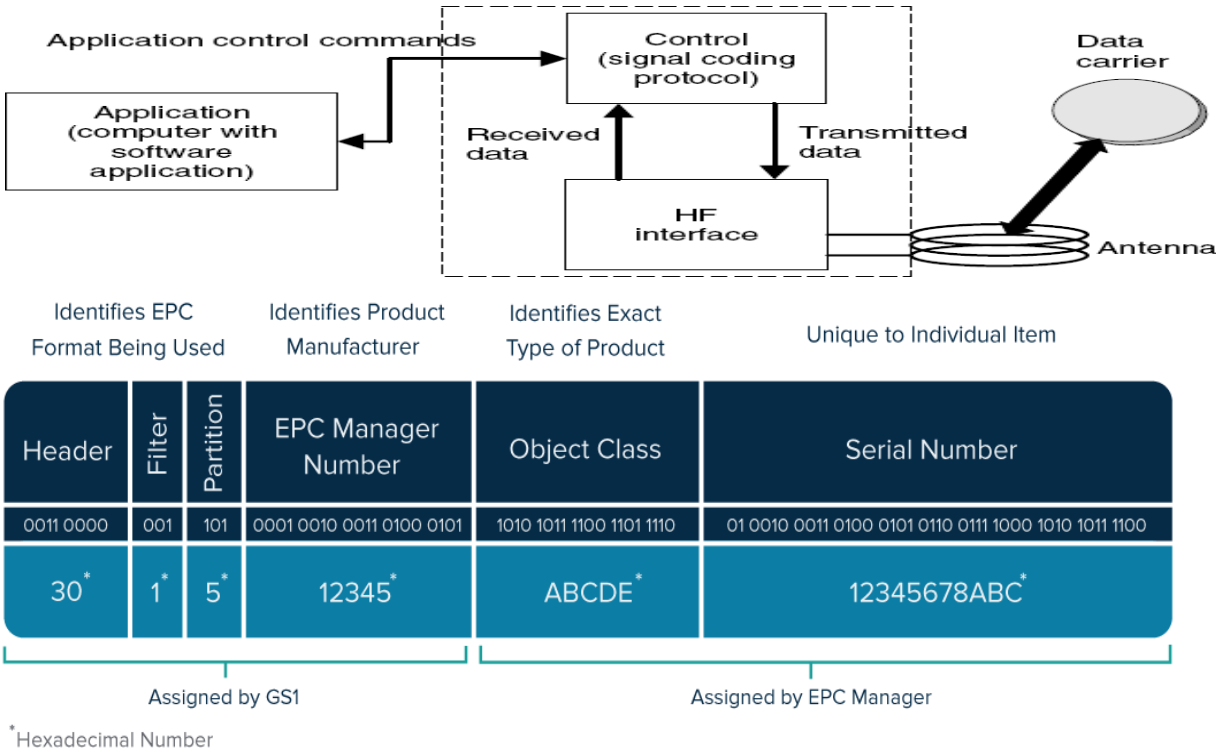


how connectivity devices will engage it.

Tag chip

RFID Tag consists of a tag chip which is used to uniquely identify their host item and deliver performance, memory and extended features to tags. The Tags consist mainly of a coiled antenna and a microchip, with the main purpose of storingdata. These passive tag chips power themselves from a connectivity device's radio waves so don't require any batteries like active tags , and are readable to 30 feet without line-of-sight ,Hence reduces the overall cost of the

tag . The chip is pre-programmed with a tag identifier (TID), which is a unique serial number assigned by the chip manufacturer, and includes a memory bank to store the items' unique tracking identifier (called an electronic product code or EPC) Which basically stores the 96- bit string of data .And every tag has different EPC code number .The total electronic product code number can be used as a key into a global database to uniquely identify that particular product.



Tag Antennas

Antennas can be made from a variety of materials; they can be printed, etched, or stamped with conductive ink, or even vapor deposited onto labels their main function is to collect energy and channel it to the chip to turn it on. Generally, the larger the tag antenna's area, the more energy it will be able to collect and channel toward the tag chip, and the further read range the tag will have. Moreover its application that defines the tag's antenna specifications. Some tags might be optimized for a particular frequency band, while others might be tuned for good performance.

Connectivity

This includes Connectivity devices like RFID Reader which basically identify, locate, authenticate and engage endpoints.

Connectivity devices communicate bi-directionally with endpoints that are within their field of operation, performing any number of tasks including simple continuous inventorying, filtering. Connectivity devices can identify and locate more than 1,000 items per second. Readers can be stationary or mobile and use an attached antenna to capture data from tags. Gateways integrate stationary readers with scanning antennas to locate and track tagged items. Reader chips and modules are designed for to be embedded in applications like handheld and drone based Reader.

RFID Reader

RFID readers are also referred to as interrogators because they query tags as the tags enter their read range. RAIN RFID readers and reader antennas work together to read tags. Reader antennas convert electrical current into electromagnetic waves that are then radiated into space where they can be received by a tag antenna and converted back to electrical current. Readers in all systems can be reduced to two fundamental functional blocks: the control system and the Ultra high frequency (UHF) interface, consisting of a transmitter and receiver, as shown in Fig.3.

The entire system is controlled by an external application via control commands.
Fig.3 RFID reader consisting of control system and UHF interface [2]The reader's UHF interface performs the following functions:

(a) Generation of high frequency transmission power to activate the transponder and supply it with power;
(b) modulation of the transmission signal to send data to the transponder; (c) reception and demodulation of UHF signals transmitted by a transponder.

The reader's control unit performs the following functions:
Communication with the application software and the execution of commands from the application software; (b) control of the communication with a transponder (master–slave principle, as shown in Fig.2); (c) signal coding and decoding. In more complex systems the following additional functions are available: (d) execution of an anti-collision algorithm; (e) encryption and decryption of the data to be transferred between transponder and reader.

Software

It aggregates and transforms data from endpoint reads, delivering real-time information to enterprise and consumer applications It sends control commands to connectivity devices and receives tag data, giving businesses access to all the information collected. This software enables businesses to integrate real-time, accurate RAIN RFID data across multiple business applications and may manage reader Asset tracking process perform remote firmware updates, and configure reader infrastructure.

RFID4U Warehouse Management & Inventory Control software provides the capability to Use RFID, barcode and NFC to collect and transfer data between the inventory items and the system.

III. RFID DRONES

Why RFID drones?

We have previously exposed how RFID readers have historically been fixed to a gate at specific points of the supply chain. This guarantees that RFID tagged items all go through a relatively small area so that they can be read. This works for track trace services in supply chain.

Implementation and Goals:-

The main purpose is to design a UAV mounted system which takes inventory of items with RFID tags from a range of several meters and maintain a list of items in a file on a USB thumb drive. The UAV can be flown by a Technician over each herd or autonomously using waypoints. Once the UAV passes within the read range of each product , the ID for each item is added to a comma separated value (*.csv) file stored in a USB drive on the Raspberry Pi. The Technical assistant can check the file to see the product IDs and location and determine if any product is missing. The UAV can then be flown again to find a desired item . The target price is roughly $3,000 which, despite increasing up-front costs, will save our sponsor money in the long run due to reduced labor time.

The features of the UAV system include:
• Maximized read range of the UHF RFID reader and tags.
• Reader mounted to the UAV to fly around and energize the RFID tags
• Ability to read multiple tags quickly and populate a list in a CSV file
• Ability to gather GPS data
• Ability to export the list on a USB stick

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Technical Specifications

The tags are energized by an incoming electromagnetic signal of ~900MHz and reflect a fraction of the received power. Once the signal is reflected the receiver reads each tag and maintain a list of Product IDs.

Specification	Target	Actual
Tag Operating Frequency	~ 915 MHz	~ 915 MHz
Output Power to activate passive tag	≤ 30 dBm	30 dBm
Read-Range for various antennae	≤ 4 m	~ 2 m (circular polarized) ~ 8 m (linear polarized)
Size of System	All aboard a UAV	0.8 x 0.8 x 0.8 ft
Weight (hardware)	< 5 kg	~ 1.5 kg
Power Source for UAV system	Rechargeable battery pack	4000 mAh rechargeable battery pack with 2 USB outputs
Communication with Database on CPU	USB/WiFi/Bluetooth	USB
Flight time of UAV	Up to 28 min	~ 25 min

Design Approach

The entire system consists of a 1) UAV (DJI Phantom 4),
2. RFID reader , an external antenna (circular and linear polarized, respectively)
3) A central processor (RaspberryPi).
4) A GPS module (Ad fruit), and 5) an external battery pack.
. A visual of the system design is shown in figure 1.

LCD display can also be implemented that allowed the instantaneous viewing of tag readings, and the external antenna of the mobile reader is mounted on one side of the UAV and angled down towards the cattle. This is done in an effort to reduce the amount of interference between the interrogator and the RFID tag. For example, a product may be placed behind another product while , the interrogator signal would have to travel through the first product to get to the desired tag. Lightweight RFID Reader should be preferred and should have adjustable power output, and is also compatible with a Linux system, and has a port for an external antenna. Once the interrogator's signal arrives at the tag, a reflection occurs and the tag sends out a signal with information regarding a product . The RFID reader receives the tags' signals and populates a list of all received tags. The list is stored in a *.csv file on a USB drive that can easily be removed and imported into an Excel file to be viewed. All communication between the different hardware within our system is via USB connection

Inventory Management Using drones and RFID
In this territory, robots have made a marked impact. They proved that they are better option than humans labor changing the day-to-day requirements in businesses. Recently, they take the form of highly capable drones. Improvements in drone technology and battery life make them even more applicable to workplaces. With these new models, companies will be able to incorporate drones in roles not previously possible. Companies like DroneScan and Hardis Group. These firms use quad copter tech to improve warehouse inventory management. In addition, Wal-Mart is developing their own version of the technology to compete with Amazon.

Furthermore, using drones in the warehouse goes beyond flying. In 2013, Amazon began using autonomous wheel drones designed by Kiva Systems to organize and prepare merchandise. These drones were designed to work efficiently and never collide with each other. Also, they're used by companies such as Zappos, Staples, and Walgreens.MIT researchers have also developed a system that enables small, safe, aerial drones to read RFID tags from tens of meters away while identifying the tags' locations with an average error of about 18 centimeters. The researchers envision that the system could be used in large warehouses for both continuous monitoring, to prevent inventory mismatches, and location of individual items, so that employees can rapidly and reliably meet customer requests

IV. APPLICATION

Benefits of ***chains are: Efficient*** Work Completion Using drones in place of humans for tasks such as barcode scanning can be far more efficient. As DroneScan points out, A drone operator can count as much stock in a warehouse in two days as a team of 70 people with handheld scanners and reach trucks can count in 2.5 days." What does this mean? IT means the Overall efficiency with improved rates of delivery and inventory management. By using drones in place of machines and workers to scan inventory also has energy benefits. Companies are able to save time and energy on the part of employees. In the place of an employee using a lift to access inventory, a lightweight drone can easily scan the respective inventory. Safety: Implementing drones to take stock of inventory reduces human interaction with machinery and stock. This reduced the risk to both the customer as well as the working staff.

V. CHALLENGES

Collision Problems
Communication between tags and readers are inherently susceptible to electromagnetic interference. Simultaneous transmissions in RFID lead to collisions as readers and tags typically operate on a same wireless channel. Therefore, efficient anti-collision protocols for identifying multi-tags simultaneously are of great importance for the development of large-scale RFID applications. There are various anti-collision protocols for RFID tag identification have been proposed, such as query tree protocol (QT), binary tree protocol (BT), frame slotted ALOHA protocol (FSA), etc., but almost all known protocols exhibit an overall identification efficiency small than 49%. There was always need for uniform IDs distribution in past. It is very useful task for pointing out the best performing features of RFID tag identification protocols, and for designing new and better protocols. In [1], we represent a novel and efficient anti-collision protocol for RFID tag identification, i.e., collision tree protocol (CT), which outperforms all the other anti-collision protocols proposed so far and the types of drones used are small, lightweight with plastic rotors and they also called RFly's. These provides 100% safety and ensure that nobody is injured in warehouse , It may be worker or customer**.**

VI. CONCLUSION

The Drones uses a variety of information, sensing identification device and information processing equipment, such as RFID, WSN, GPRS, etc, combining with the Internet to form an extensive network in order to informationize and intelligentize the entities or objects and uses this information to performs full inventory management Additionally, the system software provides the capability to categorize each inventory item, which is easily and quickly set up to meet the individual company requirements.. This paper analyzes the applications and challenges of Drone and rfid based inventory management system.

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