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Intelligent Packaging System using IoT

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***Abstract*— E-commerce, also known as electronic commerce, refers to buying and selling various goods and services online. In recent days, the word "eCommerce "has become very familiar due to the internet boom and the kind of comfort (and other services) it provides to its users. Many companies have either established their business or have increased their profits with the help of eCommerce. Many studies show an exponential increase in eCommerce sales and services, and it will reach new heights in the upcoming years. Ecommerce businesses have seen a 265% growth rate, from $1.3 trillion in 2014 to $4.9 trillion in 2021, also higher. With such a mass boom in eCommerce, people don't prefer to buy goods offline since they receive more benefits by buying online. But unfortunately, there are a few problems that both the company and its customers face. And gradually, such issues have been increasing, and significant issues were concerning the faulty delivery system. To handle such situations, we propose a solution to avoid any delivery- related problems caused during delivery and stop such problems by ensuring every customer gets the products as it is by the dealer directly without any interference while delivering. This report discusses the part of IoT insecured packaging solutions and the proposed approach.**

Index Terms: Intelligent Packaging, Microcontroller, GPS, Sensors, Arduino.

INTRODUCTION

The Intelligent Packaging System solution aims to use electronic packaging to combat the problem of tampering with packages during transit and monitor the product's characteristics and the inner and outer atmosphere of the box. The project IPS aims to use electronic packaging solutions to trigger an alert when a package is opened effectively. Monitoring is done by using many sensors in a failsafe system. The problem with single sensor-based systems is that theydo not correlate data from different means. The proposed method has many sensors like GPS that continuously track physical parameters inside the package during transit to ascertain if the box has been opened or if there has been some rise in temperature (for pharmaceutical and temperature-sensitiveproducts). Once this alert has been sent to the manufacturer, they can take necessary corrective action. If there was no alert and a standard delivery took place, the customer would have received a damaged product. Once the delivery takes place, the customer uses their mobile phone to scan a QR code displayed on the IPS kit; this will result in an OTP received at the customer's mobile, and entering the OTP will open the kit will reset the device. The IPS kit is then removed from the box and given to the delivery executive to be reused again. Internet of Things (IoT) isn't only an exciting research topic and a booming industrial trend. Although the essentialidea is to bring things or objects online to be available to all, there are various approaches because an IoT system is very application-oriented. Some problems that arise with the packaging of products are difficulty and inaccuracy in determining appropriate packaging solutions consistent with the type and condition of the merchandise to be packed. The incorrect decision of the packaging option can cause a loss in quality and physical damage to the product. Packed products might get spoilt, especially perishable and time-sensitive products. The magnetic lock could be a more practical and cost-efficient solution, especially for parcel delivery. The functionality is often managed locally. Data security is a significant concern, and thus the system is fully compliant with all data protection standards. Thanks to the enterprise-level cloud-based control system, no resident data is stored locally. With the exponential rise of eCommerce, intelligent packaging solution helps with the increasing need to manage online purchase deliveries effectively.

BLOCK DIAGRAM DESCRIPTION

The IPS development kit uses a wide variety of sensors, and the kit's brain is the Arduino Uno. The various sensors being used are the DTH sensor, LDR,GPS, MEMS sensor, and IR sensor, and also, we will make use of multiple modules like keyboard, LCD, GSM, and NODE MCU

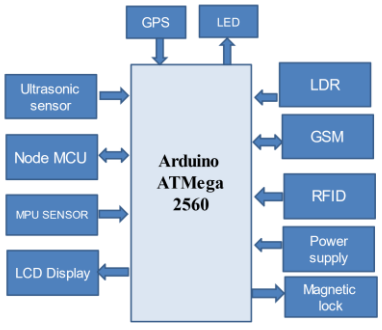

Figure 1: Block diagram

Fig 1 shows the block diagram description of the model, LCD Display used to display each operation. LDR is nothing but a Light Dependent resistor, and itcan detect light when the kit is opened without the OTP or if the equipment is not closed correctly while packing. MEMS sensor is a low-cost inertia sensor used to determine whether the IPS box has been mishandled or if any thief attempted. IR sensor is an Infrared Sensor used to detect the package's presence and can also sense any intrusion. The GPS is used to get the live location of the kit, and this

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is sent to the user via a text message with the help of the GSM module. DHT sensor is used to track the temperature and humidity inside the kit; this will be very helpful while transporting (or delivering) any food or pharmaceuticals. The core Arduino Uno is responsible for integrating all these sensors and opening and closing the magnetic lock.

LITERATURE SURVEY

Ge Wang et al. [1] proposed a packaging systemcalled Verifiable Smart Packaging with Passive RFID; in general, the courier packages, after someone orders them online, go through the packaging process and later is shipped to thecustomer; their primary job is to identify and track the items from the time it has been taken out for delivery till its delivered but what happens between getting out for delivery and reaching to the customer is not accounted, An intruder can replace the items in the box. No one would even notice which is an eventual loss to the customer, So to avoid such malicious events verifying and testing of whether its safe inside, in other words, its authenticity is necessary, In this paper, a system is introduced using Passive RF tags, This is used to check the internal health of the package and to develop a non-destructible package and called it Echoscope. It only needs to determine whether the ID and signal featurescollected at a testing site match the record at thedelivery site.
There are various ways of checking whether the inside of a package is intact, like Ultrasonic scanning, X-Rays. Still, these machines are neither cheaper nor mobile so what an Echoscope does is that it extracts backscattering signals from the package to check the status of the box. This first check is done once before the shipping phase and later before the package is delivered to the customer and reviews for any differences; if there are none, the package is delivered to the customer.

Advantage: This method is comparatively more straightforward because it uses an Echoscope whichis low cost compared to other testing methods.

Disadvantage: The results are not as accurate as Ultrasonic scanning, X-Rays because the accuracy is compromised for cost.

Jiu Wen et al. [2] designed a Map-Matching Service system for better Trajectory of the couriers. Everyday there are thousands of online orders to be delivered to different locations. These generate tonsof data about the courier trajectory. Still, it generally doesn't account for various factors. With a singleapproach, the data is sent through to the courier delivery workers and the customers about the estimated arrival of the package.
Map match plays an integral part in developing trajectories. The existing map matching either considers cars as a means of transportation or ignoresit altogether, considering a single estimated time based on distance; therefore, the accuracy of such map matching trajectories is on the lower part and cannot be guaranteed. To achieve better accuracy andsolve this problem, this paper has proposed to use a better map matching Trajectory where a wide range of factors should be considered. The fundamental problem that map-matching faces is the "Fragmentation" problem because couriers have to deliver the packages to different locations. A car's positioning system is based on GPS, which is more reliable compared to the courier services that use a wi-fi location system as their positioning system. Noteveryone delivers in a Car. Most of them provide an electric bike or walk, which are slower than the car but can cut through narrow roads and avoid comparatively more traffic. These factors create highly irregular trajectories that were previously ignored in existing map-matching circuits. Still, now after accounting for the factors mentioned above plus some more, the new map matching called Courier trajectory-based map-matching is more reliable and accurate with low time and space complexity with low latency.

Advantage: A map matching System is developed where various external factors like mode of transport are included in the map matching trajectory where wecan do accurate delivery time estimates.

Disadvantage: Positioning information for developing Trajectory is generated using a wi-fi location system, which is not precise as Global Position System (GPS). Also, Tampering with packages is not checked during transit.

Turban E et al. [3]Marimin & Maghfiroh N proposed that they can use the development and implementation of a DSS (decision support system)to improve the process of delivery. This is done by choosing the best packing option for the product. TheDSS uses previous data to teach itself and choosesthe best option available. This improves the whole delivery cycle and makes it more smooth and cost- efficient. The DSS application mainly focuses on the user and the delivery agency. When the customer or the agency authority login to the DSS using their credentials, they can use various functions or servicesto improve their experience. It uses the GPS at the delivery end and figures out the best route for delivering the package with the help of machine learning. At the same time, the courier can update the logistics status and immediately update it to the user through a communication network. This procedure does not use any hardware components, and it isheavy on software. If we cannot implement it in remote or rural places as it requires robust internet connectivity.

Advantage: The decision support system uses previous data and finds out the best route for delivering the package with the help of machine learning.

Disadvantage: It is heavy on software, and we cannot implement it in remote or rural places as it requires robust internet connectivity to function.

Joe Bianco et al. [4] proposed a package anti-theft system that looks after the delivery package and its security. In

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today's world, online ordering is a regular thing. Everyone orders through online applications since they get a lot of varieties, plus theydon't have to get out of their home. An extensive supply chain of deliveries has negative impacts, like tampering with the package when the shipment is out for delivery. To prevent this, In this paper, the author has discussed how they can use weighing sensors, cameras, and alarms to avoid such unfortunate events. First, when the delivery is about to ship, the weight is checked using a pressure sensor later. If the weight of the package changes after a certain threshold, the alarm starts to buzz and intimate the company; a motion detection sensor is used to check if someone apart from the delivery worker gets nearto the package. The motion detection is done using a PIR sensor, and it can also click pictures of the suspicious person, which we can later question. This system is a step towards improvement compared to other systems like lockers, and anti-theft briefcases, which are costlier and less efficient. The positioning system used in this is a wi-fi-based positioning system instead of GPS. The assembly building is also more accessible than other systems. The control processor used in this is Arduino.

Advantage: An Anti-theft system is developed where the weight of the package is checked, and tampering is alerted using an alarm.
Disadvantage: Dependent on internet connectivityand the exact location of tampering is not recordedfor future improvement

Skowron-Grabowska et al. [5] proposed using RFID technologies instead of other means like a barcode. Although a bit cheaper, Barcode is also much slower than RFID and cannot process a large amount of data at once. Using RFID in Couriers has been a big revolution in the past decade. RFID is 10x more efficient, and unlike barcodes where a person has to operate it for verification manually, RFID is entirely automated. It does not require any human work use it.The market in the current world is changing day by day. The courier firm needs more efficient and optimal solutions. In these ever-changing courier firms, where growth is necessary, this approach helpsbetter manage and handle the data in courier firms. RFID performs various operations like tracking, verification, handling, and managing efficiently. RFID consists of RF tags (radio frequency tags), one at the receiver end and the other at the courier servicing end. It sends back and forth using these RF tags within a given range. The courier industry has started to adopt RFID and is exploring more options to compete and be more efficient in the Domain.

Advantage: RFID is 10x more efficient and is entirely automated, unlike barcodes where a person has to use it for verification manually.

Disadvantage: Tampering of packages is not checked during transit.

Wei Tu et al. [6] proposed the online crowdsourced delivery system for on-demand foods to connect from online to offline agencies. In recent days, online food delivery has become a growing business. Due to the increasing demand for online orders, the number of delivery staff required increases. This has become a significant problem for food-tech companies, especially start-ups. This paper focuses on solving such issues using public riders as part-time delivery agents. The riders can be compensated with small rewards for their service, attracting the crowd to provide their service. They try to use IoT and 3G/4G/5G to connect the public with the food joints or food companies. We will generate an online solution consisting of all the orders and an efficient delivery route for the crowd. A hybrid mathematical solution and machine learning are employed to assignfood delivery tasks and generate the shortest delivery route in real-time. The crowd sourced riders are shared among various food delivering companies according to the area in which they operate. Althoughthis method does not require any significant investment in hardware, it requires a lot of programming. Even if this method is implemented, its efficiency is dependent on the crowd. The food is also delivered not being secured, and hence it can tamper, which is terrible for the company's brand.

Advantage: Making use of public riders as part-time delivery agents.

Disadvantage: Requires a lot of programming, implementation and its efficiency is dependent on the crowd and cannot be controlled even with efficient programming

Tanja Niels et al. [7] Designed an effective way to reduce the complexity present in the delivery system and helps the common issue faced in metropolitan cities in our day-to-day life. Due to the drastic increase in the logistics industries globally, there is high demand in the shipping of packages sent bycourier, express and parcel service, which eventually affects the increase in the traffic density mainly in cities. The delivery tours run by the courier companies are done through diesel trucks, which causes an increase in traffic congestion and leads to air pollution. The come up with an innovative solution, this paper proposes a solution for last-mile courier delivery of the allocated companies' cargo bikes and Electronic bikes. The procedure involves placing the reserved containers and truck trailer in a specific central region of the city, which acts as a mobile depot (pick up station) for delivering the packages to the nearby location. They analyze the conventional delivery data gathered and present an optimization scheme to determine a suitable place forthe designated container. Further, have come up with a simulated route for the cargo and E-bikes. This approach is feasible in densely populated and congested cities. The prime aspect of this approach is also to reduce fuel consumption, which is facilitated by implementing specific E-bikes. The vehicle mileage given by truck is

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reduced from approximately 170 km to 43km. Even in this project, there is no safety provided by the author. Still, wecan also pool our IPS concept here to securely protecta few of the expensive cargo and give an even more efficient way in the logistics industries.

Advantage: Diesel truck which in turn causes an increase in traffic congestion and lead to air pollution, can be avoided.

Disadvantage: It does not solve the problem of tampering.

Nivedita G et al. [8] proposed an Automation of parcel delivery collection using IOT to avoid answering a person at the door or collecting a door delivery. To deal with such problems, they came up with a solution to avoid the constraint of the availability of the customer at the time of product delivery using various IoT applications. Their idea is to introduce a Smart Freight Box (SFB). The Smart freight box is a courier collecting box to be installed in our home like A/C at a place where the customer can access it both from inside and outside. It consists of a barcode sensor, weight sensor loading cell, and doors on each side of the box for putting and collecting the parcel when the customer is out there. It will also contain a shifting belt where the packageis placed initially. After verifying the package, we will shift it inside a ward where it is safe until the customer comes and accesses it. There are three phases in SFB. The first one is the pre-delivery phase, where the customer will place an order online on a website. After the confirmation of the order, the retailer will send the package details, including the Barcode and the weight of the package. The customercan store these details. The next phase is the delivery phase, where the delivery worker walks in
and places the delivery on the SFB. The SFB validates the parcel with two parameters. One is Barcode, and the other is its weight which is already given to the customer beforehand. The weight sensor loading cells check the weight and shift it inside through a shifting belt, and the barcode sensor verifies the Barcode. In the last phase, which is the post-delivery phase, the delivery worker has to send an acknowledgment to the retailer that the parcel has been successfully placed after confirming with the customer.
Advantage: Automation in collecting the delivery parcel without human intervention and verifying package parameters like Barcode and weight.

Disadvantage: The package is accepted without checking for tampering and internal damages. If it exists, it will delay the return procedure.

Ajay Doltade et al. [9]proposed a basic overview of maintenance in the storage units to monitor the physical aspects of the storage centers used for storing agricultural-based products. These are considered staple food and are primarily consumed by most of the population. IoT and a few basic sensors monitor various physical parameters inside the storage unit. With the help of IoT, an alert is sent to the concerned personnel and hence constantly monitoring the storage conditions. This concept has an approach to monitoring grain storage or other edible products that might undergo spoilage if not subjected to suitable physical parameters. This paper focuses on improving the condition of such storage with the help of various sensors like DHT11, MQ2, MQ135, and PIR sensors based on the concept of IoT. This technique relies on wireless communicationto the Blynk application and desktop system, making this process simple. The desktop system will provide information regarding captured data. We will interpret the data in terms of graphs and charts. The desktop system monitors the necessary parametersthrough the local area. In the absence of a manager or concerned personnel, this application will serve the purpose of maintenance.

Advantage: High degree of monitoring and tracking was used for storing agricultural-based products
Disadvantage: This Technique is unfortunately limited to only agricultural-based products, and it does not detect any intrusion. This concept fails to protect the necessary product from theft or other suchmishaps.

Ming et al. [10] With the prevalence of online to offline (O2O) commerce, the short-distance instant logistics service has become increasingly popular in China, which is a new logistics model that emerged recently and provided timely logistics for O2O local life service. Unlike traditional logistics, extra waiting time generates when an order's pick-up location arrival time is earlier than its pick-up ready time. Dynamic orders dispatch strategy is also a key factor affecting overall logistics service quality. However, existing industry practices are dispatching orders to the nearest couriers, and couriers themselves arrange logistics sequences. To improve general dispatch solutions, we present an innovative, dynamic order dispatch system (Smart DODS) and a personalized logistics sequence recommendation (PLSR) service to optimize courier logistics sequence in real-time. Atlast, we use the historical dispatch data set of SHBJ to evaluate our system performance. The experimental results demonstrate our system can effectively optimize logistics dispatch solutions intelligent Packaging Solutions for Safe Delivery

Advantage: historical dispatch data set is used to evaluate the system performance and improve efficiency.

Disadvantage: Tampering of packages is not checked during transit.

G Prabhakaran et al. [11] proposed storagemonitoring for the food grain processing industry using an embedded system helpful in monitoring the food grain. Storage of these grains in the warehouse or the storage unit where faulty management leads to spoilage and lack of maintenance of these agriculturalproducts. To overcome

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this issue, they proposed a simple circuital storage unit that innovates a process in which the ultrasonic signals are echoed through thestorage unit. The expected waves are received by the other end by the required receiver to monitor grain condition and quality constantly. An additional feature or one more important specification of this project is that this process helps anticipate the threats faced by the rodents, such as bugs and rats, which are prevalent threats faced in our day-to-day lives. One good reason to implement this process is the drawbacks of the old practice, whose setbacks can be infiltrated in this process. Some of them are delayed in the output signal, and signals obtained on the food condition are not prioritized. The working principle of this project involves a circuital combination of a microcontroller with echo pins for penetrating thesound waves through the grains present in the storage container. With the help of the microcontroller and the required echo pin mounted on the circuit board, the sound waves (ultrasonic waves) are transmitted on the top of the grain container, which is of conical shape; however, this prototype can be fabricated for any storage unit accordingly. The designated waves travel from the triggered echo pin and are reflected from hitting on the grains to the receiving end of the circuit. Now the received output signals are designated to the microcontroller, and the programmer processes the signals to convert CMOS logic into desirable input for the microcontroller. Then the processed data is displayed on the LCD accordingly. This method is helping the consumers, wholesalers, and mainly farmers in overcoming the significant drawbacks of the traditional grain storage method. This method also provides flexibility to look into the status and condition of grain. Anyways the major setback caused due to rodents which leads to spoilage, is overcome systematically in this technique. This type of system overcomes grain storage's traditional approach drawbacks, gives efficiency and flexibility for accessing grain data, andminimizes grain wastage.

Advantages: This system overcomes traditional approach drawbacks of grain storage and gives efficiency and flexibility for accessing grain data, andminimizes grain wastage.

Disadvantage: The method of using Ultrasonic signals increases the cost of the project.

T. Wei et al. [12] To improve the ability of food packaging optimization and selection, combined withbig data analysis method. Different food best packaging methods are selected, and an extensive data classification technology for various food packaging methods is proposed based on fuzzy directivity classification. Big data parametric model which reflects the best packaging characteristics of different foods is extracted, and the extracted packaging parameters are matched by adaptive fuzzy matching. Then, the directional clustering method is used to classify and identify big data, combined with the food packaging.

Advantage: This method is used to select the best packaging methods for different foods. It has better intelligence, improves the ability to classify and recognize food packaging, and promotes theintellectual development of food packaging. It hasgood application value in practice.

Disadvantage: The traditional classification methods for different food packaging feature data's associated data are mainly fuzzy C-means clustering and K-means clustering. The above methods have some problems, such as too much computation overhead and poor accuracy in classifying large-scale different food packaging feature data.

Stephane Evoy. Et Al [13] Proposed an Intelligent Packaging Systems: Using sensors and nanosensors to monitor food quality and safety. This type of packaging analyzes the system, processes information, and presents it without generally exerting any action on the food. In this intelligent packaging System, they have used RFID signals or bar codes to keep track of the items. This paper also uses biosensors which help to control the environment in the food package
Advantage: The data systems used in this systemallow control of the environment by using biosensors
Disadvantage: The cost of the sensors and actuatorsis relatively high, and also the maintenance isexpensive

P. Suppakul, J. MiltzEt Al [14]Active Packaging Technologies with an Emphasis on Antimicrobial Packaging and its Applications: In this method, we used (LDPE) films coated with a mixture of polyamide resin in i-propanol/n-propanol and abacteriocin solution provided AM activity against Micrococcus flavus. The migration of bacteriocinsreached equilibrium within 3d, but the level attained was too low to affect several bacterial strains spread on an agar plate. When the films were in contact witha phosphate buffer solution containing strains of M. flavus and L. monocytogenes, a marked inhibition of microbial growth of both strains was observed.

Advantage: Best method for food safety and keeps itsafe for a more extended period

Disadvantage: More expensive than their primary counterparts.
Commercialization of such films could therefore become viable for high-value food products only. It isnot safe to apply chemical products to food items.

Joseph Miltz Et Al. [15] Intelligent packaging: principles and applications: Joseph Miltz The term "intelligent packaging" is defined in this research using a proposed model of packaging functions basedon the history of food packaging. A framework is also being developed to provide the concept with a more exact meaning and to explain the anatomy of the intelligent packaging system. The most recent developments in intelligent package devices are discussed, including barcode labels, radio

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frequency identification tags, time-temperature indicators, gas indicators, and biosensors.

Advantage: This system makes use of the latest advances in intelligent package devices, including barcode labels, radio frequency identification tags, time-temperature indicators, gas indicators, and biosensors

Disadvantage: This system fails to address economics, legislation, and consumer privacy.

CONCLUSION

We are designing and implementing the non- destructive package testing and verification solution using an electronic packaging solution called IPS development kit. We will place the kit inside the package with enough space to work correctly. The kitwill travel within the box to the destination, which we will remove after the delivery. If there is anytampering or intrusion during the delivery process, the kit will alert. By this, we are maintaining the integrity of the product and the reputation of the companies that use this system. We are hoping to ensure customer satisfaction by getting them the outcome they requested without any problem.

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