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"DYNAMIC DIGITAL SIGNATURE FOR FOOD PACKAGING USING SIMULATION"

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Abstract: In today's fast-paced and regulated food industry, ensuring product authenticity and traceability is crucial. Our dynamic digital signature system for food packaging enhances security, transparency, and efficiency in the food supply chain through advanced technology. By integrating digital signatures, QR codes, simulation data, and MQTT protocols, this system provides a robust mechanism for tracking and verifying food products from production to consumption. This ensures compliance with quality and safety standards. The real-time monitoring capabilities enable distributors, hub staff, companies, and clients to access accurate product information instantly[2]. This system addresses the complexities of a global supply chain involving multiple stakeholders, thereby improving reliability and traceability. Ultimately, it empowers customers with precise product information, enhancing trust and satisfaction.

Keywords*:* Food Packaging, Digital Signature, Traceability, QR Code, Food safety, MQTT Protocol, Simulation Data.

I. INTRODUCTION

The dynamic digital signature system for food packaging harnesses advanced simulation technology to enhance transparency, quality, efficiency, and security in the food supply chain. By integrating unique QR codes and secure digital signatures, the system ensures each food package can be uniquely identified and verified[1]. It provides end-to-end traceability from production to consumption, improving real-time monitoring and data authenticity. This system supports the secure transport of goods in the logistics industry, reduces the risk of fraud, and empowers stakeholders with comprehensive tracking capabilities. Ultimately, it benefits all partners involved by offering accessible, reliable, and verifiable product information.

II. RELATED WORK

1. Title: "Blockchain and IoT Based Disruption in Logistic"
Author: Huma Pervez, et.al, 2019.
In this paper mainly focused on the Smart contracts are the scripts stored on blockchain that are equivalent to stored procedures in relational database management system. Methodologies used in this paper Arduino, Geosensor, temperature sensor, space sensor. Geo sensor generate trigger of delivery of package to destination. Decentralized File storage and smart contracts.

2. Title: "Smart factory in the food industry"
Author: Rahul Vashishth, Arun Kumar Pandey, & Anil Dutt Semwal,14 May 2022
In this paper Current approaches in Industry focus on intelligent collection of data with technology from the IoT and its analysis with machine learning algorithms. This includes a
variety of data sources, including raw material data, machine data, or customer data (e.g., information about sales or complaints). In particular, production planning can be optimized with machine learning in this context e.g., using genetic algorithms for optimizing the order of production steps or integrating picture recognition for quality control. Another use case is predictive maintenance of machines. However, the focus is primarily on the view of the process and the machines. Internal processes in the food industry are not included and the view of the product is limited to identifying products with bar or QR codes. Proactive adaptation improves system performance as it forecasts adaptation concerns (e.g., through identification of patterns in historical data) and reacts either by preparing an adaptation or adapting. Real-time data of production sites would help to realize proactive adaptation and dynamic adjustment when a disruption takes place.

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3. Title: "Modeling and simulation of food properties"
Author: Jose A. Egea, Míriam R. García, and Carlos Vilas, 27 Jan 2023

Food science often proposes to apply modeling or simulation to describe the food properties and characteristics. In the following, we present some examples to indicate the bandwidth of available applications. The authors reviewed mechanistic and empirical approaches to explain and predict the effect of food matrix on chemical reactivity. Van Boekel discussed the possibility to describe aspects of food, such as color, nutrient content, and safety, in a quantitative way via mathematical models. Further, numerical simulations are applied in the food sector to simulate product or process characteristics. The advantage of such modeling or simulation-based approaches is the white-box approach, i.e., the relations of the different variables can be extracted from and explained using the models. However, due to the high complexity of the modeled aspects, these approaches always require abstractions from different aspects. This can limit their applicability in productive settings. Further, those approaches require specific knowledge of both aspects: the modeling/simulation technique as well as domain knowledge of the food properties.

4. Title: "A Digital Signature Schemes Without using one-way hash and message redundancy and its application on key"
Author: Hua Zhang, Zheng Yuan, Qiao-yan Wen

In this paper Digital signature schemes based on public-key cryptosystem are vulnerable to existential forgery attack which can be prevented by use of one-way hash function and message redundancy. In this paper the authors have proposed an forgery attack over the digital signature scheme proposed in 2004.

III. PROPOSED SYSTEM

- The proposed system uses advanced technology to create dynamic digital signatures for food packaging, enhancing security and efficiency.
- Each food packet receives a unique QR code embedded with a dynamic digital signature, which, along with a secure code, is sent to the distributor to prevent unauthorized access.
- At checkpoints like warehouses, hub staff log into the system to scan these QR codes, which is generated from the company manufactures and updating the IN/OUT status.
- The scanned data, including timestamps, location, and status changes, is stored in a cloud database for easy reference.
- Simulated IoT device for the monitoring team to know about the data of the environment. And also they can see the location of the product being transported, if any obstacles found, it signals the alarm. All these continuously uploaded to the MQTT server and displayed on a centralized dashboard, enabling real-time monitoring of storage and transport conditions.
- Distributors must log in to confirm scan details at various hubs, ensuring packages follow expected routes. If all criteria are met, the package status is marked as accepted.
- At last end users can also check food product which is approved by the distributor or not.

IV. METHODOLOGY

Our system approaches the above-described problem with two major modules: a desktop application and a mobile application. The desktop application will be used by food product companies and manufacturers to keep track of food delivery and other logistics like fire, temperature, and impact status. The mobile application will be used by store owners and consumers to scan the QR code on the packages and verify food product authenticity. The desktop interface allows the food product company to update information about every batch of food that has been manufactured and see the points where the QR code has been scanned to ensure it is on the right path. Since there is live GPS tracking, if the shipment has halted for a long time, the company can be notified, and the logistics division can be contacted immediately to know what is happening.

Module functionalities:

1. QR code generated
2. Secure code sent to distributor
3. Hub staff will scan for IN/OUT after login
4. Details stored in the cloud database for reference
5. Simulated IOT vehicle data uploaded to MQTT server
6. Company can view IOT data
7. Distributor check the hub scanned detail
8. Accept, if found all the scanned paths are correct
9. Client can also check and validate using weburl.

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A unique QR code is generated for each batch of food products, and a secure code is sent to the distributor to ensure product authenticity. Hub staff log in and scan the QR code to record the IN/OUT movements of the products. These scanned details are stored in a cloud database for tracking purposes. Simulated IoT data from delivery vehicles is uploaded to an MQTT server, allowing the food product company to monitor the data in real-time. Distributors then verify the scanned details from the hub. If all details are correct, the distributors accept the shipment. Clients also have the ability to check and validate the authenticity of the food products using a web interface. This comprehensive system ensures the integrity and traceability of food products from manufacture to the consumer, enhancing transparency.

Manufacturers can update the status of each batch in the system, providing additional information such as production dates and expiry dates. This information is accessible to all stakeholders, including retailers and consumers, via the web interface. Retailers can scan the QR codes upon receiving the shipments to verify that they have received the correct products. Consumers, on the other hand, can scan the QR codes using a mobile application to access detailed product information, including the origin of the product and the entire supply chain journey.

By integrating all these functionalities, the system not only ensures the authenticity and safety of food products but also enhances the overall efficiency of the supply chain. It reduces the risk of fraud and counterfeiting, increases accountability among all parties involved, and provides consumers with greater confidence in the products they purchase.

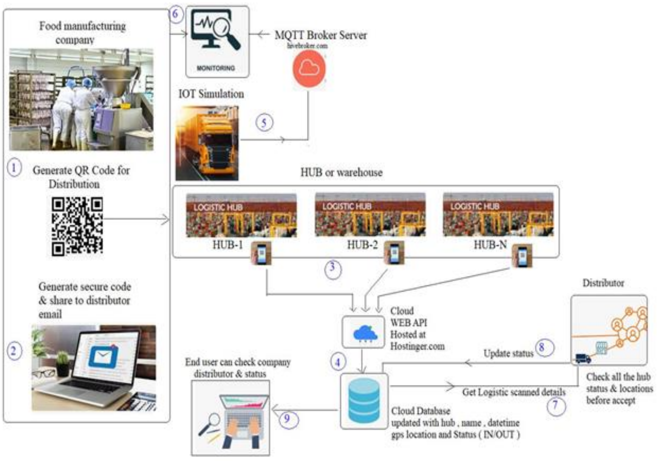

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Fig- 1 System Architecture

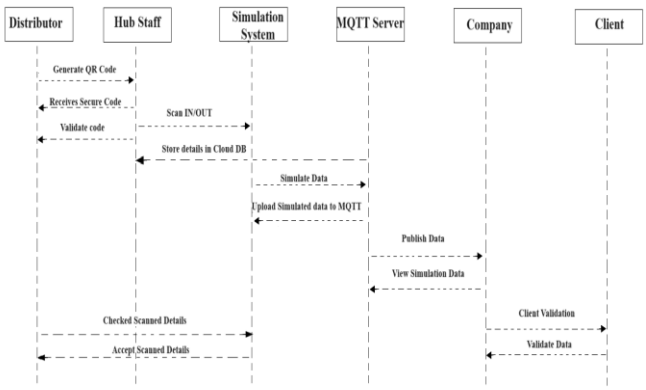

Fig -2: Sequence Diagram

1. DESIGN AND IMPLEMENTATION

We have a desktop application and a mobile application. The desktop application generates the QR code and keeps track of the logistics. The mobile application scans this QR code, and this data can be posted to the database with the option inward or outward. Inward means the package is scanned on arrival to the destination. Outward means the package is scanned before sending it to the next hub. The hub refers to the location where it is being scanned. This

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allows us to keep track of all the locations the package has been through and any deviation between these hubs can be tracked.

From our desktop application. Using this live data, we can track the logistics of the vehicle and alert the user when required. The desktop application is designed to handle attacks on the data in the database.

1.1 Mobile application flow

The application requires camera and location permissions. Once the permissions are granted, using the Google API Client, we get the location of that device. The user will have to register providing the necessary details and then will be able to login. Once they successfully logins in they will be able to scan the QR code. The user can select the option: inward or outward and post to the database accordingly.

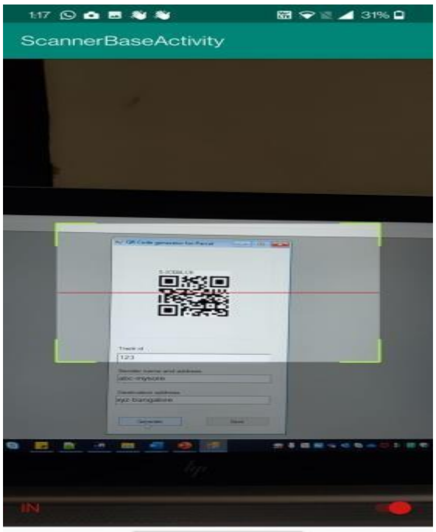
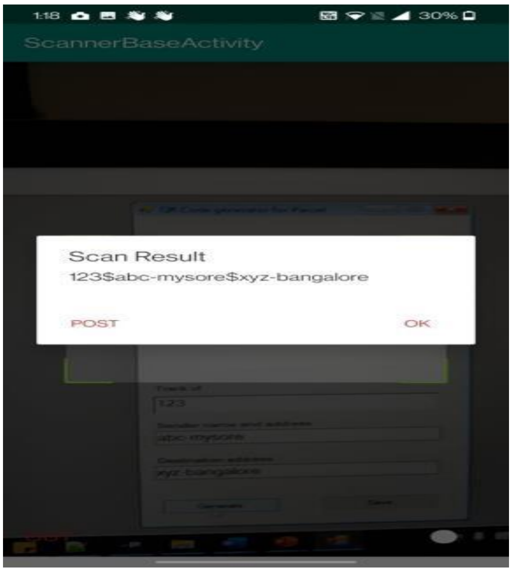


Fig -3: Flow of Mobile application.



1.2 Desktop application flow

The application uses Spire. Barcode API to generate the QR code based on the text provided. This generated QR code can be saved to the system. For the live tracking and logistics, we use GPS module, fire, and impact sensors. These hardware components are coupled with Node MCU which connects with our cloud service where we publish the data from all these components in a queue to a specific topic. The cloud service being used is Hive

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MQTT which is an enterprise broker to fast, efficient, and reliable movement of data to and from connected IoT devices. All the data from the queue will be subscribed in the desktop application. Once the data is received, they are compared to a threshold which if crossed the application alerts the user.

To manage data security, whenever the data is inserted into the database, we calculate checksum for the entire data using Adler-32. The entire data along with checksum is duplicated into another database. Thus, whenever any hacker tries to manipulate the data in the database, the checksum is calculated and compared with the redundant table. If any mismatch is found, original data would be recovered.

Fig -4 : Desktop application Logistics Screen

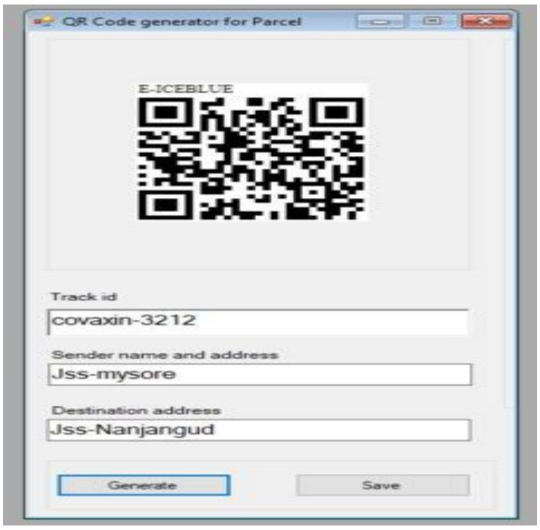

Fig-5: QR Code generation screen

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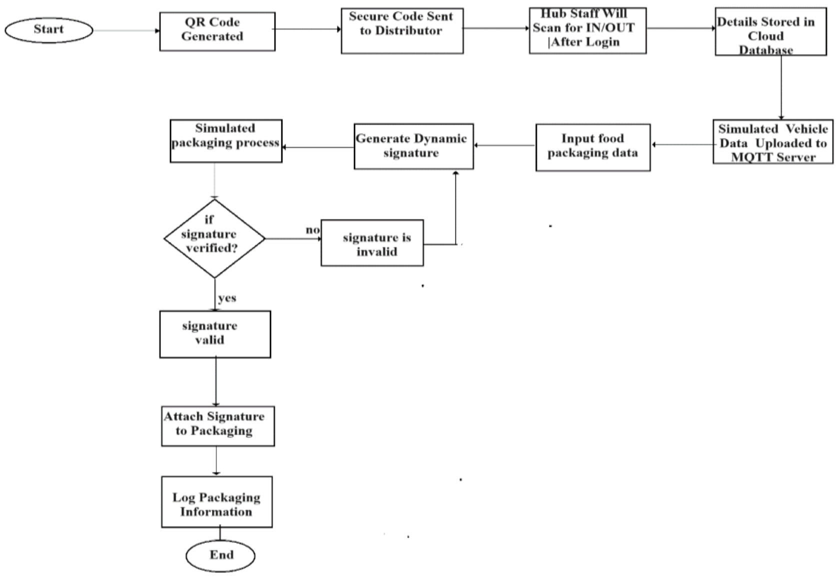

Fig-6: Flow of implementation

V. IMPLEMENTATION

The proposed system leverages advanced technology to enhance the security and traceability of food packaging through dynamic digital signatures and unique QR codes. Each food packet is assigned a QR code embedded with a dynamic digital signature, which, along with a secure code, is sent to the distributor to prevent unauthorized access. As the packages move through checkpoints like warehouses, staff log into the system to scan the QR codes, updating the IN/OUT status in a cloud database that records timestamps, locations, and status changes. Simulated IoT devices monitor environmental conditions and track the product's location during transport, with data continuously uploaded to an MQTT server and displayed on a centralized dashboard for real-time monitoring. Distributors log in to confirm scans at various hubs, ensuring that packages follow their expected routes, and end users can verify whether a product has been approved by the distributor.

VI. CONCLUSION

The proposed system is helpful while monitoring, tracking, and tracing transports by using the GPS module that reduces risks in regard to fraud or fake goods through real-time monitoring of goods. This is done by using the QR code or barcode details on the goods or item in a carrier for security purposes. This system helps the customers to have access to information on the item, services, the supplier, and carrier, and gives customers provenance of data and the cargo route. It remains clear, therefore, that building this dynamic digital signature of the food package and implementing its validation interpretation by simulation demonstrates the secure approach to these products throughout the chain.

It will further strengthen the foundation of strong performance under real-world conditions by using advanced cryptographic models and comprehensive models of simulations. This robust, scalable, and effective solution focuses on optimization of each process in food packaging enhancement and improvement of traceability throughout an end-to-end supply chain, overcoming key components and challenges.

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