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EFFICIENT MOBILE RFID AUTHENTICATION PROTOCOL FOR SMART LOGISTICS TARGETS TRACKING

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Abstract: Target tracking is one of the problems existing in the supply chain management. The use of radio frequency identification (RFID) in target tracking helps improve the monitoring accuracy and status visibility of the tracked target. For mobile RFID system, its three entities have to authenticate each other's identity in order to guarantee the data transmission security. The mobile RFID authentication protocol cannot achieve both high security and low complexity at the same time. For this problem, a new efficiency mobile RFID authentication protocol is proposed in this paper, which implements secure authentication among different communication entities by different operation modes .

For example, the protocol adopts Hash Function between reader and cloud server, and exchange-cross bitwise operation between tag and cloud server, to achieve low computing cost at tag-end while improving the security of mobile communication data. At the cloud server end, the protocol proposed in this paper adopts index data table as the storage mode, which further improves the could server efficiency in retrieving the authentication of tags and readers, and reduces the risks of sensitive data disclosure. According to the security analysis, this protocol can resist impersonation attack, replay attack, trace attack and other attacks launched by attackers. Its security performance is further reproved by BAN logic, prover if tool and random oracle model. On the other hand, the simple operation at the tag-end of the protocol lowers the tag cost to a larger extent.

I. INTRODUCTION:

Traditional target tracking in the logistics management system is mainly to track the location of the cargo, not the status of the goods. Therefore, traditional target tracking is not applicable for cold chain and pharmaceutical logistics processes. During recent years, a target tracking system based on RFID sensor network has been proposed, which achieves position and property tracking of the mobile targets by RFID and sensor technologies. It enables legal users to completely and visually master the cargo status, thereby delivering cargo in accurate amount and appropriate conditions at specific site. In the target tracking system based on

RFID sensor network, sensors are responsible for searching information around the target and write into RFID tag. Then the RFID reader inside the smart phone of the driver sends the private data collected by the sensors to the cloud server. RFID, which is featured in non-contact recognition, satisfactory applicability in various environments, and large data capacity, improves the visibility of object status in the tracking system, and greatly enhances the performance of the target tracking system.

The market scale of using RFID in smart logistics system in China had been expanded from 68 billion in 2018 to 100 billion in 2020. With the increase of use, data transmitted in RFID system has been expanding day by day, which highlights the urgent demands on data security and privacy protection. Impersonated tags or the interception of tag information may lead to cargo data disclosure, threatening user data security and endangering economic benefits. To improve the data transmission security, identities of all related communication entities in RFID system must be authenticated to achieve mutual trust among communication entities. Most identity authentication protocols are based on an assumption that the communication channel between reader and server is private and secure.

Therefore, the mutual authentication is only achieved between two entities of reader and tag, such as the EPC gen2 protocol. However, in the target tracking system, data between RFID reader and cloud server are transmitted by wireless network, for which, the channel is not secure. It is a security measure to prevent fake entity from passing the RFID target detection, which is significantly important for protecting RFID system security and data privacy.

Scope of the Project:

The scope of a project focused on target tracking in the logistics management system. target tracking system based on RFID sensor network has been proposed, which achieves position and property tracking of the mobile targets by RFID and sensor technologies. It enables legal users to completely and visually master the cargo status, thereby delivering cargo in accurate amount and appropriate conditions at specific site. In the target tracking system based on RFID sensor network, sensors are responsible for searching information around the target and write into RFID tag. Then the RFID reader inside the smart phone of the driver sends the private data collected by the sensors to the cloud server. RFID, which is featured in non-contact recognition, satisfactory applicability in various environments, and large data capacity,

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improves the visibility of object status in the tracking system, and greatly enhances the performance of the target tracking system.

II. PROPOSED SYSTEM:

Target tracking is one of the problems existing in the supply chain management. The use of radio frequency identification (RFID) in target tracking helps improve the monitoring accuracy and status visibility of the tracked target. this problem, a new efficiency mobile RFID authentication protocol is proposed in this paper, which implements secure authentication among different communication entities by different operation modes.

This project presents an efficient mobile RFID authentication protocol designed specifically for smart logistics target tracking. The proposed solution aims to overcome the limitations of existing systems by enhancing security, reducing communication overhead, and improving the overall tracking accuracy of goods and assets throughout the logistics network. By leveraging advanced cryptographic techniques and optimized mobile RFID communication strategies, this protocol enhances the performance and scalability of logistics tracking systems, making it a reliable choice for modern, dynamic supply chain management.

Block Diagram:

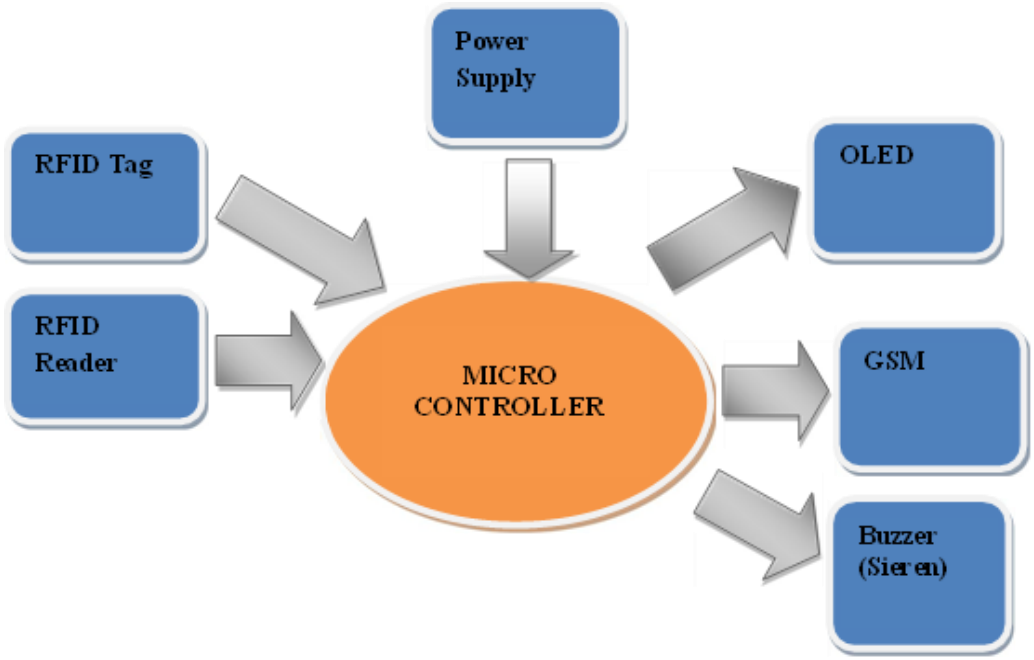

Fig 1: Block Diagram

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Power Supply:

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

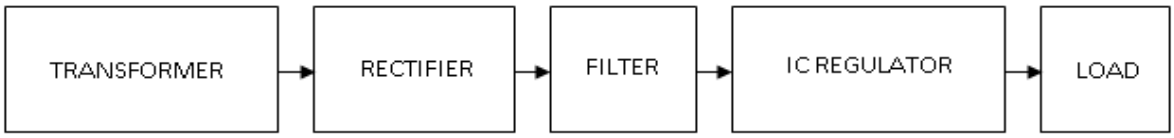

Fig 2: Block Diagram of Power Supply

Raspberry Pi Pico

The Raspberry Pi foundation changed single-board computing when they released the Raspberry Pi computer, now they're ready to do the same for microcontrollers with the release of the brand-new Raspberry Pi Pico. This low-cost microcontroller board features a powerful new chip, the RP2040, and all the fixings to get started with embedded electronics projects at a stress-free price.

Raspberry Pi Pico is a brand new, low-cost, yet highly flexible development board designed around a custom-built RP2040 microcontroller chip designed by Raspberry Pi. Raspberry Pi Pico – 'Pico' for short – features a dual-core Cortex-M0+ processor (the most energy-efficient Arm processor available), 264kb of SRAM, 2MB of flash storage, USB 1.1 with device and host support, and a wide range of flexible I/O options.

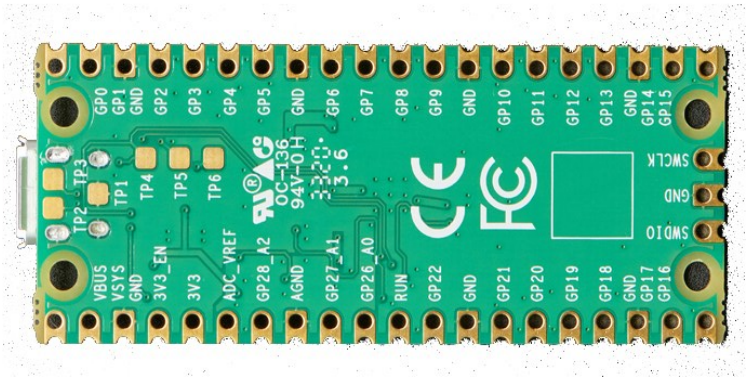

Fig 3: Raspberry Pi Pico

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OLED (Organic Light Emitting Diodes):

OLED (Organic Light Emitting Diodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and so are thinner and more efficient than LCD displays (which do require a white backlight).OLED displays are not just thin and efficient - they provide the best image quality ever and they can also be made transparent, flexible, foldable and even rollable and stretchable in the future. OLEDs represent the future of display technology. An OLED is made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. Click here for a more detailed view of the OLED technology. OLEDs are organic because they are made from carbon and hydrogen. There's no connection to organic food or farming - although OLEDs are very efficient and do not contain any bad metals - so it's a real green technology.

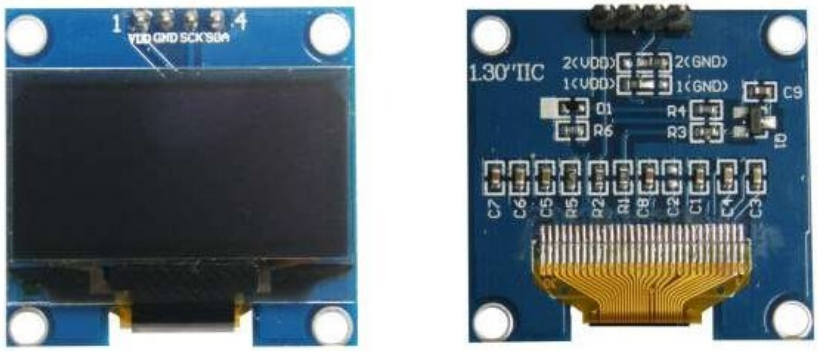

Fig 4- OLED’s

RADIO FREQUENCY IDENTIFICATION:

RFID, short for Radio Frequency Identification, is a technology that enables identification of a tag (that is normally attached with an entity) by using electromagnetic waves. RFID Reader Module, are also called as interrogators. They convert radio waves returned from the RFID tag into a form that can be passed on to Controllers, which can make use of it. RFID tags and readers have to be tuned to the same frequency in order to communicate. RFID systems use many different frequencies, but the most common and widely used & supported by our Reader is 125 KHz.

RFID Reader:

The reader, or scanner, functions similarly to a barcode scanner; however, while a

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barcode scanner uses a laser beam to scan the barcode, an RFID scanner uses electromagnetic waves. To transmit these waves, the scanner uses an antenna that transmits a signal, communicating with the tag's antenna. The tags antenna receives data from the scanner and transmits its particular chip information to the scanner.

Fig 5- RFID Reader

The data on the chip is usually stored in one of two types of memory. The most common is Read-Only Memory (ROM); as its name suggests, read-only memory cannot be altered once programmed onto the chip during the manufacturing process. The second type of memory is Read/Write Memory; though it is also programmed during the manufacturing process, it can later be altered by certain devices.

RFID Tag:

RFID tag is a small device which stores and sends data to RFID reader. They are categorized in two types – active tag and passive tag**.** Active tags are those which contain an internal battery and do not require power from the reader. Typically, active tags have a longer distance range than passive tags. Passive tags are smaller and lighter in size than the active tags. They do not contain an internal battery and thus depend on RFID reader for operating power and certainly have a low range limited up to few meters.

Fig 6- RFID TAG

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GSM:

Global System for Mobile Communications (GSM) modems are specialized types of modems that operate over subscription based wireless networks, similar to a mobile phone. A GSM modem accepts a Subscriber Identity Module (SIM) card, and basically acts like a mobile phone for a computer. Such a modem can even be a dedicated mobile phone that the computer uses for GSM network capabilities.

Traditional modems are attached to computers to allow dial-up connections to other computer systems. A GSM modem operates in a similar fashion, except that it sends and receives data through radio waves rather than a telephone line. This type of modem may be an external device connected via a Universal Serial Bus (USB) cable or a serial cable. More commonly, however, it is a small device that plugs directly into the USB port or card slot on a computer or laptop.

It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.

Buzzer:

A buzzer or beeper is a signalling device, usually electronic, typically used in automobiles, house hold appliances such as a microwave oven, or game shows.It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong

Fig 7: Buzzer

III. RESULT:

The proposed system leverages mobile RFID technology combined with an efficient authentication protocol to enhance security and accuracy in logistics target tracking. RFID tags are attached to logistics items (targets), and these tags store unique identification information.

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Mobile RFID readers, which can be installed on transport vehicles or carried by personnel, scan these tags to identify and track items in real-time as they move through the supply chain. To ensure the integrity and authenticity of the data collected, a mutual authentication protocol is established between the RFID tag, the reader, and the backend server. When a reader detects a tag, it initiates an authentication handshake. The tag and reader exchange encrypted challenge-response messages, often using lightweight cryptographic operations to minimize energy and computation costs. This process ensures that only legitimate tags and readers can communicate with the system, protecting against common threats such as tag cloning, unauthorized tracking, or data tampering.

Once authentication is successful, the system records the tracking information—such as location, timestamp, and item ID—and updates it in the backend database. The backend system continuously monitors the movement of items, enabling real-time tracking and status updates. If an authentication attempt fails, the system generates alerts and logs the incident for further analysis, which strengthens the overall security framework.

This approach not only ensures efficient and secure tracking of logistics assets, but also optimizes the supply chain visibility by combining lightweight cryptography, mobile RFID capabilities, and smart backend processing. The result is a scalable, cost- effective solution tailored for modern logistics environments.

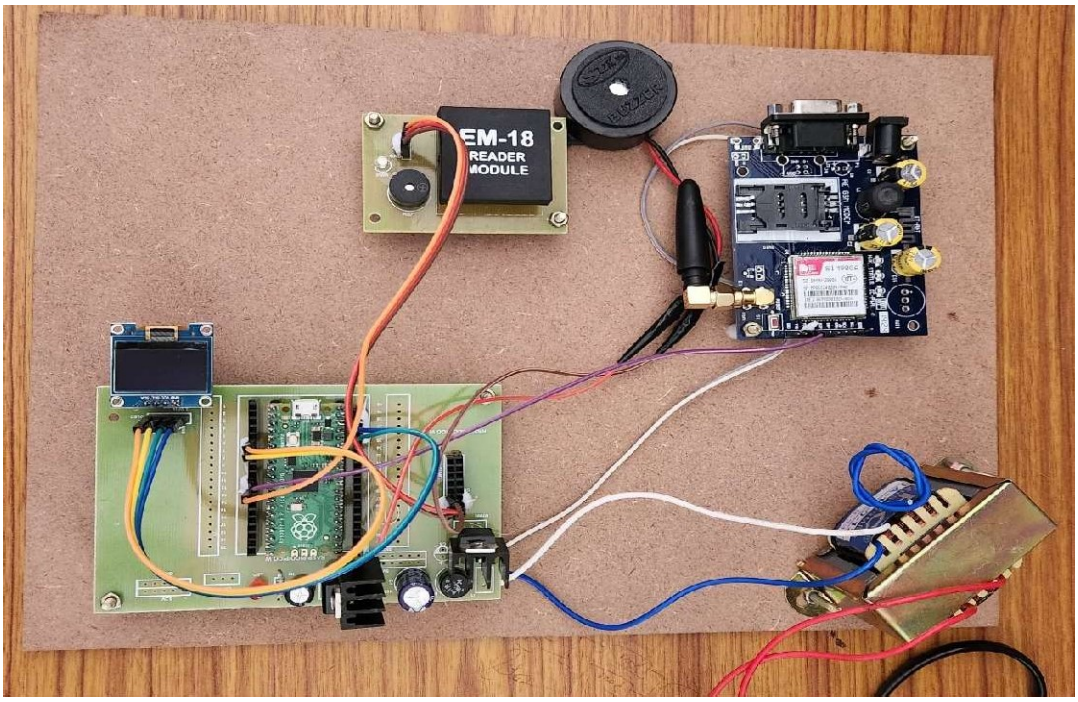

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Fig- 8: Hardware Kit

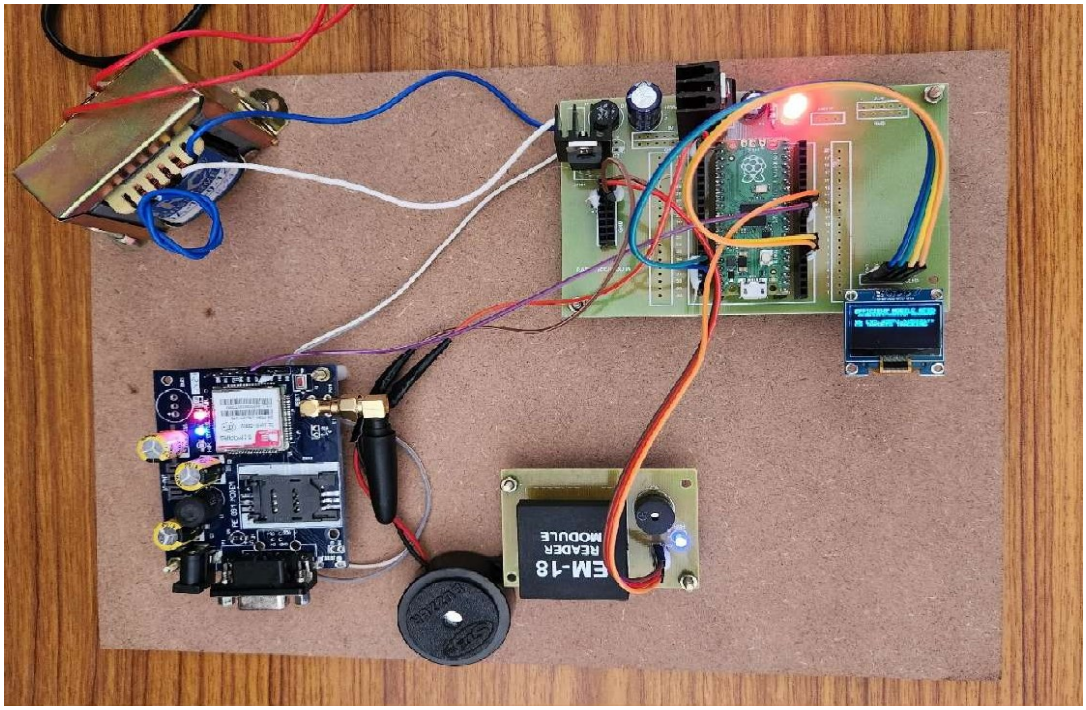

Fig- 9: Hardware Kit When Supply is ON

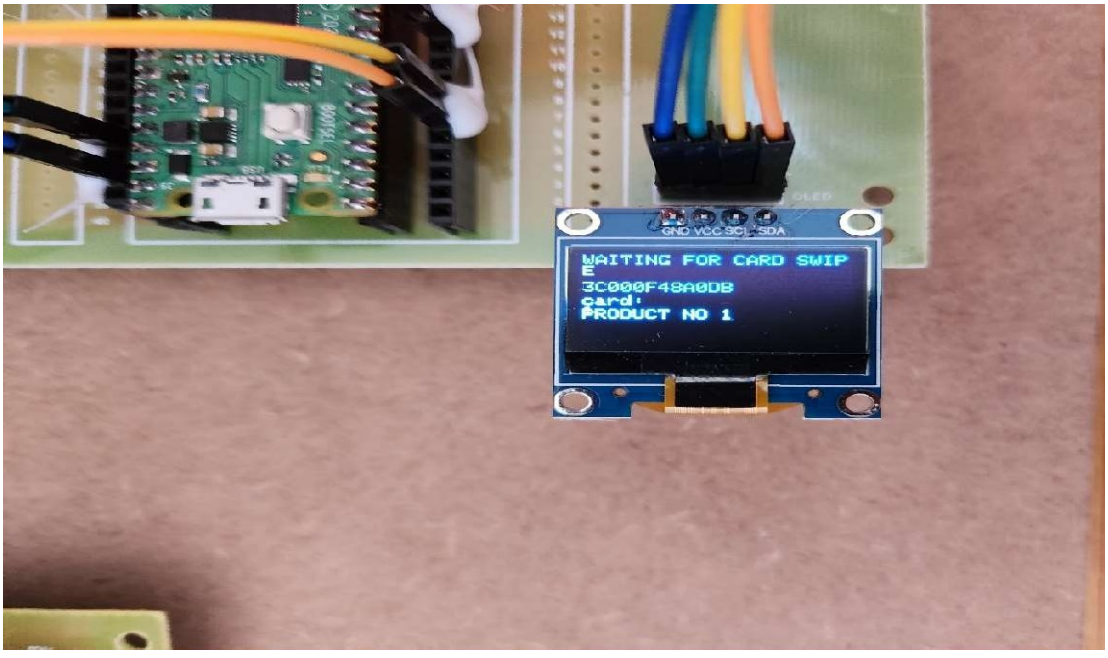

Fig- 10: OLED Display RFID Reader Detected (Product 1).

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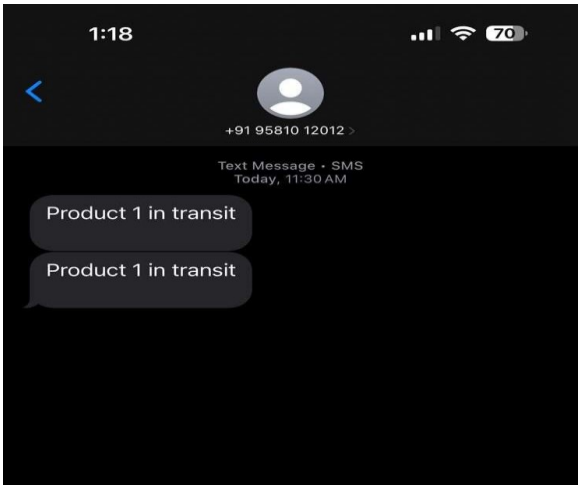

Fig- 11: Status of Target (Product 1) Tracking.

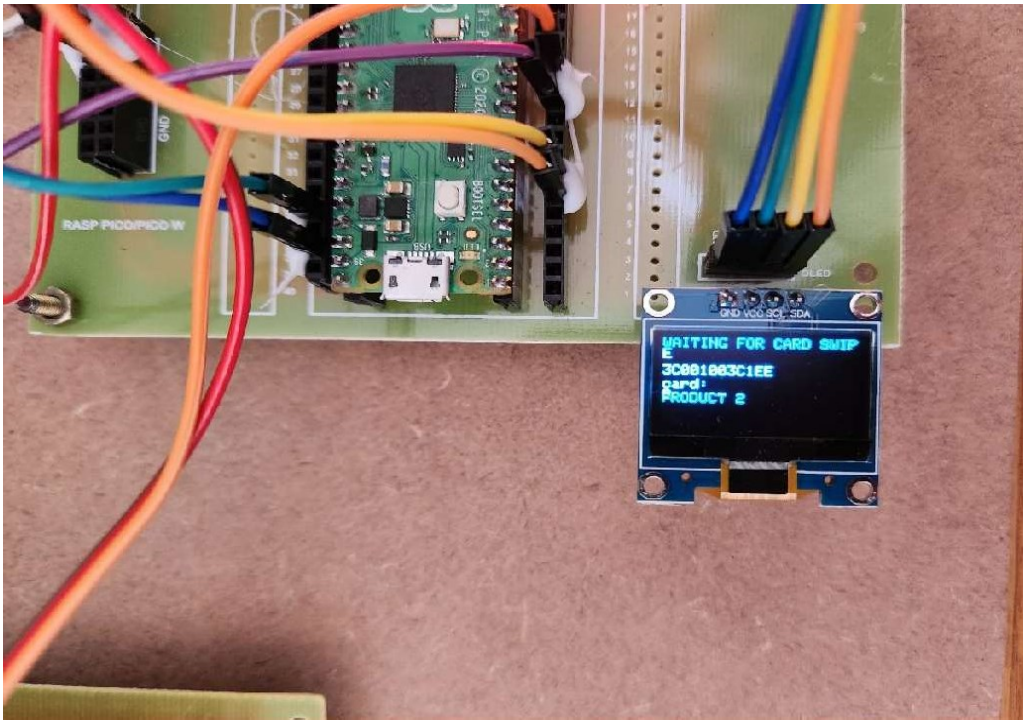

Fig 12: OLED Display RFID Reader Detected (Product 2)

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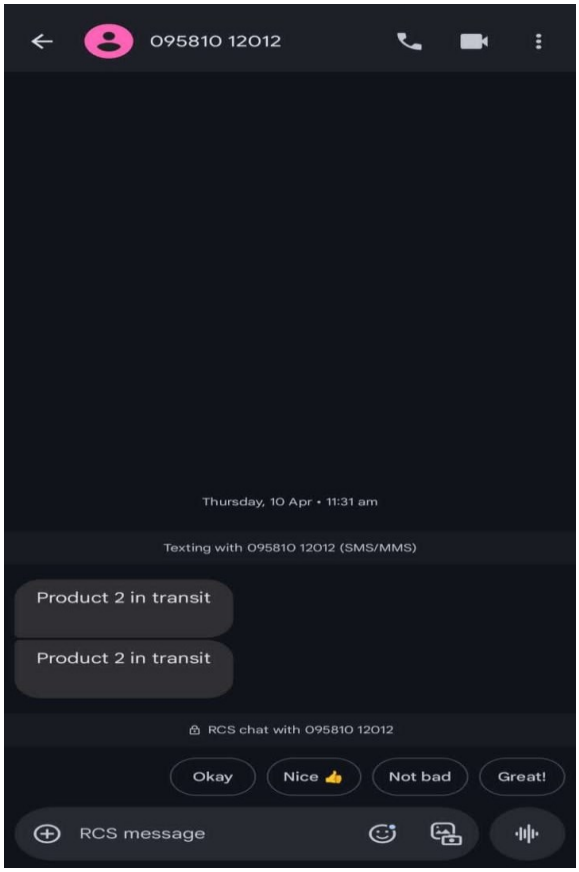

Fig- 13: Status of Target (Product 2) Tracking.

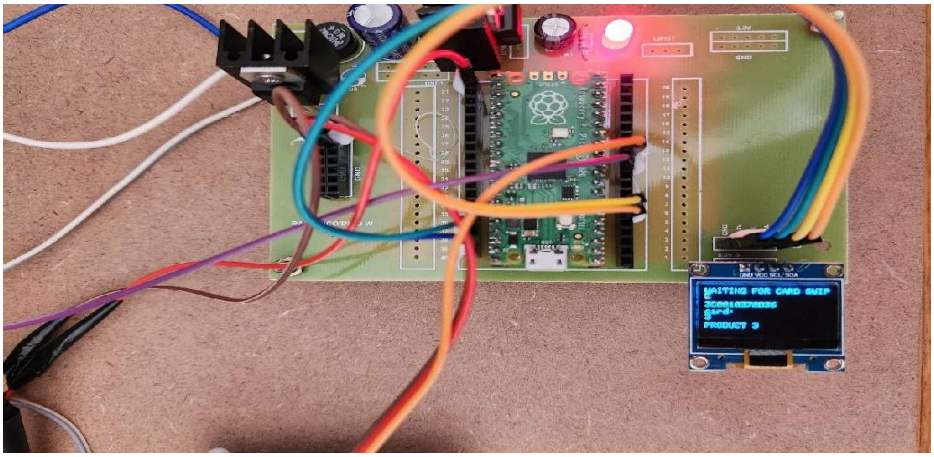

Fig 14: OLED Display RFID Reader Detected (Product 3

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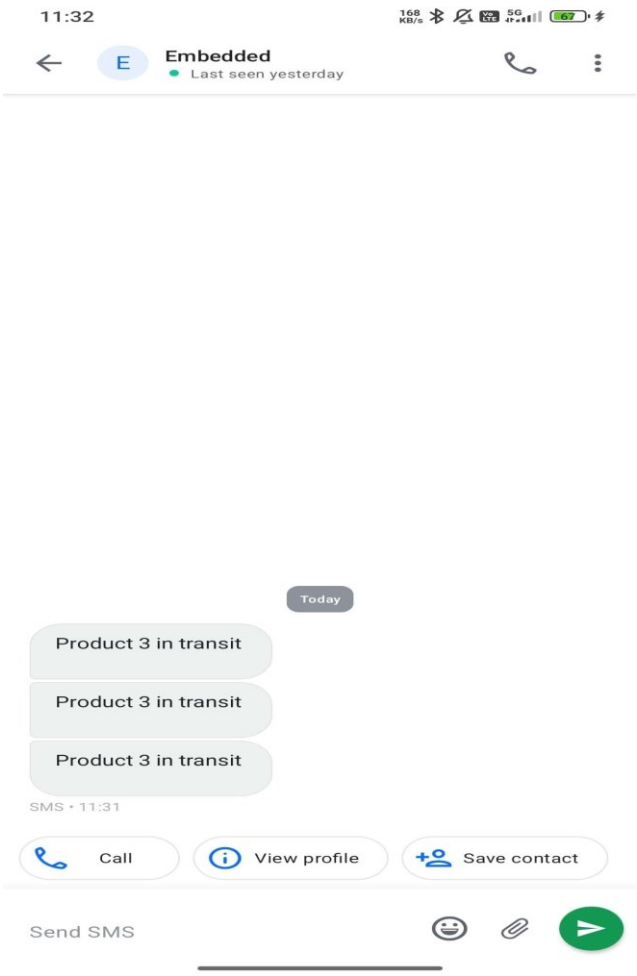

Fig- 15: Status of Target (Product 3) Tracking.

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Fig- 16: RFID Tags (Product 1,2,3).

IV. CONCLUSION:

An efficient mobile RFID authentication protocol is proposed in this paper. It can be applied in a low-cost RFID system to provide a secure environment for the secure storage and communication of private data in the system, and resist various known attacks. For this protocol, the Hash Function is used at the high-performance reader end to calculate authentication information, and the exchange-cross bitwise operation is used at the performance-restricted tag end to calculate the authentication information.

The Hash Function helps improve the security of the authentication information while the exchange-cross bitwise operation guarantees low computation cost at tag end and the tag anonymity. The cloud server stores the encrypted information in form of index data table, which enhances the cloud server's retrieval efficiency during its authentication to the tag and the reader, and reduces the risk of sensitive information disclosure of the cloud server. By doing so, the safe and efficient identity authentication among tag, reader, and server is perfectly achieved.

According to the non-formal security analysis, the efficient mobile RFID authentication protocol designed in this paper is featured in enhanced security function and capability in resisting known attacks like impersonation attack, replay attack, and tracked attack, etc. In this paper, the protocol security is further proved by BAN logic formal analysis, prover if tool, and random oracle model, while the low computing cost of the protocol and the low storage cost of the tag-end are also proved by the performance analysis. In a word, this is a safe, efficient, and low-cost RFID mobile authentication protocol applicable to the target tracking system.

The lightweight authentication protocol currently uses security analysis to prove the security, and the subsequent research work is to establish a security model to prove the security of the authentication protocol under the standard model. The protocol proposed in this paper does not support the integration with physical identification systems (e.g., fingerprints) for the time being, and the next research direction is to gradually adjust the protocol to achieve the integration with physical identification systems in practical applications.

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