

# **“SK@D” Smart Kit at Door - Internet of Things (IoT) Based Smart System Enabling Notifications**

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## **Abstract**

*The research proposes an innovative device that provides a cost-effective solution for receiving alerts and remote monitoring for the contents of a bag hanging outside doors in metros. It leverages the power of the Internet of Things (IoT) to keep owner informed about the status of the bag, whether the expected delivery item is picked up or not. Smart bags are often used by travelers or other persons for charging their gadgets and for different activities. Serving the purpose, they are designed for, their usage for daily household activities is limited. Proposed invention is a smart bag hanging outside an apartment. There is a need to develop an application-specific smart bag with instant notifications for the delivery of small perishable items such as dairy products or flowers*

*Due to lack of alerts, items remain inside the bag, throughout the day, rendering them unusable. To address a real-world problem related to security, convenience and the changing landscape of e-commerce, the present work is an ideal solution. It facilitates the power of IoT and electronic systems to offer an innovative solution with broad interdisciplinary relevance.*

*The key contributions of the methodology are to Design and develop a compact, efficient Smart Bag that notifies the owner when items are dropped. Also, to prevents spoilage of dairy and consumables by informed decision-making. Besides the proposed bag captures images of the person dropping items and sends alert notification to intended owners for making suitable arrangements for pickup of deliverables.*

**Keywords:** *Alert Notifications, Electronic Systems, Innovative Solutions, Interdisciplinary Relevance, Internet of Things*

## **1 Introduction**

With technology growing at a fast pace, smart cities are equipped with smart gadgets in their homes [1-3]. A need arises for a smart bag outside the home to monitor our daily order-delivery activities as well. A smart bag that is equipped with sensors to notify its users whenever something is dropped inside it. With the integration of smart home system, IoT is ubiquitously available to make life comfortable and secure [4]. IoT has been integrated in healthcare systems as well for keeping track of vital parameters of person [5].

A bag, such as a travel bag, leather bag, or others, is an integral part of the travel life of a person, has its own importance and carries different functions and utility [6]. There arises a need for an alert mechanism when some package is dropped inside the smart bag hung near the main door to notify the owner about the delivery of expected item along with the image of the person dropping the delivery as well as weight of the items being placed inside delivery bag. People in metro city usually hang a delivery bag outside their front door as a convenient spot for delivery drop-offs, especially when direct hand-offs aren't feasible or when utilizing delivery apps for daily routine essentials.

The authors in [7], have proposed a solar energy-based Smart Traveler Bag to provide day-to-day required features needed for safety and tracking. Through this project, the problem of dragging luggage was tackled, and additionally, some security features were provided. The location of the system can be obtained by the user on their smartphone, and they can also stop and start the bag. The authors in [ 8] suggested developing a versatile smart bag that can fit the role that is given to it, like carrying material, tracking, security, weight checking, and more. In this system, a charging unit is provided, which is powered by a solar panel, and the solar panel also provides the charge to the microcontroller for functioning. The authors in [9] developed a prototype that is attached to a school bag. For the proper functioning of the Radio Frequency Infrared Detection (RFID) system, the smart school bag implements the use of a real-time system. As soon as the student places books /items, for instance lunch box, a hat inside the bag, the RFID reader scans the tags and checks for the corresponding books as per saved information on the database. These bags [10, 11, 12, 13] serve the purpose they are designed for, security and ease while traveling. However, these bags didn't fit for the activity, which is required in daily household activities. The objective of the research is to develop an application-specific smart bag with instant notifications for the delivery of small perishable items such as dairy products or flowers. The key contributions of the methodology are outlined below.

- Design and develop a compact, efficient Smart Bag that notifies the owner when items are dropped
- Prevents spoilage of dairy and consumables by informed decision-making
- Captures images of the person dropping items and sends alert notification.

A prototype of an IoT-based smart bag for daily activities is presented in the current research. The proposed bag can be hung at the main door outside a flat in the apartment. Whenever an item is dropped in the bag, it will send an alert in the form of notification to the owner of the flat on a mobile device. Besides this, whenever a packet is being dropped, an image of the person delivering the same can be captured and reflected in a mobile application installed on the owner's cell phone. Besides image of delivery person and notification alert , weight of items that are being dropped inside will also be reflected in registered owner mobile phone. The article is organized in sections as follows. Introduction is explained in Section 1. Section 2 dedicated for literature review. Section 3 discusses

about methodology implemented. Results are discussed in Section 4. Research is concluded in Section 5.

## 2 Related Work

This in-depth review of the literature will address essential aspects of the investigation. The authors in [14] has proposed solar energy based Smart Bag to provides day-to-day required features. This bag is less complicated and compact which can be used for handling difficult tasks. This bag being user-friendly people of any age group can use it according to their requirements. The authors in [15] suggested a versatile smart bag which solves nearly all the problems which a person can face while moving out from his/her house. This system is all about developing a versatile smart bag which can fit in the role which is given to it like to carry material, for tracking, security, weight checking and more. With this system in place security issues will be solved along with charging of electronic devices, tracking of children if they are lost is made easy and weight.

There are many travelers bag, delivery bags, mail drop bags or door hanging bags nationally and internationally available, some with solar powered charging, some with electronic critics and monitoring [16]. The authors in [17] developed a prototype that is attached to a school bag. As soon as the student places books/other stuff's (for instance lunch box, Hat) inside the bag, RFID reader scans the tags and check for the corresponding books as per the saved information on database (DB). Grounded on that's days' timetable, a notification will be generated in the developed mobile application. Table 1 represents the comparison of the smarts bags available in the literature. Table 2 gives idea about some models available. But, a bag specific to the application of daily small, degradable products delivery items and notification to the user are not available. There are few lockers available commercially as well as with RFID technology. RFID based locker system are easy to install and maintain however these systems are not secure as tags can be cloned easily. These systems do not support for remote access or real time alerts and no integration with modern systems. Commercial smart lockers are cloud-based systems for multiple users. It is not suitable for single user delivery notification application due to higher initial cost and maintenance cost.

Table 1: Summary of Smart Bag with features Available in the literature

Features	Usage	Security	Notification Alert	Detection Method	Connectivity	Recording Capability
Ref. No						
[7]	Travelers	X	X	NA	✓	X
[8]	Travelers	X	X	✓	✓	X
[9]	Women Hand Bag	✓	NA	X	X	X
[10]	Outdoor activities	X	✓	✓	X	X

[11]	Airport Packet drop	X	X	✓	✓	✓
[14]	Multipurpose Smart Bag	X	✓	X	X	X
<b>Proposed SMART BAG</b>	Household Consumable Drop Box	✓ Password Protected	✓ Yes in registered Mobile	✓ Image Capture	✓ Cloud	✓ Yes historical data can be accessed

Table 2: Summary of Models of Smart Bag commercially Available

Ref No.	Application Name	Features	Limitations and future scope	Images
[18]	Eufy Security SmartDrop	Secure package, delivery box, Built-in camera & motion sensor, Remote access & notifications, Integrates with Eufy security system	Specific to the delivery application, Not weatherproof,	
[19]	SmartDrop - Brock Solutions	Dedicated & common-use options, touchless bag drop Fast transaction time, 3 layout Options for flexibility	Requires integration with airport BHS, Not all airlines support self-service bag drop	Not available
[20]	PEELCO 19" Extra Large Mailbox Dropbox Safe	Large capacity for mail & small packages, Weatherproof galvanized steel construction,	No remote access or monitoring	
[21]	DuraBox	Wall mount, recessed, or freestanding options, Secure locking mechanisms	Limited size options for larger packages, no remote access or monitoring, no security features like cameras	

Smart drop as presented in [19] developed by EUFY provides the facility of mail notification. Get a notification and watch every package delivery with a 1080p HD camera right from your phone in real-time. You can even talk to the courier via two-way audio. It also provides Round-the-Clock Protection: Receive packages whether you're home or out and about. Besides it Works with All Couriers: As your delivery approaches,

Durabox [21] available are equipped with facility of being convenient, Ideal for receiving a wide variety of items like keys, car remotes, checks, cash, books, magazines, mail, and packages. The Dura box will keep your items safe. Perfect for homes, offices, schools, and businesses. This parcel drop box provides a convenient way to receive mail. SECURE – The mail box's unique design prevents packages and mail from being fished out. The

hinges are located inside making it difficult to pry it open. The parcel box can be mounted to a wall or onto the floor for added security

Both Dura box and drop box are suitable for keeping belongings safe and hence are made of tough materials of metal. Moreover, these are not designed for delivery of daily consumables grocery items like dairy products and others. Others items invented are designed for specific task. An intelligent bag is a need of a user which will be used to solve the problems that can be faced by a person while moving out from the house. The main objective to design the existing smart bags were to implement security, timely charging, remote tracking. Many types of travel bag, including shoulder bags, tourist bags, and suitcases, use this technique for discrete purposes. Security of vital objects will be ensured by these smart traveller bags installed with system to serve purposes [22].

A review of existing smart bag solutions reveals that current market offerings are largely limited to travel bags, handbags, and student backpacks, focusing on features such as GPS tracking, anti-theft mechanisms, and solar charging. While these designs effectively address mobility-related needs, they do not cater to the daily household requirements of working professionals. Notably, there is a clear gap in the availability of a household-oriented smart bag capable of providing real-time alerts when items are placed inside the bag, along with contextual information such as item weight and captured images of the person delivering the expected item. Furthermore, existing solutions do not support remote monitoring for users who are physically away from home. The absence of such an intelligent, door-mounted smart bag highlights a significant research and application gap, particularly for metro residents and working professionals who require timely notifications, accountability, and convenience in their fast-paced lifestyles.

### 3 Problem Formulations Methodology

The present work is an integrated system designed to address the needs of residents of a house by issuing notifications when items are dropped into the designated collection bag placed near their front doors for deliveries. The delivery person will place the items in the proposed smart bag containing various sensors integrated at different locations, which confirm the presence of items being placed through the integrated flaps. The system comprises both hardware and software components that work in tandem to ensure seamless and efficient functionality. The complete block diagram of the IoT-based system is shown in Figure 1

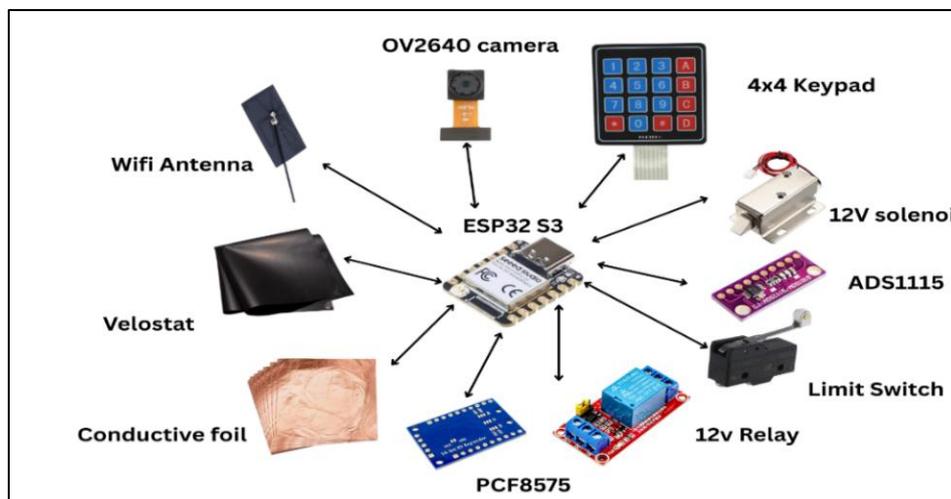


Figure 1: IoT system block diagram

The smart bag is designed to be compact, weather-resistant, and equipped with various sensors strategically placed at different locations to confirm the presence of items. The system consists of a microcontroller, a memory module in data communication with the controller, and two different groups of sensors. The sensors include pressure sensors and optics-based proximity sensors, which are connected to a microcontroller. Besides sensors, the microcontroller is connected to a keypad and actuators. A keypad is used for the opening of the bag by owners, and actuators are integrated to allow only one-way opening of the bag from the outside. This is done to allow outside people to drop items in the bag.

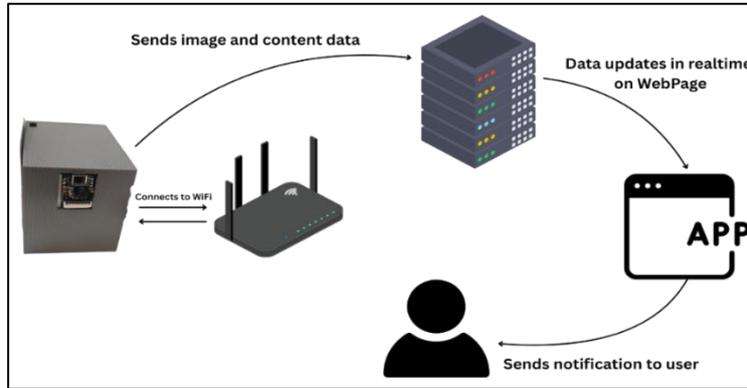


Figure 2: Hardware Components of Smart Bag

Figure 2 includes the description of components which are used in the development of smart bag for alert notifications and their connectivity with central microcontroller. The microcontroller is responsible for processing the data received from the sensors and determining whether the bag is empty or not. IoT system design and architecture are represented in Figure 3.

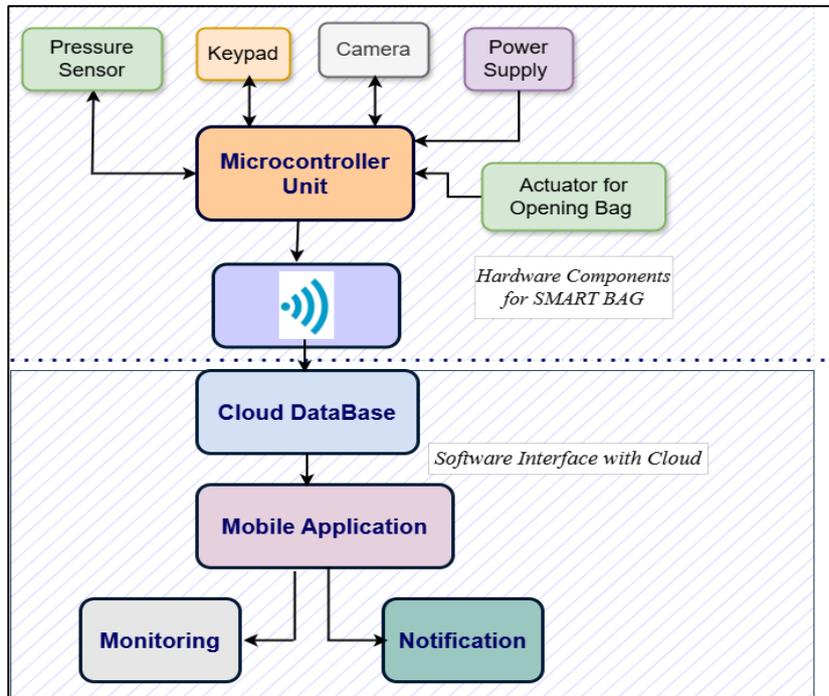


Figure 3: IoT system design and architecture

In addition, the sensors in the smart bag include a camera OV2640, to capture images of the delivery person. This is activated via a Limit Switch, which signals the camera to capture the image. Since the image of the person can be seen by the owner from a distant place, the system needs connectivity from the home router. To have satisfactory

connectivity with home routers, a Wi-Fi antenna is also connected to hardware components for efficient signal processing. This provides an added layer of security and accountability. So, the overall system consists of Hardware components and software. The system is powered by a direct power source connected to a power socket. However, in the event of a power outage, the system automatically switches to a battery mode to ensure uninterrupted operation, which can be charged using a port. The system has a function acting as a switch that can be used to activate it or deactivate it. Whenever an item is delivered, the system gets activated. The actuator allows the item to be dropped inside the bag, and the pressure sensor senses the item and activates the optics sensor for clicking the picture of the person delivering the items. The image gets stored in the RAM of the of the owner. So, the overall system consists of Hardware components and software. The Microcontroller then sends a notification to the Mobile Application regarding the update. An alert notification is also generated by the app and is received on the owner's mobile. The description of the components used in the proposed Smart Bag is illustrated in Table 3. Different components and their description are included in this table.

Table 3- Components with justification needed for the Design of Smart Bag

Component	Description	Purpose
OV2640 Camera Module	2MP resolution, JPEG output, works with ESP32-CAM	Capturing images
4x4 Matrix Keypad	16-button membrane keypad	Used for password input
ESP32-S3	Wi-Fi-enabled microcontroller	Controls the system, processes inputs, and manages communication
Electromagnetic Lock	12V DC, solenoid-based locking mechanism	Used for door unlocking upon valid input
Limit Switch	Small mechanical switch with a lever	Detects the position change of the lid
Relay Module	Single-channel, 5V control, supports AC/DC loads	Controls high-power devices with a low-power signal
Copper Foil Sheet	Conductive, flexible	Used as electrodes in the custom pressure sensor
Velostat Conductive Film	Pressure-sensitive, conductive polymer film	Used to create a custom pressure sensor
PCF8575	I2C-based 16-bit I/O expander	Expands GPIO availability for connecting more components
ADS1115	16-bit ADC with I2C interface	Provides high-resolution analog readings
Auxiliary components	Wires, connectors, mounting materials, enclosure, etc.	To complete the circuit and product

The schematic, as shown in Figure 4, represents a microcontroller-based embedded system that integrates multiple peripherals for analog sensing, digital input processing, and actuator control. The system is built around the SEEED Studio XIAO ESP32-S3 microcontroller, represented in Figure 4 as U7, which serves as the central processing unit for the entire circuit. The technical aspects of the circuit as described below. The circuit is powered by a DC-DC boost converter (U1: XL6019), which provides a regulated 5V output to the microcontroller and other components. This ensures stable operation across

all connected devices. The ESP32-S3 module is powered through its 5V input pin, while its logic operates at 3.3V. An ADS1115 16-bit ADC (U3) is used to extend the microcontroller’s analog input capability. The ADC is connected to a Velostat pressure sensor (U5), which exhibits variable resistance based on applied pressure.

The sensor’s output is read by the A0 channel of the ADS1115, while a 3.3kΩ pull-up resistor (R1) ensures proper signal conditioning. The ADS1115 communicates with the ESP32-C3 using the I2C protocol via the Serial Data Line (SDA) (D4) and Serial Clock Line (SCL) (D5) lines. To manage multiple digital inputs efficiently, a PCF8575 I/O expander (U2) is integrated into the system. The PCF8575 operates via I2C, reducing the number of General-Purpose Input Output (GPIO) pins required on the ESP32-C3. It is primarily used to interface with a 4×4 matrix keypad (U4), allowing the user to enter inputs that the microcontroller processes for control operations.

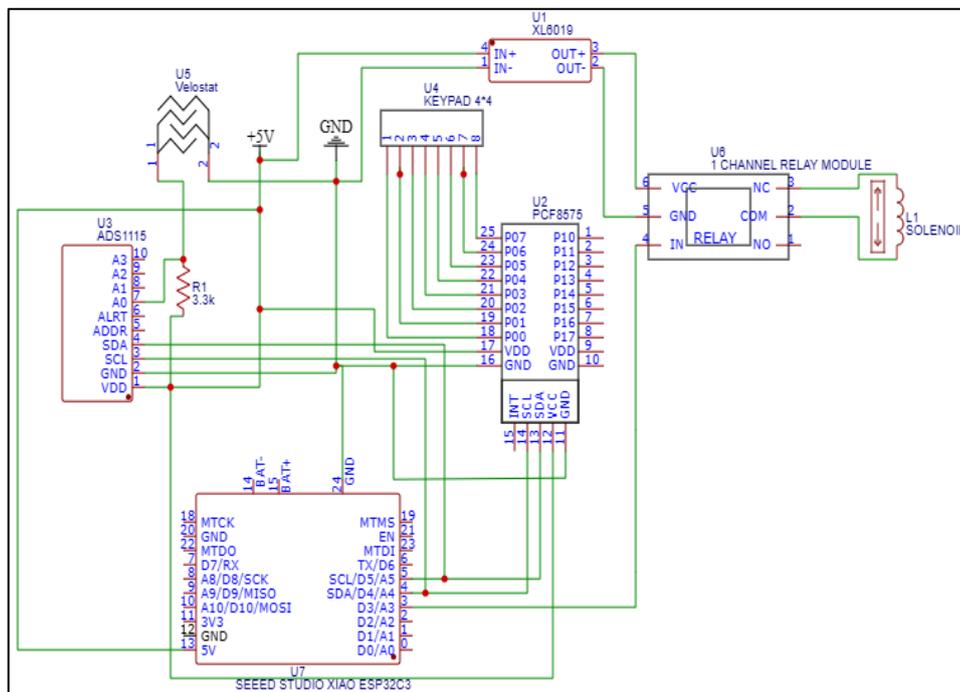


Figure 4: Circuit Schematic

A single-channel relay module (U6) is included in the design to control high-power actuators. The relay is triggered via an output from the PCF8575 I/O expander, enabling the activation of an external solenoid (L1). The relay’s normally open (NO) terminal is used, ensuring that the solenoid is only powered when the relay is energized. The ESP32-S3 communicates with the ADS1115 and PCF8575 via the I2C bus, sharing the SDA and SCL lines. The PCF8575 receives input signals from the keypad and sends appropriate control signals to the relay. The ESP32-S3 processes analog data from the Velostat sensor to determine pressure levels and can trigger the relay based on pre-set conditions.

### 3.1. Hardware Design Challenge and Solutions

While designing the smart parcel security box, the key challenge was, implementing a custom reliable sensor to detect when a parcel has been placed inside. Velostat is a pressure-sensitive conductive material. This was chosen due to its affordability and flexibility. However, designing a custom sensor needs two requirements to be fulfilled. The first one is ensuring sensitivity and reliability. The second one is calibrating signal variations. To ensure sensitivity and reliability, appropriate pull-up resistors were used.

The pull-up register's value was set to 3.3 K ohms, computed based on equations 1 and 2. To minimize the false triggers, the resistance change needs to be precisely measured to differentiate between weights. The signal variations were calibrated by trial methods with different weights.

Designing a pressure sensor with precise sensitivity to detect the weight of a very lightweight single item is a critical engineering task. The perishable items, such as a flower bouquet, can weigh from approximately 50 GM to 150 GM, depending on the size. The off-the-shelf pressure sensors were insufficient to deal with such requirements of the sensitivity adjustments. The sensitivity (SS) of Velostat as a pressure sensor is typically defined as the relative change in resistance per unit pressure applied. Mathematically, it can be expressed as in equation (1):

$$S = \Delta R / \Delta P \quad (1)$$

where:  $\Delta R$  is the change in electrical resistance ( $\Omega$ ) of the Velostat material due to applied pressure. And  $\Delta P$  is the change in applied pressure (Pa).

Alternatively, if using relative resistance change, the sensitivity equation can be written as:

$$S = (\Delta R / R_0) / \Delta P \quad (2)$$

where  $R_0$  is the initial resistance before pressure is applied.

The resistance of Velostat typically decreases non-linearly with increasing pressure due to its piezoresistive properties. Hence, the sensitivity may vary across different pressure ranges.

To convert the resistance, change into a voltage signal that can be read by the ESP32, a voltage divider circuit was used. The circuit consists of:

Fixed Resistor:  $R_1 = 3.3k\Omega$

Variable Resistor (Velostat):  $R_2$  (varies based on applied pressure)

Input Voltage:  $V_{in} = 3.3V$

Using the voltage divider formula;  $V_{out} = 3.3V * R_2 / (R_2 + 3.3k\Omega)$  (3)

The other problem we encountered was the locking mechanism using a 12V Solenoid. It faced overheating issues due to a high current draw from a 12V wall adapter. The continuous activation caused the solenoid to overheat. It was crucial to limit the current flow without affecting the solenoid's functionality. To prevent excessive heating, the solenoid needed to activate for a short duration. This is achieved by optimizing the duty cycle. It was implemented to ensure the solenoid is only activated for a short duration to prevent excessive heating.

The second problem faced was the handling of camera processing speed and memory. We switched to the Seeed Studio ESP32-S3 Sense to mitigate the limitation of camera processing speed and memory while using the ESP32-AI Thinker CAM. Integrating multiple components seamlessly and achieving power management was another critical task for the success of the project. The Velostat-based sensors unit for parcel detection is integrated with a microcontroller for processing and camera functionality, with a relay-controlled solenoid for secure locking or unlocking. To maintain the power stability DC-DC voltage regulator is used. The ESP32-S3 Sense had fewer broken-out pins, making it challenging to connect multiple sensors and actuators. To mitigate the challenge of limited GPIO pins on ESP32, I/O capabilities have been extended by using PCF8575, which

facilitated the additional digital I/O. ADS1115 was used for high-resolution analog readings.

### 3.2. Software Design Challenge and Solutions

The challenge of dealing with image storage on the cloud was so crucial. The selection of an appropriate backend technology presented itself as the main development obstacle because it required scalability with flexible data handling capabilities. The system demanded a backend infrastructure to process dynamic data components, which should operate efficiently with frontend integration with high operational speeds. The implementation of Node.js Express.js proved superior to alternative choices because its asynchronous architecture improves system handling of concurrent requests while maintaining high responsiveness.

- **Asynchronous and Non-Blocking Architecture:** Enables efficient handling of multiple concurrent requests, enhancing system responsiveness.
- **Scalability:** Supports microservices architecture and real-time applications, ensuring adaptability to increasing workloads.
- **Seamless Integration with MongoDB:** Facilitates efficient data retrieval and processing, optimizing database interactions.

The storage system for images within the database proved to be a substantial problem requiring a suitable resolution. When keeping binary image files directly inside the database users faced problems with poor system performance as well as bigger storage needs and complicated retrieval operations. Base64 conversion of images before storage resulted in improved storage functionality through three main advantages:

- Images could be stored as string data within MongoDB documents, reducing storage complexity.
- The database operations became more efficient because separate file storage systems no longer existed.
- The system enabled smooth integration between frontend applications and it eliminated complications in displaying stored files.

*Mobile Application for Smart Bag.* The main objective of the software integration is to receive timely notification of the delivery. With this objective the key functionalities of the mobile app are instant alert, real time monitoring, and historical data access.

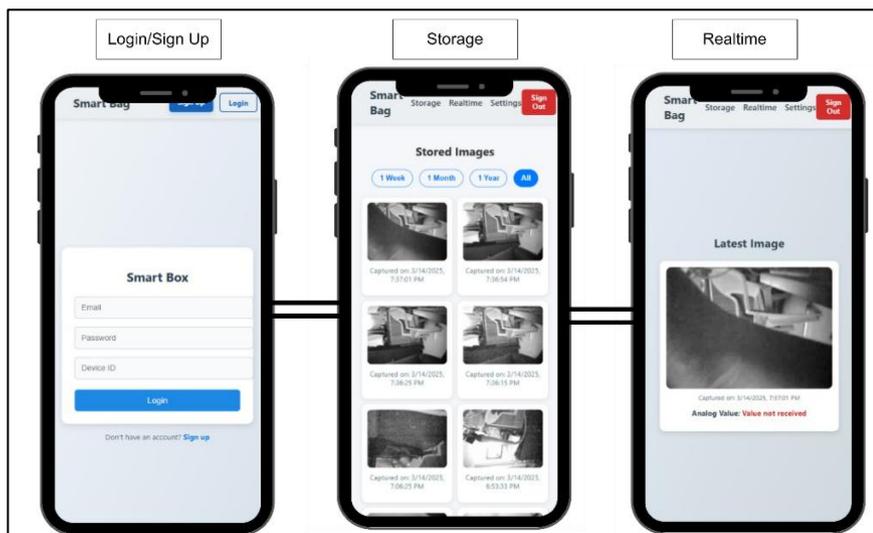


Figure 5: Screenshots of pages of the Web App

The various pages of the application are shown in Figure 5. The application retrieves information from the Azure cloud server to present a clear and current picture of the delivery boy. Data Alert Notifications: The mobile app includes an alert system to ensure delivered perishable items can be picked timely manner. This proactive alert system helps users take timely actions. The mobile app ensures that the authorized users are protected and are the only ones who can access the data. Users can securely log in to their accounts to access the data specific to their bag systems through the use of the authentication feature integrated into Firebase, adding an extra layer of privacy and control. Also for Cross-Platform Compatibility: The Flutter app is designed for cross-platform compatibility, meaning it can be installed on Android and iOS devices. This flexibility ensures users can access the proposed mobile application from their preferred platform without any hassle or emulators. The mobile app includes a feature that allows users to see the graphical representations of the current (real-time) and previous sensor data, be it a few hours or days. Description of App is presented in Table 4.

Table 4: Description of the App navigation

Page	Feature Description	Need for Internet Connectivity
<b>Login/Sign Up</b>	Users can authenticate their account through the Login/Sign Up interface by using a combination of email, password, and device ID. The application provides authentication services through JWT tokens.	Yes (Required for authentication)
<b>Storage</b>	This page provides visual storage of images that match the device ID belonging to the current authenticated user's account. Images are fetched from the Database.	Yes (Required to fetch stored images)
<b>Realtime</b>	Shows the most recent image uploaded for the logged-in user's device ID. Updates dynamically with the latest image.	Yes (Required for real-time updates)

## 4 Result and Discussion

The smart delivery bag was tested over a period of 30 days to evaluate battery performance, notification accuracy, and also to assess pressure sensor sensitivity under realistic usage

conditions . It was observed that the 5000mAh 10C battery provided continuous operation for up to 83 hours, supporting 4 to 5 deliveries per day. This clearly indicates that the proposed system is suitable for real world deployment without the need of frequent recharging and also is energy efficient. Figure 6 demonstrates the pressure sensor's response to a low-weight item, such as a bunch of flowers weighing approximately 50 grams. Successful detection of light weight items indicate high sensitivity of pressure sensor which is much required for household deliverables. Figure 7 shows the sensor's performance with a medium-weight item, such as a milk packet. In both cases, the pressure sensor functioned as expected, and timely notifications were successfully received by the owner, allowing prompt action. The results achieved in both scenarios confirm that the proposed system performs reliably across a range of commonly delivered household perishable goods. The consistent notification performance and long battery life suggest that the smart delivery bag can effectively reduce delivery-related delays and potential spoilage, making it a practical solution for unattended perishable item delivery.



Figure 6: Image of the low-weight perishable item notification

Figure 7 indicates a medium-weight item like Milk delivery. In both cases pressure sensor demonstrated as expected and notification was received by the owner to take timely action. The designed product works effectively with both light weight and medium weights consumable items. The results achieved in both scenarios confirm that the proposed system performs reliably across a range of commonly delivered household perishable goods. The consistent notification performance and long battery life suggest that the smart delivery bag can effectively reduce delivery-related delays and potential spoilage, making it a practical solution for unattended perishable item delivery.



Figure 7: Image of the medium-weight perishable item notification

Figure 8 represent the sensitivity analysis of the Velostat sensor. Same weight item is repeatedly tested for ten times to check the sensitivity. The sensitivity value is computed using the equation 2. The velostat value before dropping the item and after dropping the item is recorded. From Figure 8, it has been observed that for small weight items, the change in the velostat value differs at the most 7%. For large size and large weight items the difference does not increase beyond the 2%. This minor change is the result of uneven Velostat surface. As the sensor is not yet made with complete industry standard due to budget concern, the surface of the Velostat sensor is little uneven due to which sensitivity differs at different point on the surface.

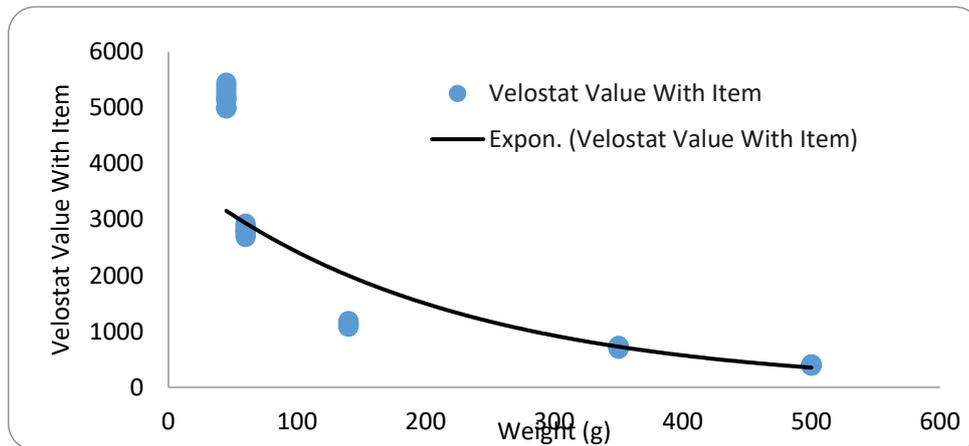


Figure 8: Sensitivity curve (Velostat value with Item vs. Weight (g))

There are three types of the notifications implemented in the system. First notification is sent when lid is opened by the delivery person and immediately system captures the image of the delivery person. The image notification is sent as second notification. Third notification is for item delivered and its weight. All these notifications are sent with the millisecond to second delay. The Table 5 below shows the notification delay distribution.

Table 5 Notification Latency distribution with respect to the event

Event	Est. Latency	Critical Bottleneck
<b>1. Lid Open Alert</b>	Approx 0.8 – 1.2 Seconds	Internet Round Trip Time (RTT)
<b>2. Picture Upload</b>	Approx 3.5 – 5.0 Seconds	WiFi Upload Speed tested with medium strength signal -70 dBm with 75mbps download speed and 30 mbps upload
<b>3. Sensor Update</b>	Approx 0.8 – 1.2 Seconds	Internet RTT

To optimise the power consumption, the system is designed with interrupt-based logic. The system is in soft sleep mode. The ESP32-S3 in Light Sleep uses roughly 800µA. The camera (OV2640) in sleep mode consumes about 600µA. In waiting state per day, the systems drain approximately 19 - 48 mAh per day. Table 6 represents the power consumption including sensor notifications.

Table 6 Power consumption distribution with respect to the activity.

Activity	Current Draw (Approx.)	Duration	Energy Cost / Impact
Soft Sleep (Idling)	~1.5 mA	Continuous	~36 mAh per day (Base drain)
Sensor Notification	~150 mA	< 1 second	Negligible (Tiny battery usage)
Taking Picture	~300 mA	~0.5 seconds	Low (Brief spike)
Uploading Picture	~450 mA	3 - 5 seconds	High (~0.5 mAh per upload)

The bag is designed and implemented with customised sensor using Velostat as per the specific requirement of the application in the college laboratory. Faults can be categorised in three types (1) False positive: Item dropped but did not send notification (2) False Negative: Item not dropped and sent the notification (3) Incorrect weight notification due to sensitivity issue. The chances of occurring of fault number 1 and 2 are rare as there 3 different notifications of a delivery event. Incorrect weight calculation may happen due to sensitivity variation at different point but the delivery notification will be delivered correctly. In all the test runs we have not encountered the fault event point 1 and 2. For fault type 3, the incorrect weight notification received 10 percent of the total notification

Further care needs to be taken for handling missing data [23] and also for storage of old data for retrieval needed later on. Besides these with increased usage there arises a need for integration of the proposed system with Machine learning models for ease of usage and general adaptability[24].

## 5 Conclusion

The proposed system combines hardware and software components for efficient functionality. It features a microcontroller, memory module, and two groups of sensors, including pressure sensors to detect whether items are present and an optical sensor to capture images of the delivery person—enhancing security and accountability. Designed to be compact and weather-resistant, the sensors are strategically placed to monitor contents accurately. The system runs on direct power but automatically switches to battery mode during outages, ensuring uninterrupted operation. However, there are a few concerns which need to be improved in the future are as follows Detecting very lightweight items (e.g., a single rose flower weighing 5–50 grams) can be challenging due to the nonlinear resistance changes in Velostat. This may lead to false positives or missed detections, especially for extremely lightweight items. Heavier items may not be accurately detected, and excessive weight could damage the sensors or the bag's structure. The system assumes that delivery personnel will place items gently into the bag.

However, rough handling or improper placement of items could lead to sensor malfunctions or damage to the bag. The system relies heavily on cloud connectivity for image storage, real-time notifications, and data processing. Any disruption in internet connectivity can hinder the functionality of the system, making it less reliable in areas with poor network coverage. Although the ESP32-S3 Sense improves image processing speed compared to the ESP32-CAM, there are still delays in capturing, processing, and uploading

images to the cloud. This could result in a slight lag in real-time notifications, especially in low-network conditions. In both cases pressure sensor demonstrated as expected and notification was received by the owner to take timely action. The designed product works effectively with both light weight and medium weights consumable items.

Further care needs to be taken for handling missing data and also for storage of old data for retrieval needed later on. Besides these with increased usage there arises a need for integration of the proposed system with Machine learning models for ease of usage and general adaptability

## ACKNOWLEDGEMENTS

The authors would like to thank the Symbiosis Institute of Technology, Pune, Symbiosis International (Deemed University) Pune and Atlas SkillTech professional University, Mumbai for the support

## FUNDING STATEMENT

This project was funded by Symbiosis International (Deemed University) under the Minor Research Project (MRP) Grant Scheme, approval reference SIU/SCRI/MRP-Approval/2024/1409.

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