IoT Based Parcel Monitoring System

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Abstract. Hassle-free delivery of products gained importance due to the rapid increase of online shopping portals and relocation of people due to various factors. In shopping portals, exchange of important documents, parcels of any kind, the delivery is becoming significant and growing in numbers and types in the transport mediums. An efficient Parcel Monitoring System is significant to avoid damage during the mode of delivery, mishandling, or loss of parcels. To overcome the age-old problem, this framework proposes an Internet of Things (IoT) based solution to monitor and ensure the safe and secure delivery of the parcels. The proposed framework monitors the environment of the parcels during transport with the help of sensors such as Temperature, Humidity, Gyroscope, etc to get information about the parcel's surroundings remotely using IoT technology and sending alert messages. The framework helps in avoiding unethical claims and identifying mishandling of products while the transfer of parcels.

Keywords: Delivery of Products · Hassle-free · Internet of Things.

1 Introduction

The shipment of merchandise or other high-value packages is known as parcel delivery. Considering the safety and security of products sent, continuous monitoring needs to be done until delivered to the destination. Hence parcel monitoring has now become the major concern because of the various human or system-made mistakes that lead to loss or damage of products(goods/documents/gifts) which cause loss to customers and business.[1] states services that are provided to the customers matters the most, which is directly mapped with the cost they pay and the experience they incur out of the overall process. To provide better

Quality of Service (QoS), parcels have to be transmitted to the respective person properly without any damage occurring to the parcels. To ensure better QoS and efficient way of tracking safe and damage-free delivery to the right person and right time using IoT-based technologies.[2] also throws light on the significance of IoT in the Supply Chain and how it helps to improvise in this area. IoT is a connected network of computing equipment, objects, and living beings having UIDs that have the capacity to transfer data without human or computer interaction. Parcel monitoring in the given application is based on IoT, which deals with the accurate monitoring of parcels by notifying the users with real-time updates caused to the parcel, by giving them brief details about the humidity values, temperature values, parcel tampering details. The users (Recipients, senders, courier authority, drivers) are notified with the necessary information with an alert for the drivers and an email notification if any damage occurred to the parcel. The estimated time of delivery is also to be communicated to the recipients and prioritizing the parcel based on its type. The tampering which is the major concern of the system involves Radio-Frequency Identification(RFID) technologies to monitor the parcel's handling by the authoritative people since this issue is handled smoothly customers can rely on parcel services, and give feedback to improve the quality of monitoring hence QoS. The system tries to ensure the safe and secure delivery of products for better customer satisfaction and a win-win situation.

2 Related Works

The literature consists of two parts: The first one is the Minimization of delivery time with the help of IoT, followed by the literature review on monitoring restricted conditions and RFID(Radio-Frequency Identification).

A. Literature review on Minimization of delivery time with the help of IoT

[3] concentrates more on UAE's parcel delivery system, by reducing the delivery time by integrating the GPS(Global Positioning System) module, which detects the user location and integrates the google API(Application Programming Interface) which provide them a proper direction to fasten the delivery time, while [4] expresses concern over the user's consent to a contact-tracking application that comprehensively tracks using Geo-Spatial Big Data and Analytics with visualization to track the spread of the CoViD-19 disease.Similarly, [5] computes the distance between the destination and the source is calculated. and optimizes the allocation of people to respective deliveries. Unlike these papers, [6] proposed drone technology by attaching the drones to the train services and attaching the train time tables with them by removing redundant round-trip times, and [7] focused on improving the efficiency of the drone delivery modes in terms of reduced delivery time, energy consumption and battery charging with the help of Dynamic Programming Algorithm.

[8] considers reducing the actual delivery duration by avoiding unnecessary visits to various hubs and sub-hubs by enabling end-to-end delivery wherever possible for reduction of source-destinations distance, and [9] considers improving the architectural efficiency of IoT platform in logistics application by proposing an enhanced routing algorithm, Efficient Route Election procedure(EREP) to minimize end-to-end delay in a WSN to improve the QoS, and [10] proposes the potential use of unmanned aerial vehicles for the faster delivery in a short-range mission like that of supplying medical aid, essential commodities to a disaster-affected community.[11] mainly focuses on the inefficiencies of managing parcels at Kolej University Poly-Tech Mara, that is the parcel being lost or misplaced or tampered. The solution provided is a computerized tracking of delivered parcels using the barcode.

B. Literature review on monitoring restricted conditions and RFID

[12] proposes the use of Wireless Sensor Network (WSN) networks in order to send data to the people at receiver end, employing RFID technologies to sort the parcels,and prioritising them to send them as soon as possible.[13] proposed that while sending the data to the receiver it was also important to monitor the temperature surrounding the parcel and communicate the data directly to the central office if it crosses the threshold.

[14] focuses mainly on the Agri-food Supply chain by introducing an IoT Based Coordination System DEMATEL-ISM.[15] considers the reliable delivery of perishable goods like agri-products and medicine with the help of low power IoT sensor devices to monitor physical and environment of the parcels like temperature, humidity and location,similarly [16] considers safe and reliable transportation of critical consignments like donated organs with Cloud Computing, Message Queuing Telemetry Transport (MQTT), Docker based IoT solution that monitors temperature, humidity, luminosity, location and notifies the stakeholders. [17] encompasses the idea of intruder detection in military regions by employing different communication systems in order to communicate the information about humans to the central node ,the main reason to go for this technique was to detect n number of humans as PIR(Passive Infrared Sensor) motion sensor considers a lot of n number of person as single trespasser. Whereas, [18] states that using the PIR motion sensor in order to detect leaves and other object's sound and communicate to the central node, the PIR motion sensor computes the average speed and direction in which the intruder moves , thereby notifying the central node with proper coordinate values.

The remaining paper is organised as Section 3 describes the Proposed Solution including the Schematic Diagram, Hardware Components and the Working of the system. Section 4 mainly describes the Results by illustrating the web based application developed for tracking of the parcels by the shipping officials and customers followed by comparative study,finally conclusion and future work is presented in section 5.

3 Proposed Solution

Reliable delivery of parcels is becoming significant and growing in numbers due to the types of threats imposed in the modern world. The aspect of the security of these parcels is of rising concern, especially with parcels containing consignments like important documents, fragile items, crucial things like life stocks or donated organs. The objective is to develop an IoT based Parcel Monitoring System which monitors the delivery of the parcel and will provide GPS Tracking, Damage Control, Transportation Monitoring, Reliable Delivery and informs the status of the parcel to the involved stakeholders. This IoT based Parcel Monitoring System uses sensors to continuously monitor the environmental factors of the parcels like temperature, humidity, alignment, tampering, etc, to ensure the safety and security of shipments involved and to avoid any unforeseen activity occurring.

3.1 System Schematic Diagram

The diagram (see Fig. 1) represents the Circuit Diagram of the proposed system.

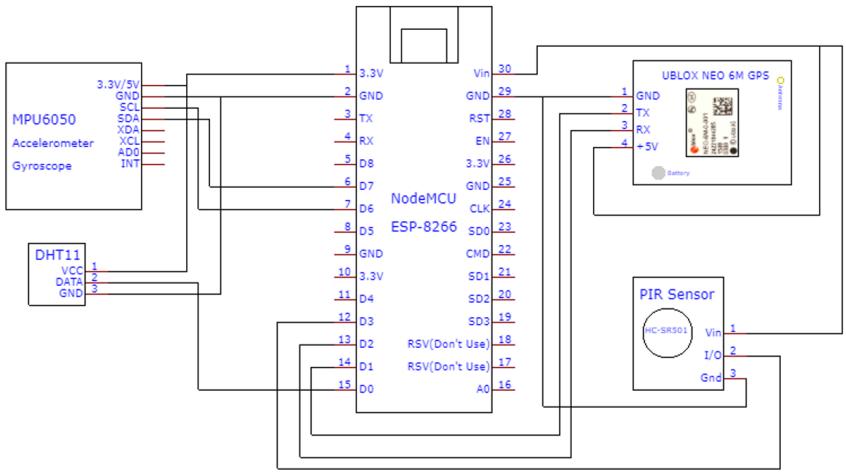

Fig. 1: Schematic Diagram for Parcel Tracking

3.2 Hardware Components

The system uses sensors (see Table. 1) like Temperature & Humidity to monitor the environment's climatic conditions, PIR(Passive Infrared Sensor) Motion Sensor to track any human motion, Gyroscope to monitor alignment, Accelerometer

and GPS to track the transportation, store this in cloud through MQTT and an app to analyze these readings for any happening of undesired events and report the status to respective stakeholders for further actions.

Table 1: Components Used

Component	**Features**	**Justification**
NodeMCU ESP8266F	RISC Microprocessor 128 KB RAM 4MB of Flash Memory	Interfacing sensors, sending data to the Firebase Database via WiFi module.
DHT 11 Temperature & Humidity Sensor	Calibrated Digital Signal Output of temperature and humidity	Measure the humidity and temperature in the surroundings to intimate the transporter whenever the values exceeds the tolerance capability of the parcel. Since this sensor comes with the advantage of measuring humidity readings as well , this is preferred over other temperature sensors.
HC-SR501 PIR Motion Sensor	Repeatable and Non- Repeatable Trigger The sensor outputs high, if there is human activity in its sensing range. The output will always remain high until the people leave	Detection of humans surrounding the parcel in order to overcome parcel tampering issues.
MPU 6050 Gyroscope & Accelerometer	6-axis Motion Tracking Device. Combines 3-axis Gyroscope, 3-axis Accelerometer and Digital Motion Processor all in small package. It has also has the feature of on-chip Temperature sensor	To detect if the parcel moves or it's orientation gets disturbed. Accelerometer values are used to predict expected delivery.
UBlox Neo6 GPS Sensor	Gives The Latitude, Longitude, Date and Time TTFF under 1 s	The parcel has to be tracked throughout the journey for intimating the current location of the parcel to both sender and the receiver
Buzzer	Continuous Beep	Raise an alarm when there is some tampering with the parcel or when the temperature and humidity values raise beyond the tolerable level.

3.3 Working

The sensors are connected with the NodeMCU ESP-8266 as shown in the Schematic Diagram on a breadboard using jumper wires. The Arduino IDE along with the NodeMCU ESP-8266 WiFi Module is used to interface the sensor values received from the sensors in the parcels. The interfacing code is written in C. The received real-time values from the various sensors are sent to the cloud-hosted NoSQL database Google Firebase,the structure of which is shown in Fig. 2.

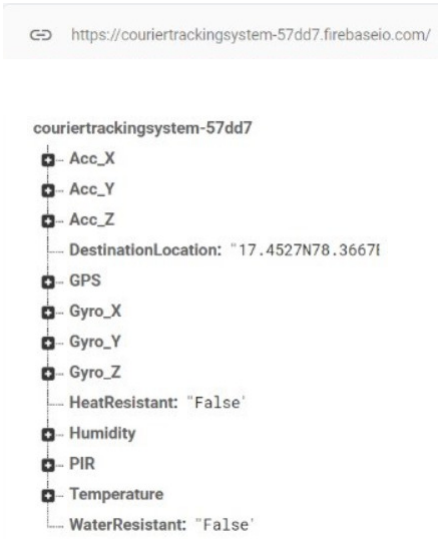

Fig. 2: Google Firebase Database

The parameters Heat Resistant And Water Resistant are used to decide whether an alarm should be raised when the parcel's environment temperature and humidity values exceed the corresponding threshold values which are specified by the sender of the parcel.

The accelerometer gives the acceleration of the parcel along the 3 axes, using this the velocity of the parcel is calculated in the time interval of 60 seconds using The Equation of Motion

$$v = u + (a * t) \tag{1}$$

where:
v = final velocity
u = initial velocity
a = acceleration
t = time over which the motion occurred

The GPS Sensor will send real-time values of the location(latitude and longitude) of the parcel.With the location of the destination of the parcel and value returned by the GPS sensor, the distance yet to be covered by the parcel can be computed using Haversine formula

$$d = 3963.0 * \arccos[(\sin(lat1) * \sin(lat2)) + \cos(lat1) * \cos(lat2) * \cos(long2 – long1)] \tag{2}$$

where:
d = distance in miles
$lat1$ = latitude of destination in radians
$lat2$ = latitude of current location in radians
$lon1$ = longitude of destination in radians
$lon2$ = longitude of current location in radians

Using the distance and velocity the time can be estimated by.

$$time = \frac{distance}{speed} \tag{3}$$

A working live demonstration of our system

4 Results

A Flask based web application is developed for real-time tracking of the parcels by the transporters and customers (stakeholders). The application provides interface to plot the real-time temperature and humidity trends in a graph as shown in Fig. 3.

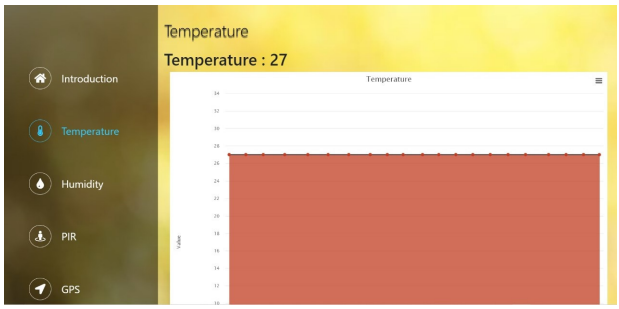

Fig. 3: Live Temperature Plot

Similar pages are available to visualize the unauthorised motion detection, current location and acceleration values along with estimated arrival time so as

to keep the stakeholders posted with the real-time status of the parcels, moreover whenever the threshold is reached for any of the sensor values, the system triggers the buzzer as a warning along with sending email notifications to the relevant stakeholders. Fig. 4 depicts the Flask based web application that shows the delivery status of the parcel.

Fig. 4: Flask based web application

The table (see Table. 2) depicts the comparative study of the proposed solution with the literature survey given in related works.

Table 2: Comparisons with Literature in Related Works

Reference	RFID or Bar Code	Temperature or Humidity Alert	Motion Detection	GPS Tracking	Orientation Monitoring	Estimated Delivery
Iot enabled last-mile delivery [3]				✓		
Location-aware systems [4]				✓		
An adaptation of iot [5]				✓		✓
A new parcel delivery system [6]				✓		✓
Scheduling of parcel delivery system [7]				✓		✓
A design of a parcel delivery p2p [8]				✓		✓
Autonomous payload delivery [10]				✓		✓
Parcel tracking -barcode scanner [11]	✓					
Applications of iot in smart logistics [12]	✓					
An rfid based smart logistics [13]	✓	✓				
Iot based system in supply chain [14]	✓			✓		
Intelligent cargo management system [15]		✓		✓		
Iot-enabled shipping container [16]		✓		✓		
order surveillance intruder detection[17]			✓			
Intruder tracking using WSN [18]			✓			
Our Solution	✓	✓	✓	✓	✓	✓

Our framework focuses on reliable and quality parcel delivering services, the ability of the system to monitor the physical and environmental conditions of the parcel and integrate it with the email services enables a user-friendly platform for the stakeholders to track the status of the parcels. In Addition to that, the orientation monitoring feature in our system enhances the safety and security of fragile and critical parcels that need such additional care. Moreover the system monitors the specified thresholds for each sensor and alarm the stakeholders for necessary probe or further steps in the case any unforeseen events.

5 Conclusion

Parcel Monitoring System developed to provide an efficient framework with a minimal cost-based tracking system to ensure safe and damage-free delivery of parcels. With the help of DHT11 sensors, gyroscopic sensor the temperature, humidity, and the orientation of the parcel is preserved and notifies the user if it crosses the threshold, using the PIR motion sensor authorizes the person to handle the parcel followed by giving real-time updates regarding the delivery with the integration of GPS module. The future improvements to this paper could be with the accelerometer and gyroscope values the position (Orientation - Tilted, Rotated, Toppled, Upside Down) of the parcel can be predicted using ML Algorithms and when fragile parcels are sent additional care can be taken care. Use an Electrical Ink based mechanism to handle tampering in addition to the PIR Sensor. When there is a prediction of rain based on humidity values, open a cover to wrap up the parcel and prevent it from getting wet.

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