IoT-Driven Innovations in Railways

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***Abstract*:**

The integration of Internet of Things (IoT) in the railway industry has revolutionized the way railways operate, manage assets, and ensure passenger safety and comfort. This paper presents a comprehensive survey of existing trends and technologies in railways, employing IoT. Various applications of IoT in railways were reviewed, including predictive maintenance, real-time monitoring, safety enhancements, and passenger experience improvements. In this paper discussion about diverse scenarios in the rail industry is carried out and comparative differences among the various IoT technologies introduced in other papers are identified. Additionally,this paper presents a proposed system that consists of an Aadhar based Ticket reservation and Biometrics based ticket verification system, along with biometrics-based casualty and corpse identification system. This system will enhance the ticket reservation & verification system making it more robust. Furthermore, the applications of IoT in the railway sector are discussed.

***Keywords*: IoT, Railway, Aadhar, UIDAI, Biometrics, Ticket-Reservation, Ticket-Verification, Casualty-Verification, Corpse-Identification.**

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I. INTRODUCTION

The traditional railway system, while serving society for centuries, is embracing a new era of intelligent transportation. This transformation is driven by the Internet of Things, a network of interconnected devices collecting and exchanging data. By integrating sensors throughout trains and infrastructure, railways are becoming smarter, creating a ripple effect of benefits for passengers, operators, and the industry as a whole.The railway industry is undergoing a prominentrevolution with the advent of IoT technologies. IoT enables the interconnection of several devices and systems, enabling data collection, analysis, and decision-making in real-time simultaneously. In the rail transportation sector, IoT has immense potential to enhance operational efficiency, safety, and passenger experience. This paper provides a comprehensive survey of prevailing trends and technologies in railways utilizing IoT.

A. Background and Motivation

The railway industry is on the brink of a transformative era, driven by the amalgamation of IoT technologies. Traditionally, manual inspections and maintenance practices have led to inefficiencies, safety risks, and service disruptions. However, IoT offers real-time monitoring, predictive maintenance, and enhanced passenger services. This paper explores IoT trends in

railways, focusing on applications, benefits, challenges, and future directions. The research aims to inform policymakers, industry stakeholders, and researchers about IoT's potential to drive innovation, improve safety, and enhance passenger experience.

Railways have long been a vital mode of transportation, offering reliable and efficient movement for people and goods. However, traditional systems suffer from limitations. Maintenance often happens after breakdowns occur, leading to delays, risk aggravation and safety concerns. Additionally, limited data makes it difficult to optimize operations or ensure passenger comfort. To address these issues, the railway industry is embracing the Internet of Things technology. By integrating a network of sensors throughout trains and infrastructure, railways are transforming into intelligent systems. This promises a future marked by proactive maintenance, data-driven operations, and a personalized passenger experience – a future where railways are not just reliable, but truly smart.

B. Importance of IoT in Railway

The Internet of Things is a interconnection of physical devices that utilizes sensors and RFID technologies to communicate without human intervention. It is a promising technology that offers flexibility, low cost, and eases of deployment, making it an excellent solution for collecting data from physical environments in critical environments.IoT technology comprises three segments: sensing, accessing, and processing. Sensors collect information from railways, trains, and other infrastructure. Data is efficiently transmitted to IoT platforms using wireless technologies, eliminating human effort. The platform then analyzes and measures the data. An interdisciplinary study reveals IoT is a crucial technology for achieving smart railways, as it enables efficient data delivery and analysis.The Internet of Things (IoT) envisions for a inter-connected world, enabling users to virtually controleverything from anywhere. IoT can be leveraged in various applications, including the railway network, to create a more rational and user-friendly system.IoT can significantly enhance the railway system by automating systems and reducing accidents related to railways.The railway industry is promoting the usage of open source IoT environments, cheap microcontrollers, and the internet boom to implement automated systems, reducing human error and improving passenger experience. Real-time train movement detection through IoT simplifies train tracking for passengers.

C. Graphical Analysis

Train accidents are a global issue due to increased negligence in infrastructural improvement, lack of technological implementation and exploitation of limited resources available in order to fulfill consumers demand, leading to collisions, derailments, fires, and level crossing accidents, these being the most harmful and recurring train accidents.[5] Indian Railways, the world's largest rail network, plays a crucial role in infrastructure development for industries like coal, electric power, steel, and concrete. The Indian government is investing in modernizing the railways and focusing on the IoT technologies for expansion and excellence. The railway is India's lifeline and the cheapest mode of transportation, carrying over 20,000,000 passengers and 2,000,000 tons of freight daily.

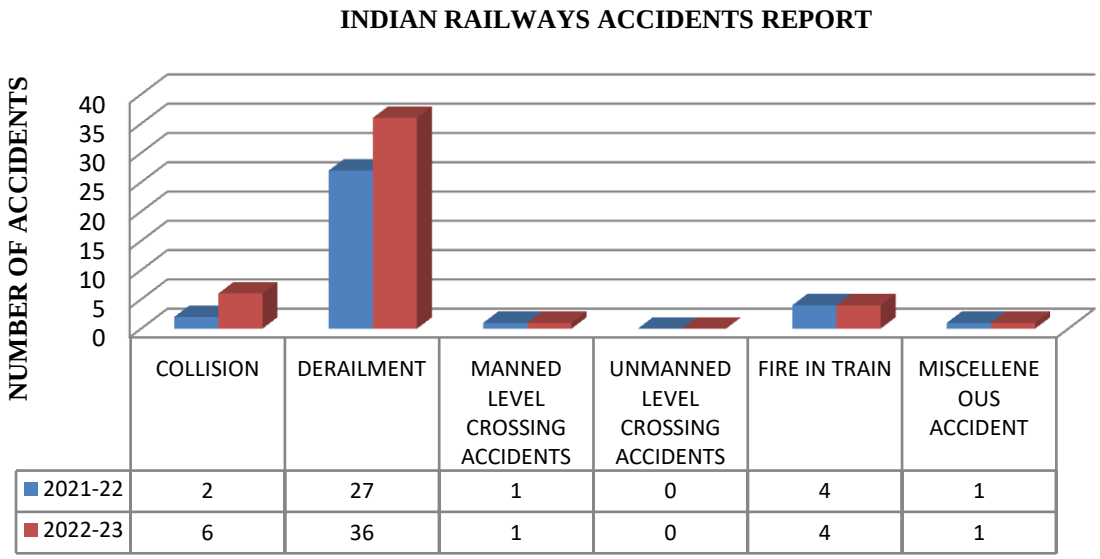

Fig.1: Graphical representation of Indian Railways Accidents

However, many train accidents occur, with a review of train accidents from 2021-22 and 2022-23 revealing a high number of accidents due to derailments and collision.[6] The graph in fig.1 represents the number of accidents in Indian railways Category-wise, where-in its clearly visible that Derailment, Collision and Level Crossings majorly contribute to train accidents. The growth of IoT technology has been significant, with the number of connected devices expected to increase exponentially. Between 2019 and 2030 (illustrated in fig.2), the population of IoT inter-connected devices is predicted to grow by 2.5 times due to dynamically changing global technology and demand for IoT-based technologies. The development of new communication technologies, such as 6G and 7G technology, and Federated Learning, has the potent to make IoT applications safer, faster, and more reliable. IoT technology is extensively applied in the railways, including functioning, administration, maintenance, video supervision systems, and train controlling systems. Advanced computation, fog networking, AI/ML and big data analysis can help process large amounts of data, improving productivity and security in the autonomous train system. The growth in connected devices will see exponential growth for IoT implementation in the rail transport industry and other domains, potentially reducing the risk of accidents caused by unresolved mechanical and infrastructural defects and human error.[7]

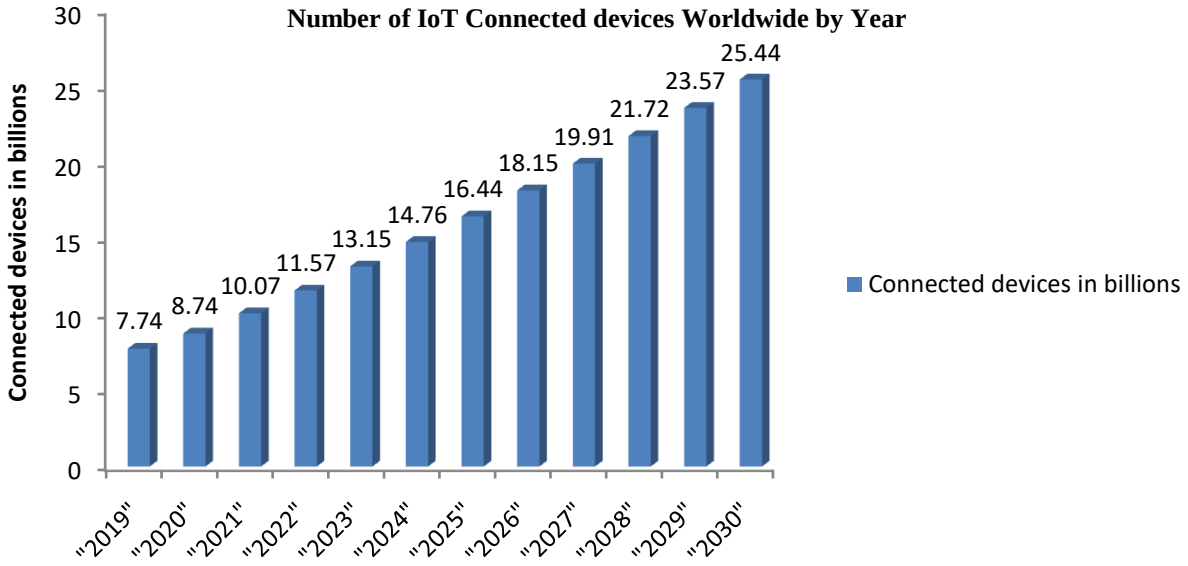

Fig.2: The Quantity of IoT devices connected 2019 -2030

Taking the gradual growth of usage of IoT devices, there arises an ardent need of incorporating this technology in Indian Railways to minimise the possible problems and bring solutions to overcome some challenges that cannot easily be solved. IoT as a technology can be used to deal with human errors caused which contribute to a lot of accidents and keep a vigil check on tracks, alarm and alert systems and automate trains to bring the era of smart railways in Indian Railways.

D. Research Plan

The Table 1 illustrates the several digital databases that were queried as part of the research plan.At this point, a more sophisticated search was carried out by connecting the keywords, phrases, synonyms, and abbreviations using Boolean OR/AND operators. The automated and manual search phases make up the two primary parts of the search strategy. Using the specified keywords based on the objectives of this paper, an automated search is conducted in the first step. The terms "Internet of Things" AND "Railways" OR "Trains" AND "Tracks" AND "Railway system" OR "Indian Railways" AND "Automation," for instance, are used. In order to cover the most relevant and related papers, the keywords are generated from the declared research topics and the structure of this Paper.Additionally, predetermined keywords are used to generate and explore the search string in the digital database sources. In addition, the search query is saved across all database providers so that, upon search completion, notification of each new article that is published is provided. Following their retrieval from the database sources, the research articles are selected in accordance with the inclusion and exclusion criteria as well as the objectives. Utilizing backward & forward search strategies to follow the primary studies citations, the second stage is manually screening the references in the primary studies.To make sure this Paper is adequately thorough, Google Scholar was used to find other relevant research that the original studies had mentioned. Any missing studies were also identified from the first stage.

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Table 1: Data Source

Sl.No	Digital Library	Keywords	Algorithms
1.	IEEE Xplore	Train, Railway, Internet of Things, Level Crossing, Train derailment, Accidents, Collision, Passenger, Ticket, Track health, Automation, Smart Railways, Disaster, Sensor, Real-time, technology.	TITLE-KEY (("train transport" OR "smart railway" OR "Internet of things" OR "passenger train") AND ("rail monitoring" OR "technology" OR "sensors" OR "train collision avoidance system" OR "unmanned level crossing" OR "train derailment" OR "Smart ticket reservation")) AND PUBYEAR > 2016
2.	Elsevier.		
3.	Springer		
4.	Science Direct		
5.	Arxiv		

E. Paper Inclusion and Exclusion Criteria

In order to make sure that the chosen studies are pertinent to the research topic and address the objectives of the paper, the inclusion and exclusion criterion words must be included in the research procedure. The primary goal of establishing the criteria was to guarantee that the included research were apt to and associated with the use of IoT in Railway automation approach. Consequently, all of the predetermined criterion phrases must be met by the chosen research papers.

The inclusion and exclusion criterion terms are tabulated in Table 2.Furthermore, the research that doesn't fit the inclusion requirements (found in Table 2) are not included.In addition, a screening process is used to choose the appropriate literature review that fits the parameters of this study. There are three steps to the screening process:

1. Title and abstract stage: This step used the title and abstract to weed out researches that were not relevant. The studies that satisfy at least a few of the criteria listed in Table 2 are then chosen and moved on to the following phase for additional processing.
2. Full-text reading stage: Studies that did not satisfy the requirements in Table-2 were not included in this step, which was based on full-text or partial reading.
3. Stage of final selection: At this point, Table's- 2 criterion words are used.
   -The study's relevance and relationship to the research topics must be established.
   -The comparative analysis of IoT in Railway automation is included in the research paper.
   -There is enough technical implementation and technique information regarding application of Iot in Railway in the research paper.
   - The research investigation provides a sufficient explanation of the outcomes that were discovered.

Table 2: Paper Inclusion and Exclusion Criteria

Sl.No	***This Paper Includes***	***This Paper Excludes***
1	Listed at one of the database sources.	Not accessible full version.
2	Conferences, journals, book chapters written in English.	Written in different language.
3	Includes latest technologies used to Automate Railways using IoT by addressing key accident reasons such as derailment, collision, level crossing fault, track fault etc.	Redundant and unconnected studies (e.g., surveys and reviews of books, editorials, and research articles that are not publicly available).
4	Related to Smart railway system using IoT, detection and mitigation approach to accidents in order to avoid and minimize human errors.	Not related to Internet of Things And Railways
5	Related to Objectives of the paper.	No proper explanations.

II. LITERATURE SURVEY

Study is being carried out to enhance services & security standards in the Railway Infrastructure. Numerous systems were developed based on various technologies in order to enhance the quality of safety, security and performance.

According toK.Dhiman and Er. R. Ck[1] An improved train ticketing system uses an app, ticket validators, and a central server to streamline passenger experience. Passengers purchase tickets through the app, which generates a QR code for validation. Upon entering the train, passengers scan their QR code at the validator, which verifies the ticket's authenticity with a central server. The system can also include an optional onboard kiosk for ticket purchases without a smartphone and track boarding/disembarkation data (optional) for better train management. This approach improves efficiency, convenience, and security while offering flexibility for passengers with or without smartphones.

According to Sandhya and Sudha[2] The automatic ticket checking system on trains uses biometric recognition to verify passengers' identity. Passengers can use unique identification methods such as Genetic Code(DNA), facial features &infrared thermography, ears, fingerprints,hand, finger shape, iris, typing patterns, palm prints, signature, and voice. The system uses fingerprints for ticket verification, allowing passengers to scan their fingerprints to verify their reservation. The fingerprint data is stored in a database while ticket reservation. The ticket authentication segment includes a finger print sensor, Wi-Fi, LCD, and DC motor. When a passenger places their finger over the sensor, the fingerprint is uploaded and authenticated in the database, confirming the passenger's ticket. If the fingerprint is authenticated, the entrance gate unlocks for access.

According to B. et al. [3]The Smart Passenger Reservation System (SPRS) in India uses the Aadhaar Number (UIDAI) as the primary identification key. The system addresses several problems faced by the current PRS, such as the issue of multiple passengers per ticket, the Reservation Against Cancellation (RAC) passenger, the requirement for senior citizen passengers to request concession fare, and the need for an authorized representative to present the UIDAI of all passengers and their own UID (Aadhaar Card) while traveling. To overcome these issues, the system uses algorithms to verify the primary passenger OTP and allow passengers to reserve tickets for other passengers using their UIDAI numbers. The system also checks the age and sex of the senior citizen and applies the appropriate concession fare. The ticket validation machine checks the Aadhaar card of the senior citizen, and if the card bears the same details, concessions may be applied. An unauthorized representative of the passenger must also present their UID and finger-print, which are recorded in railways database.

The system also requires passengers to carry their Aadhaar cards while traveling. The Smart Passenger Reservation System (SPRS) can overcome several challenges and improve the passenger experience. The ticket generation process involves matching passenger details with the UIDAI data base and railway reservation database. If payment is made, the ticket is validated, and if confirmed, the passenger enters the train. The smart railway reservation database, maintained by two databases, efficiently performs query-service between them. If both databases match, information related to the passenger, such as name, age, sex, and address, is fetched from the UIDAI database to the railways database.

According to Lipare and Bhavathankar [21] Railway accidents can hinder immediate help for passengers and drivers. To improve safety, an emergency detection system is proposed using sensors like crash and fire sensors. This system sends messages, GPS location, SMS, and real-time data to emergency response staff. The system integrates with a firebase database, alerts the onboarded staff to stop trains, alerts police, doctors, and firemen. Passengers can download the application or scan the QR code.

According to Karaduman et al. [20] the study proposes a method for monitoring railway equipment using poles and cameras. Images are captured from diverse angles of the pantograph and locomotive body, sent to a centrally administered system via wireless sensors and processed in MATLAB. The Contrast-limited Adaptive Histogram Equalization approach compensates for natural light changes.

According to Sharma et al. [4] There are certain difficulties in investigation/ examination viz. problems in identification of unknown cases which have mutilated bodies, it is one of the major issue faced by investigating officers/ medico legal experts. Other factors adding up to the cause are Mass Casualties, Deformity of bodies and mutilated parts, Decomposition of bodies, Unavailability of efficient process with police authority to trace the unknown, lack of accurate passenger information.

Here, the mentioned table (Table 3.) is a comprehensive display of all the papers surveyed for literature review. It defines the objectives of the papers including the technologies used according to each scenario.

According to article from Economic Times [8] IoT helps mitigate the prevailing shortcomings of the Railway sector in India. There are several benefits in installing IoT devices on the trains. The devices communicate with the clouds to exchange data from the control centers, provide data regarding track status, presence of obstacles, etc. Indian Railways is progressively testing an IoT based advanced system called “Tri-Netra” – Terrain imaging fordRiversINfra-red, Enhanced,optical & Radar Assisted system to minimize the challenges faced by the drivers during dense fog, heavy rains and in night to detect obstructions on tracks using ultrasonic waves. The system consists of Infrared& Optical Cameras alongwith Radar assisted imaging system.

According to Mondal et al. [22] it propose a fog-enabled system for elephant monitoring. The architecture contains of three layers: smart cameras, actuator lights, and fog nodes. The fog node detects and calculates the elephant's coordinates, while the

top layer is a proxy server and cloud. The fog-based scenario is simulated using iFogSim, and the application model includes motion& elephant detection, elephant tracker, camera control, and light interface modules.

Table 3: Literature Survey Table

References	*Scenario*	*Objective*	*Technology used*
[1]	Train Ticketing & Validation	Ticketing through app and QR code for validation.	Application, Kiosk, QR code validator
[2]	Ticket Verification	Automatic ticket verification using fingerprint.	Finger-print sensor, Microcontroller, Wi-Fi, LCD, Direct Current motors.
[3]	Ticket Reservation	Aadhaar based ticket reservation using fingerprint and OTP.	Finger-print sensor, Java, MySQL, GSM-R, LTE, 5G, IEEE 802.11
[4]	Railway Accident and Forensics	Railway Crime Investigation.	Digital Forensics, Forensics Investigation, Cyber security
[20]	Railway Emergency	Emergency detection and response.	Arduino UNO, Collision Switch Sensor, Bluetooth Module, Flame sensor, Firebase Database.
[21]	Elephant Corridor	To avoid Elephant and Train collision using IoT, Fog, and Cloud.	Cameras, Fog nodes, Cloud Computing, Proxy server, Signal Light, ISP-provided internet connection through a gateway.
[22]	Platform monitoring	Platform monitoring using IoT, Image processing for contactless fault diagnosis.	Cameras, Wireless sensors, Machine Learning Algorithm (Classification Algorithm).

III. CASE SCENERIOS

Four case scenarios has been taken after the literature survey which mainly includes the applications of IoT in Railways about the level crossing, train derailment, train collision and passenger services as shown in Figure 3. The features explaining the case scenarios are being discussed in Table 4, Table 5, Table 6 and Table 7 respectively.

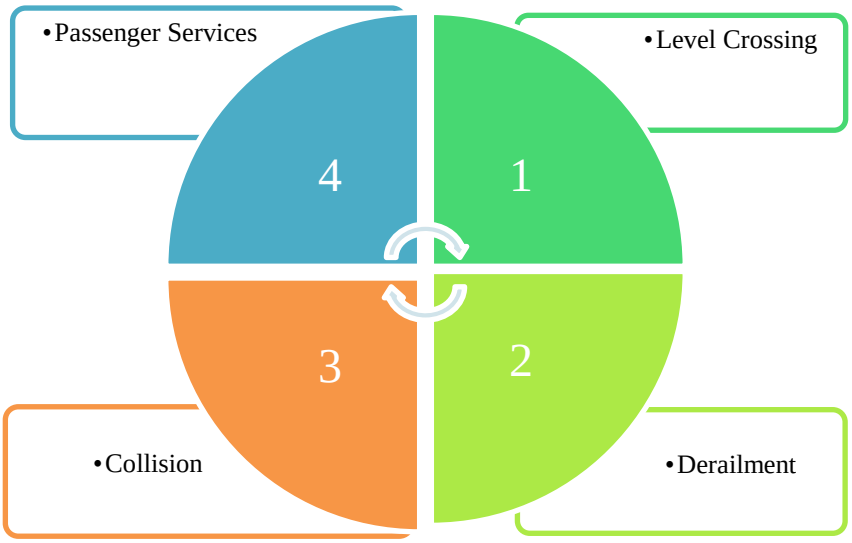


Fig. 3: Case Scenarios of IoT applications in Railways

A. *Level Crossing:*

Table 4: Feature's explaining Level Crossing scenarios

Feature	***System 1 (Infrared Sensors) [9]***	***System 2 (Wemos D1 &ThingSpeak) [10]***	***System 3 (Control Room & Train Tracking) [14]***
Gate Control	IR sensor detection	Train location data (GPS on train).(<=500metres distance)	IR Sensor(3 km distance) and object detection (ultrasonic sensor).
Safety Measures	CCTV Cameras with Microcontroller changing signal green to red..	SMS alerts about train location to drivers (using GSM module)..	Prioritizes safety with object detection (ultrasonic sensor) to prevent gate closure during obstruction. SMS to loco pilot using GSM module.
Train Detection	Infrared sensors (IR1, IR2).	Train location tracer using GPS.	IR Sensor(Arrival and Departure: 3km).

B. Train Derailment:

Table 5: Feature's explaining Train Derailment scenarios

Feature	***IoT-RMS[12]***	***Fishbolt Looseness Detection System[13]***	***IoT-based Track Monitoring System [14]***
Sensors	Accelerometer on axle box.	Electrical Pulse Generator (EPG)	Accelerometer
Data Processing Unit	Cloud-based system (MongoDB)	Embedded system (Arduino Uno)	Raspberry Pi
Alert System	Cloud server	SMS alerts to authorities	Visual and audible alerts for driver, SMS alerts to authorities

C. Train Collision:

Table 6: Feature's explaining Train Collision scenarios

Feature	***TMCS (Train Monitoring and Collision Avoidance System)[14]***	***IoT-CAS (IoT-based Collision Avoidance System)[15]***	***RFID-GSM-RF System[16]***
Train Unit	Microcontroller, RFID reader, GPS receiver, Inertial sensors, GSM module, RF transceiver	Microcontroller, RF receiver	Microcontroller, RFID reader, GSM modem, RF transceiver, LED indicator.
Collision Detection	Monitors train locations and issues commands based on pre-defined rules	Identifies potential collisions based on received codes from trackside sensors.	Monitors train locations based on RFID data, Detects same track occupancy through RF communication.
Collision Avoidance	Automatic braking and stopping commands issued by central control room	Alerts train drivers and flags potential collisions.	Sends alerts via SMS and LED indicator warnings.

D. Passenger Services:

Table 7: Feature's explaining Passenger Service scenarios

Feature	*CARE System (uses LTS - Raspberry Pi Network)[17]*	*Proposed System (uses Raspberry Pi Network)[18]*	*ICN Based Traditional IoT System (Speculative)[19]*
Passenger Requests	Submitted via touchscreen interface in each coach	Submitted via web interface on mobile devices	Fixed user interface deployed in each coach.
Crew Location Tracking	BLE beacons and devices track crew location within the train	Wi-Fi signal strength analysis tracks crew location	Strength of wireless signal close to Raspberry pi.
Crew Notification	Not specified	Message sent to crew mobile device with passenger details (coach number, seat number, service type)	Message sent to nearby mobile device of crew wit details(coach number, berth number and request for service).

IV. PROPOSED SYSTEM

The system being proposed includes an Aadhaar based ticket reservation and verification system, which makes the ticketing system more efficient androbust. Additionally, the proposed system also introduces a biometrics-based casualty or corpse identification system,that can be used to identify passenger in caseof any accident. This proposed system ultimately showcases how application of IoT can transform the Railway system into a Smart one.

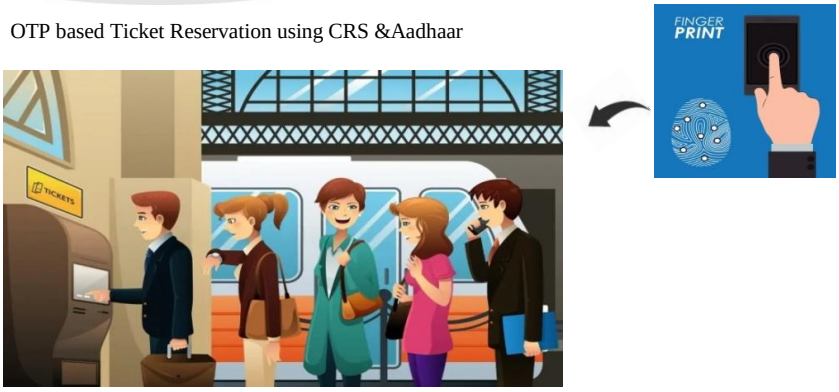
A. Ticket reservation and verification system using Aadhaar and Biometrics:

Enhancing security and streamlining train ticketing are the goals of the Aadhaar-based Railway Reservation and Verification System. For passenger verification, it uses the Aadhaar database, which is a biometric data repository for citizens of India. A Central Reservation System (CRS) that links to Aadhaar and manages bookings is part of the system. To book tickets and verify their identity using a one-time password (OTP) connected to their Aadhaar mobile number, users engage with a mobile app or website. After a successful payment, e-tickets with QR codes are generated, and passenger data is obtained from Aadhaar. Biometric Verification Units (BVU) at stations compares passenger fingerprints to Aadhaar data.When fingerprints match, boarding is authorized; when they don't, an alert for additional checks is triggered. This system promises better data accuracy, faster boarding, increased security, transparency with e-tickets, and user-friendly interfaces. User authentication, reliable communication protocols, and secure data storage are allsecurity-related factors. Before a wider rollout of this system, implementation would probably involve pilot testing on particular routes. The pictorial view is shown on Fig. 4.

B. Identification system for casualty during accident using biometrics:

The fingerprint (biometrics) data already fetched from the UIDAI Database will be stored as an instance for each train journey separately which will be used if any unfortunate mishap occurs during the journey in order to identify casualties if their condition doesn’t allow them to prove their identity. Moreover, in case of dead bodies during mass casualties such as Train Derailment, Train collision, this system can be utilized to identify the corpse if it is unidentifiable by face (if mutilated).The pictorial view is shown on Fig. 4.

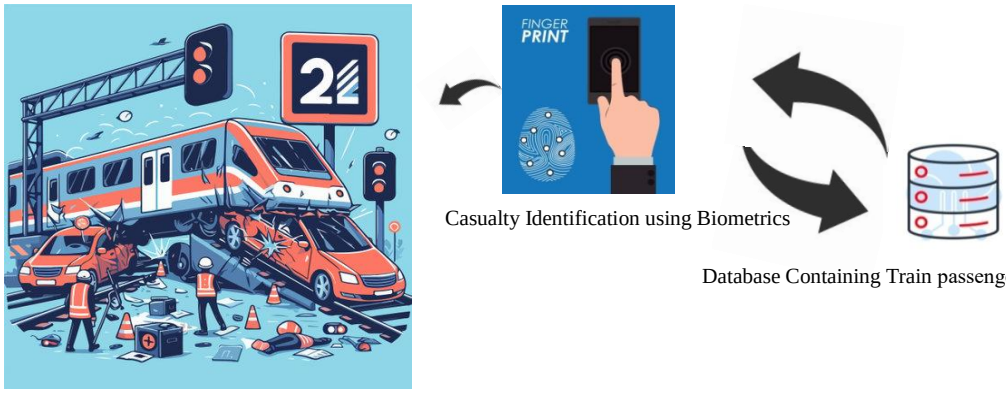
OTP based Ticket Reservation using CRS &Aadhaar



Biometric Verification Unit (BVU)

Alternate / Conventional Verification of ticket if BVU fails

Entry into Railway Platform after Ticket verification



Casualty Identification using Biometrics

Database Containing Train passenger's biometric information

Fig. 4: Proposed System

V. WORKING PROCESS OF PROPOSED SYSTEM

A. Algorithm 1: Ticket Reservation System

Step1: A passenger uses the Railway ticket reservation app/website which is part of the Central Reservation System (CRS) to book tickets for one or multiple passengers by providing Aadhaar as their Proof of Identity.

Step2:After entering all the personal details and Aadhaar number, OTP is sent to the users registered number in order to verify their identity using UIDAI Database.

Step3: Upon completion of verification process, users may proceed to the Payment portal and pay the required amount to book ticket.

Step4: Aadhar based Ticket reservation is completed.

The flowchart view of algorithm is shown on Fig. 5.

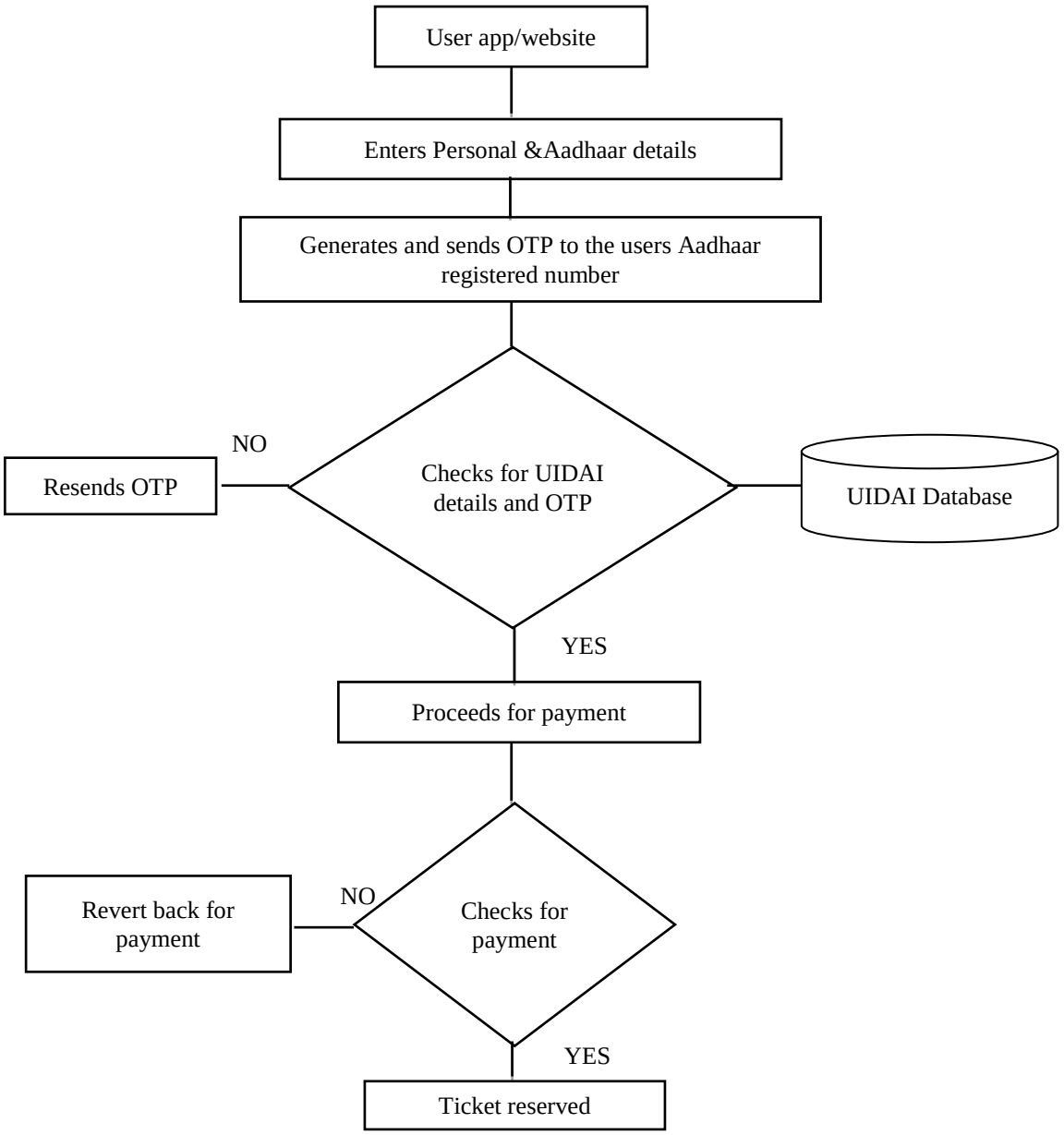


Fig. 5: Central Reservation System in Railways

B. Algorithm 2: Fingerprint based TicketVerification System

Step1: Before entering the Platform, the Biometric Verification Unit (BVU) is used for Fingerprint verification for each passenger.

Step2: The BVU fetches Fingerprint Data from The UIDAI Database in order to match it with the passengers Fingerprint and verify their identity.

Step3: Upon verification of a passenger's identity, they are allowed to board the train. And if not verified an additional identity verification is alerted.

Step4: Biometric (Fingerprint) based Verification of passengers is completed.

The flowchart view of algorithm is shown on Fig. 6.

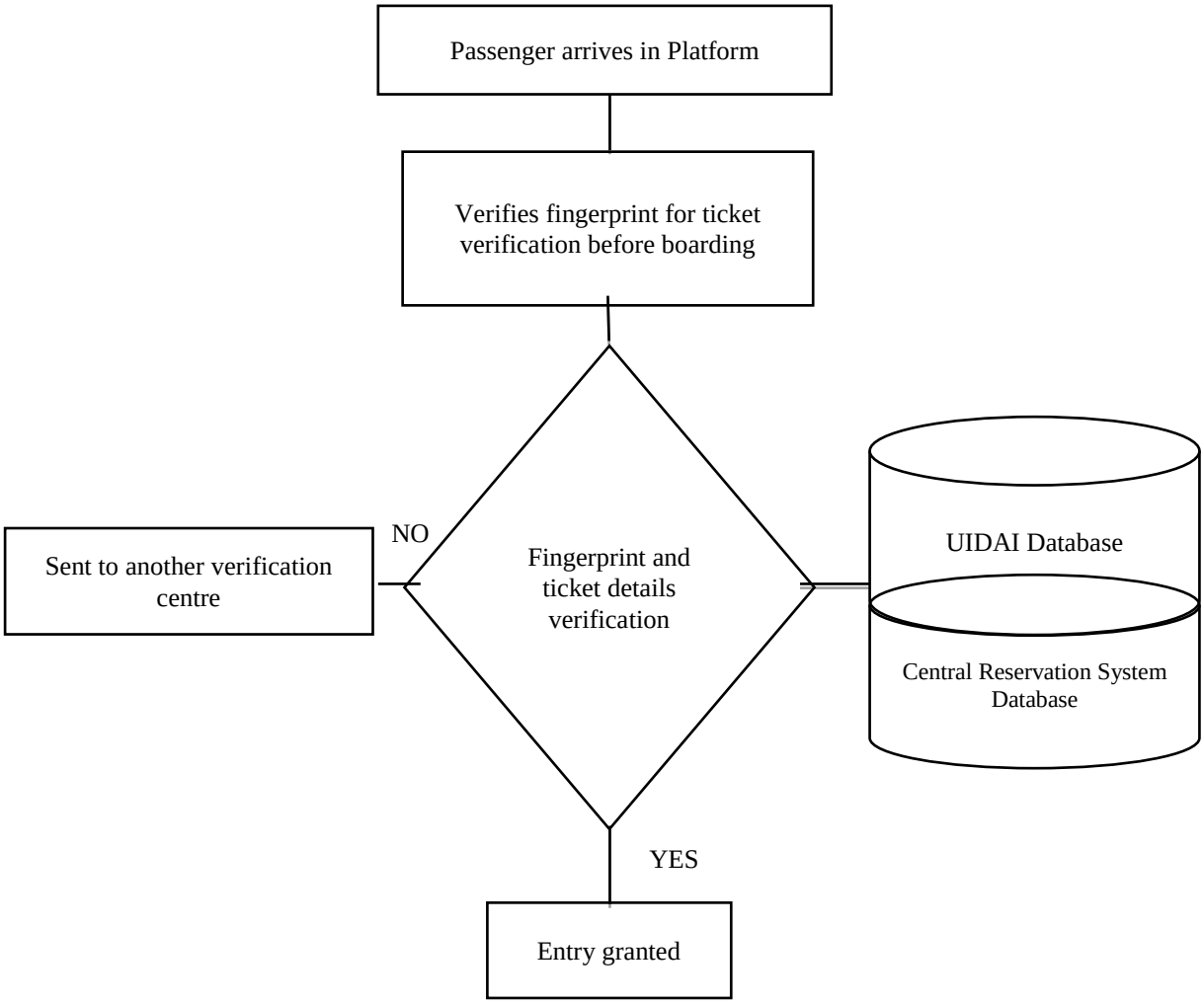


Fig.6: Biometric Verification Unit

C. Algorithm 3: Fingerprint based Casualty identity Verification

Step1: An unconscious casualty or a corpse could be identified using its Fingerprint.
Step2:The Database Instance containing passenger's details and biometric information created for each train journey will be utilized for this purpose.
Step3:This system will thus be beneficial to accelerate the identification process of casualty and corpse after an accident has occurred.
Step4:In case, casualty or corpse not identified Conventional method should be used.
The flowchart view of algorithm is shown on Fig. 7.

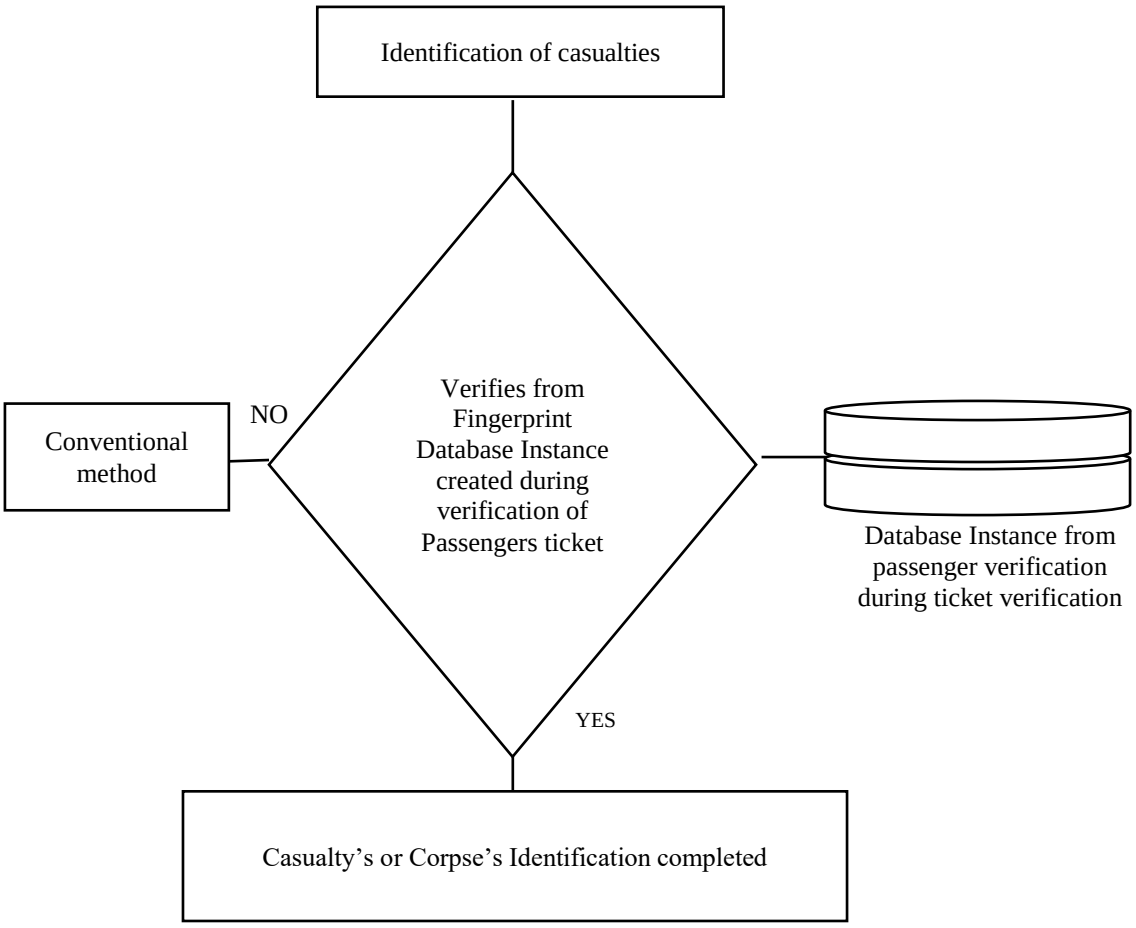


Fig. 7: Identification system for casualty during accident using biometrics

VI. EVALUATION AND DISCUSSION

The adoption of IoT in the railway industry is revolutionizing operations, enhancing efficiency, safety, and passenger experience. IoT enables real-time data collection, which allows for proactive maintenance and reduces accident risks. For instance, sensors can detect and predict rail defects, preventing derailments and collisions.The proposed Aadhaar-based system for ticket reservation and verification shows how IoT can streamline operations and enhance security. By using biometric verification, this system makes boarding quicker and reduces fraud. Despite these benefits, challenges like data security and high implementation costs need addressing. Careful planning and pilot testing are essential to ensure these systems work effectively. As IoT technology advances, with new communication methods like 6G and 7G, the potential for further improvements in railway operations grows. These advancements will make IoT applications faster and more reliable, leading to even safer and more efficient railways.The proposed system also introduces a casualty or corpse identification system using biometrics which will further expedite the identification process in case of any mishap or accident occurring . This is done using the Database instance created during passenger verification process which is done before passenger boarding their train.
Author B.et.al has [4] proposed a SPRS (Smart Passenger Reservation System) in which fingerprint is needed for reservation of ticket which is a time taking process, whereas the proposed system in this paper only will require an OTP which will make the Ticket Reservation process time-efficient. Furthermore, this paper also proposes a Corpse/Casualty Identification system using Biometrics which will be utilized in case of any accident. This showcases how IoT technology could be utilized and beneficial for making the Railways a smarter one.
In summary, IoT is revolutionizing the railway industry, offering numerous benefits and transforming traditional railways into smart, connected systems.

VII. CONCLUSION

In conclusion, the integration of the IoT in the railway industry is a game-changer, transforming traditional railways into intelligent, efficient, and safer systems. By enabling real-time surveillance, predictive maintenance, and enhanced passenger services, IoT addresses long-standing challenges and elevates the overall travel experience. The proposed Aadhaar-based Railway Reservation and Verification System along with Casualty identification system exemplifies how IoT can streamline processes and improve security. While challenges such as data security and investment remain, the potential benefits are immense, paving the way for a future where railways are not just modes of transport, but integral components of smart, connected communities.

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