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Original Article

RFID-Enabled Integrated Digital Infrastructure for Advancing Visibility in Multimodal Goods Transportation

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Abstract: *Goods transportation involves a complex network of multiple modes of transportation, including trucks, trains, and ships. However, the lack of a unified digital platform for tracking and monitoring its movement across these modes often leads to inefficiencies, delays and a lack of transparency in the supply chain. The challenge is to develop a digital platform that provides multi-modal visibility of goods transportation, allowing stakeholders to track the movement of goods from source to destination seamlessly. This platform provides real-time insights into the location, status, and condition of the shipments. The solution will create a scalable and robust system that integrates data from various sources, such as GPS devices, sensors and transportation management systems. The platform should be capable of handling large volumes of data from different modes of transportation and ensure the accuracy and reliability of the integrated information. The platform should identify and track load carrying vehicles, wagons, or ships, and provide accurate information on their location, movement, and capacity utilization. The platform should help the stakeholders to monitor and analyse the goods transportation process effectively. In order to identify that the goods are loaded properly to the respective truck, we are using RFID reader with tag and to detect any accidents with location and also to monitor the package missing or theft during transportation, we are using vibration sensor, Load cell and RFID respectively. To detect the location of the vehicle and to intimate the owner and the supplier we are using GPS and GSM module. This will lead to improved operational efficiency, reduced transportation costs, enhanced transparency, and better decision-making for all parties involved in the goods supply chain.*

Keywords: *Goods Transportation, GSM, GPS, RFID Reader, Vibration Sensor, Theft Detection.*

I. INTRODUCTION

An intelligent transportation system (ITS) is an advanced application which aims to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. Some of these technologies include calling for emergency services when an accident occurs, using cameras to enforce traffic laws or signs that mark speed limit changes depending on conditions. Although ITS may refer to all modes of transport, the directive of the European Union 2010/40/EU, made on July 7, 2010, defined ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport. ITS may be used to improve the efficiency and safety of transport in many situations, i.e. road transport, traffic management, mobility, etc. ITS technology is being adopted across the world to increase the capacity of busy roads, reduce journey times and enable the collection of information on unsuspecting road users.

II. LITERATURE SURVEY

Recent years have witnessed significant strides in leveraging cloud computing for Intelligent Transportation Systems (ITS) and connected vehicles. Peter Arthurs and his team presented a comprehensive taxonomy and survey, delving into the myriad applications of cloud computing in this domain. Their work offers valuable insights into the diverse use cases and potential applications, shedding light on the evolving landscape of ITS and connected vehicle technologies.

Saif Iqlas and his collaborators contributed to the realm of vehicle security with a pioneering vehicle tracking system coupled with theft detection. This innovative system provides real-time updates on vehicle location via SMS through a GSM modem, bolstering security measures with minute-by-minute location updates. The system's ability to thwart potential theft incidents underscores its significance in enhancing vehicle security and safety.

Mehmet Baygin et al. introduced a cutting-edge blockchain-based approach to smart cargo transportation, harnessing UHF RFID tags for automated tracking and traceability of shipments. By leveraging cloud-based storage for IoT data, this solution ensures cost-effectiveness while maintaining robust tracking capabilities, thereby revolutionizing cargo logistics and supply chain management practices.

Çağrı Koç and his collaborators undertook a comprehensive review of vehicle routing with simultaneous pickup and delivery (VRPSPD), offering a holistic analysis encompassing mathematical formulations, algorithmic strategies, case studies, and real-world applications. Their work not only provides a comprehensive overview of existing methodologies but also identifies emerging trends and future research directions, guiding further advancements in the field of vehicle routing optimization.

Vahid Azizi et al. addressed the need for cost-effective and user-friendly vehicle tracking systems by developing a solution that leverages GPS and GSM technology within an IoT framework. Their decision-making model, which considers various factors such as distribution center locations, vehicle routing, and direct shipment, stands out for its ability to enhance operational efficiency and streamline logistical processes.

Nazmul Islam Akanda and his team focused on designing a multi-product pickup and delivery supply chain with location-routing and direct shipment capabilities, emphasizing the importance of low-budget solutions, improved geographic coordinates, and user-friendly access. Their work underscores the significance of practicality and accessibility in modern supply chain management systems, paving the way for more efficient and streamlined logistics operations.

III. PROPOSED WORK

The proposed system aims to address the limitations of existing goods transportation systems by introducing a unified digital platform that enhances efficiency, transparency, and security within the supply chain. By leveraging advanced technologies and integrated data solutions, this system offers a comprehensive solution to streamline the transportation process. At its core, the proposed system integrates data from various sources, including GPS devices, sensors, and transportation management systems, into a centralized platform. This integration provides real-time visibility into the location, status, and condition of shipments across multiple modes of transportation, such as trucks, trains, and ships. Stakeholders can access this information through a user-friendly interface, enabling them to track shipments seamlessly from source to destination. The Block diagram of the idea is shown in Figure 1.

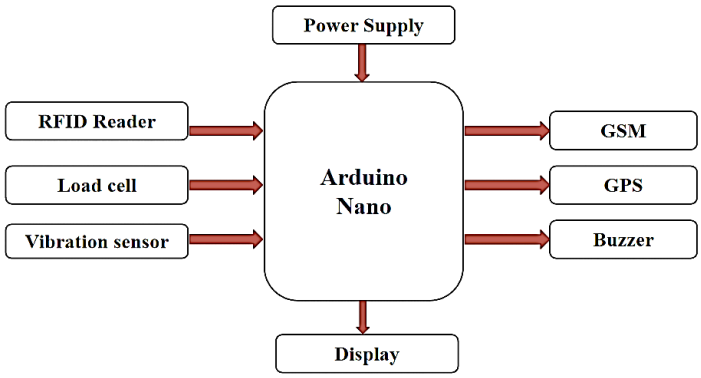

Figure 1: Block Diagram

One of the key advantages of the proposed system is its ability to address security concerns effectively. By incorporating technologies such as Load cell and vibration sensor, the system can detect and respond to potential threats such as theft, tampering, or accidents during transit. Real-time monitoring and proactive alerts enable stakeholders to take immediate action to mitigate risks and ensure the safety and security of goods.

Furthermore, the proposed system streamlines administrative processes by automating tasks such as documentation and paperwork. This reduces the reliance on manual processes, minimizing errors and delays while improving overall efficiency. Additionally, the platform facilitates better resource allocation and route optimization, leading to cost savings and improved operational performance. Overall, the proposed system offers a scalable and robust solution to the challenges faced by existing goods transportation systems. By providing multi-modal visibility, enhancing security measures, and streamlining operations, the system drives value creation and competitiveness in the supply chain ecosystem. With its comprehensive approach to goods transportation management, the proposed system sets a new standard for efficiency, transparency, and security in the industry.

IV. RESULTS AND DISSCUSSIONS

The proposed system for goods transportation addresses the shortcomings of current methods by introducing a unified digital platform designed to optimize efficiency, transparency, and security throughout the supply chain. This innovative solution integrates advanced technologies and data-driven approaches to streamline the transportation process seamlessly. Figure 2 shows the Working model of the idea.

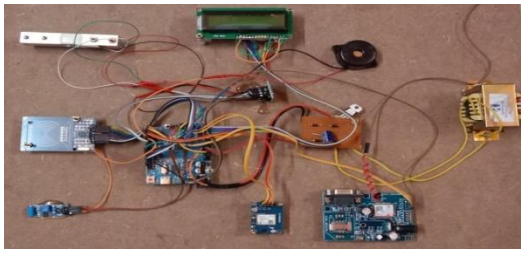

Figure 2: Hardware Setup of the Proposed Work

At its core, the system consolidates data from diverse sources including GPS devices, sensors, and transportation management systems, centralizing information on a single platform. This integration enables real-time tracking of shipments across various transportation modes, offering stakeholders immediate access to critical information such as location, status, and condition of goods. A pivotal feature of the proposed system is its proactive security measures. By incorporating load cell, RFID and vibration sensor, the platform detects anomalies like theft, tampering, or accidents, triggering immediate alerts for prompt intervention. This real-time monitoring ensures the integrity and safety of goods throughout their journey, instilling confidence among stakeholders.

Moreover, the system automates administrative tasks, reducing reliance on manual processes and paperwork. This automation not only minimizes errors and delays but also enhances operational efficiency. Additionally, by facilitating optimized resource allocation and route planning, the platform contributes to cost savings and improved overall performance. In essence, the proposed system offers a scalable and robust solution to the challenges facing current goods transportation systems. With its comprehensive approach to data integration, security, and process optimization, the platform sets a new standard for efficiency and transparency in the industry, ultimately driving value creation and competitiveness in the global supply chain. Figure 3 shows the message to scan the RFID Tag. The number of loads, its count and its box number are shown in Figure 4, Figure 5, Figure 6 respectively. The Alert message during abnormal vibrations or changes in load is shown in Figure 7.

Figure 3: Scanning RFID Reader

Figure 4: Load Count 1

Figure 5: Load Count 2

Figure 6: Counting Load in Container A

Figure 7: SMS to Mobile Phone

V. CONCLUSION

In conclusion, the proposed unified digital platform for goods transportation presents a transformative solution to the inefficiencies and challenges prevalent in current supply chain operations. By integrating advanced technologies and data-driven strategies, this system offers a holistic approach to optimizing efficiency, transparency, and security throughout the transportation process. Centralizing data from multiple sources enables real-time tracking and monitoring of shipments across diverse transportation modes, providing stakeholders with immediate insights into their goods' location, status, and condition. This enhanced visibility not only improves decision-making but also fosters trust and collaboration among supply chain partners. Furthermore, the proactive security measures embedded within the platform, such as RFID readers, Load cell and Vibration sensor, ensure the safety and integrity of goods during transit. By detecting and addressing potential threats in real-time, the system mitigates risks and safeguards valuable assets. The automation of administrative tasks streamlines operations, reducing errors, delays, and costs associated with manual processes. Additionally, optimized resource allocation and route planning contribute to overall efficiency and cost savings within the supply chain. In essence, the proposed digital platform revolutionizes goods transportation management, setting a new standard for excellence in the industry. With its comprehensive features and benefits, the system not only addresses current challenges but also paves the way for future innovation and success in the dynamic global marketplace.

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