Journal of Telecommunication, Electronic and Computer Engineering
ISSN: 2180 – 1843 e-ISSN: 2289-8131 Vol. 16 No. 4 (2024) 17 – 22
jtec.utem.edu.my
DOI: https://doi.org/10.54554/jtec.2024.16.04.003

Utilizing GPS Data Tracking Design for Stopped Truck Analysis in an Industrial Loading Process

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Article Info

Article history:
Received Oct 16th, 2024
Revised Nov 14th, 2024
Accepted Dec 12th, 2024
Published Dec 20th, 2024

Index Terms:
Transportation
Blynk Application
GPS
RFID Technology

Abstract

Economic growth has become essential for improving people's livelihoods, particularly as more enterprises are established. This expansion has increased the demand for transportation, where timely delivery of goods is crucial for the success of growing businesses. Consequently, vehicles have become a vital component of the logistics chain, transporting items from one location to another. However, traffic delays often hinder timely deliveries, and administrators struggle to locate trucks during unexpected stops. Additionally, some truck drivers waste time, causing unnecessary delivery delays and increasing operating costs. This study proposes a solution that integrates an RFID sensor module to address traffic congestion issues at loading bays and a GPS module with TTGO TCALL ESP 32 to track the whereabouts of trucks. This approach aims to improve operational efficiency, reduce costs and streamline the logistics process.

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I. INTRODUCTION

A truck, also known as a lorry in some regions, is a vehicle used to transport cargo. In the corporate world, road freight transportation has become the mainstay of trade and commerce. Trucks form part of a larger logistic network that includes aircraft, rail, marine, and inland waterways. Each mode has unique advantages, and together, they form an integrated system. A key component of supply chain management is the coordination and integration of activities among supply chain participants, including suppliers, manufacturers, distributors, intermediaries, third-party service providers, and customers [1].

Most daily necessities, such as fresh food, newspapers, magazines, and clothing, rely on trucks for a part of their distribution. Many critical public services, such as garbage collection, firefighting, and construction, are delivered by trucks. With advancements in truck transportation, the number of trucks on roads and their share of motorway traffic have increased significantly worldwide. In China, trucks account for an average of 25% of vehicles in most motorways, with some roads seeing percentages as high as 60%. In the United States, the number of trucks has increased by 75%, and this trend is expected to continue over the next decade [2]. Similarly, in Hungary, an EU member state with a surface area of 93,030 km^2 and a population of 9.8 million people, road transport is the dominant mode of freight transportation. In 2020, 3.7 times more cargo was transported by road than by rail. As of 2020, the country had 1,738 km of highways (including expressways) and 7,017 km of main roads serving road traffic, with a distance-based electronic toll system for heavy vehicles in place across approximately 6,500 km of this network [3].

The increase in trucks on roads presents various challenges to companies, one of which is time management [4]. Time management is critical for timely delivery of goods to avoid delay and time wastage, which translates to financial losses in the business world. The growing number of trucks increases travel times and extends waiting times at loading bays. The integration of RFID (Radio Frequency Identification) and GPS (Global Positioning System) technologies provides a comprehensive and effective solution to the operational challenges faced by logistics companies [5]. These technologies enhance visibility, improve security, and streamline tracking and monitoring processes, helping reduce unnecessary costs associated with driver behavior, truck maintenance, and idle time. RFID provides a reliable means of managing inventory and ensuring accurate cargo tracking, while GPS enables real-time location monitoring, optimizing routes and reducing risks such as theft or damage. Together, these technologies not only enhance operational efficiency but also ensure the security of both goods and assets, making them indispensable tools for modern logistics operations. Therefore, adopting RFID and GPS solutions is essential for companies seeking to improve cost-effectiveness, operational productivity, and the overall security of their supply chains [1], [6].

RFID is commonly used in warehouses for inventory management and material handling. However, once RFID-tagged goods leave the warehouse, they are frequently untraceable until the next loading bay [7]. Freight carriers frequently use GPS transponders to track the current location of truck fleets, addressing this gap [8]. Although GPS is widely used for vehicles tracking, it only provides the physical location and does not link to business process data.

This project enables company administrators to track and monitor truck movements throughout their journey. It also helps identify or notify when a truck stops during the journey to avoid delays and prevent cargo theft via the Blynk Application. Apart from the tracking monitoring system, this project facilitates the updating of output data collected at f the loading bay using RFID. The system updates driver details, mobile numbers, truck numbers, and records the time and count of trucks entering and exiting the loading bay, thereby minimizing queuing time.

II. RELATED WORKS

The current version uses embedded software to continuously monitor a moving vehicle and report on the status of the requested vehicle. A GPS receiver and GSM modem are serially interfaced with a microcontroller to achieve this functionality. The car's latitude and longitude are sent from a remote location using a GSM modem, which continuously provides information, such as the car's position in terms of latitude and longitude [9].

The creation and implementation of a system to track an entire logistical chain include temperature and humidity readings, alerts for potential threats, and real-time truck position information. An Internet of Things (IoT)-based monitoring system operates in real time. The system is divided into three parts: the measurement system, the tracking system, and the visualization system. Using a Wi-Fi network, the sensor system tracks the truck's location with GPS, ultrasonic sensors, and temperature and humidity sensors. Data from the sensor database is extracted by the monitoring system, converted into a more contextually relevant format, and displayed on the admin and tracker dashboards. The display system shows real-time data within the truck to ensure all sensors are functioning correctly. If the rear truck door opens, notification alerts are sent to the dashboard and to the truck driver with a security alert. The findings of the proposed study were compared to the standard approach using t-tests and variance analysis, showing no significant differences [10].

Users can book a truck online via an app or a website. The increasing number of vehicles, such as vans and trucks, traveling long distances with empty space has led to inefficiencies. By combining people and their luggage who are traveling to the same destination in a single vehicle, the number of vehicles on the road can be significantly reduced, lowering pollution levels. Service providers can also reduce transportation costs using the innovative BIDING concept. SP has integrated location tracking as a security feature using Google Map. To properly monitor luggage and its entire journey details, the system provide users with a tracking ID [11] [12].

The importance of road transport in in freight transportation in Europe means that circumstances that may obstruct smooth operations in this sector must be carefully considered to enable evidence-based actions. Among these critical conditions are when, where and how truck drivers stop, as driving times and rest intervals are rigorously regulated, often causing supply chain delays. However, researchers face challenges in obtaining reliable estimates of freight traffic flows and road infrastructure utilization. This study presents a robust data processing approach to identify rest area pauses and calculate driving and rest hours. A comprehensive spatial-temporal truck stop database for along Hungary's toll road network has been developed using navigation information provided by private fleet toll registration services. Driving and parking times were evaluated, including micro-scale analysis of specific rest locations, providing insights into truck driving patterns and cost-effective ways to streamline freight transport operations in other situations [3] [13].

Standard GPS data alone does not provide precise activity information for specific stops or vehicle movements. Researcher divide stops events into two categories: primary stops, where items are transferred, and secondary stops, such as rest stops, where vehicle and driver needs are addressed. The proposed entropy technique assesses the diversity of truck carriers stopping at a specific site for 15 minutes or more. Higher entropy is observed at location sued for secondary purposes, such as fuel refills and rest breaks, reflecting the broader diversity of trucks and carriers that use these facilities. Conversely, primary shipping depots and locations where commodities are transferred show lower entropy due to fewer carriers using these facilities [14].

The digital component of the system reduces errors when converting paper-based logs to digital form for analysis. A method for collecting static and dynamic data related to freight vehicle operations supplements vehicle tracking data with daily driver activity surveys. These surveys enable creative data analysis and modeling. Demonstrations in Singapore provided data-driven insights in urban freight operations, including freight vehicle overnight parking patterns, tour patterns and associated vehicle usage characteristics, as well as commodity flow patterns. The analyses confirm the potential of this data collection method for enhancing the understanding of freight vehicle operations [15].

III. METHODOLOGY

The block diagram of the GPS truck tracker is shown in Figure 1, where the TTGO TCALL ESP 32 SIM800L GPRS Module was connected to the power source. When power was applied, the GPS NEO 6M Module searched for satellites while the TTGO TCALL ESP 32 board sought a network connection. Once the TTGO TCALL ESP 32 and GPS NEO 6M Module establish connections, the Blynk application displayed the truck's longitude, latitude, speed, and timer data.

The Figure 2 shows the Block Diagram of RFID system where the RFID module was connected to the Arduino NANO pins. The hardware was then connected to the laptop using the cable from Arduino NANO. When a RFID tag card was scanned at the hardware module, the data output was sent to the Microsoft Excel.

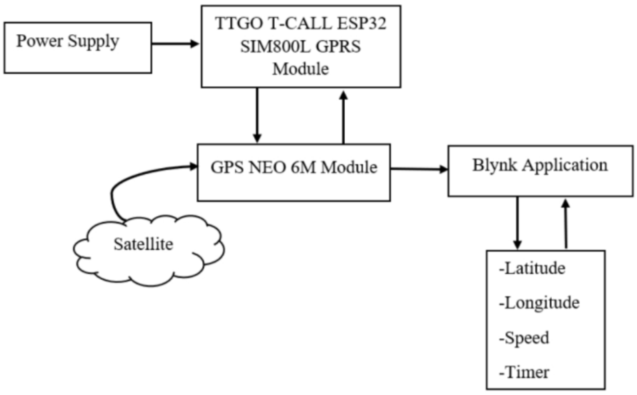

Figure 1. Block Diagram of GPS Truck Tracker

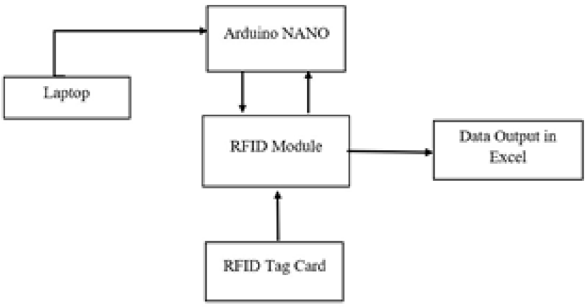

Figure 2. Block Diagram of RFID System

A general overview of the project system was determined based on the investigations, and the GPS truck tracking and RFID system were designed. Following the completion of the system design, the project was implemented utilizing an Arduino NANO and a TTGO T-Call ESP-32 with SIM800L GPRS Module as a microcontroller. During this phase, the system's algorithm was developed, which included programming the GPS Module and RFID sensor to control the system with the TTGO T-Call ESP32 with SIM800L GPRS Module board and the Arduino NANO, respectively. The system was then tested to ensure proper functionality. If issues arose during testing, the problem was solved, and the system was modified to improve its performance.

Figure 3 shows the program code flowchart of GPS truck tracker. The system started when the TTGO T-Call ESP SIM800L GPRS Module was powered on. It searched for a mobile network while the GPS Module simultaneously searched for satellites, powered by a rechargeable battery. Once the TTGO T-Call Module connected to the mobile network and the GPS Module established satellite communication, the Blynk Application went online. The system then sent latitude, longitude, speed and timer data to the Blynk Application. The timer functioned when the truck was stopped for 20 minutes, detected based on the speed data sent from the GPS to the Blynk Application. The timer began counting when the speed of the truck dropped below 3km/h, and if the timer reached 1200, a notification was sent to the Blynk Application.

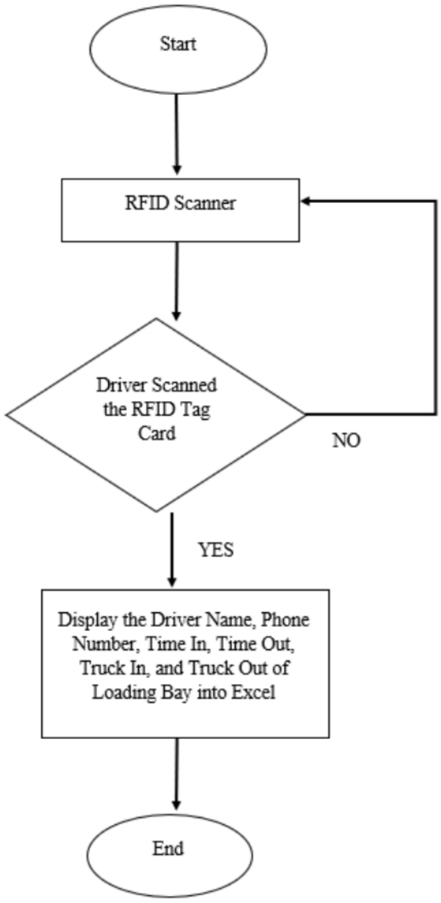

Figure 4. Program Code Flowchart of RFID System.

Figure 4 shows the program code flowchart of the RFID system at the loading bay. This system utilized a Radio Frequency Identification (RFID) sensor to detect truck entry and exit counts at the loading bay. Data was collected when drivers tapped an RFID tag card at the module upon entering and exiting the loading bay. The system transferred the collected data into Microsoft Excel via PLX- DAQ.

IV. RESULTS AND DISCUSSION

Figure 5 shows the Prototype of GPS Truck Tracker. When the Truck Tracker was in the “ON” mode, the red lights indicated that the TTGO TCALL ESP 32 board and the GPS NEO 6M Module were powered on and actively searching for a mobile network and satellite connections, respectively.

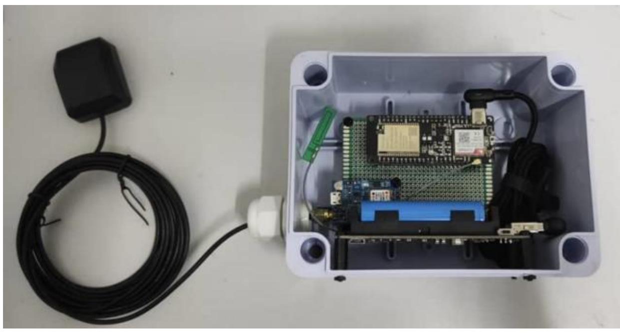

Figure 5. Prototype of GPS Truck Tracker

The data output was achieved from the RFID tag scanner for two drivers. The tag was scanned when the truck entered the loading bay, and the output updated the “Time In” and “Lorry In” fields, along with particulars such as the driver’s name, mobile number, truck license plate number and ID card number in the Microsoft Excel via PLX DAQ. The RFID tag was scanned again when the driver exited the loading bay, updating the "Lorry Out" and "Time Out".

Table 1 shows the total number of truck entries over five days. Figure 6 illustrates the peak entry dates based on this data. For the five-day period, the trucks BFY 9501 and PBW 2608 recorded the highest entries, with a total of 10 each. Conversely, truck PMG 2012 entered the loading bay for only two days, with the lowest total of five entries. Meanwhile, the trucks PHL 2787, WRR 0145, and WRR 4145 entered the bay for four days, each recording nine entries, as shown in Figure 6.

Table 1
Data Collected for Sum of Truck In

Sum of TRUCK IN	BFY 9501	PBW 2608	PHL 2787	PMG 2120	WWR 0145	WWR 4154
18-May	2	3	3	-	3	2
19-May	3	3	2	-	3	1
25-May	3	2	2	3	-	2
30-May	1	1	2	2	2	-
31-May	1	1	-	-	1	2
Grand Total	**10**	**10**	**9**	**5**	**9**	**7**

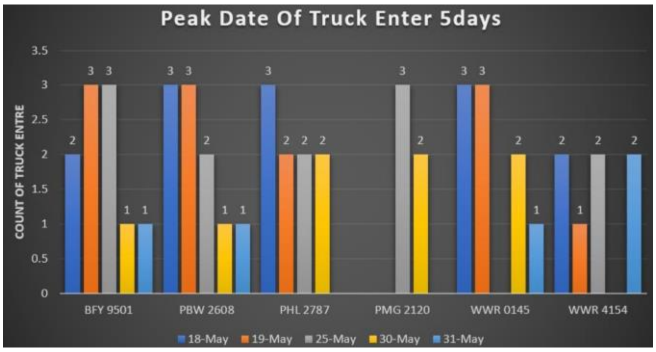

Figure 6. Peak Date of Truck Enter for 5 Days

Table 2 presents the data collected on "Person Entries" over the same five-day period. Based on this data, an analysis was performed to determine the average number of people entering the loading bay each, as illustrated in Figure 7. Lee Kheong recorded the lowest average number of entries, while Mohammed Ali had the highest average. Both Ahmad Hazman and Velloo shared an average of 10 entries each.

Table 2
Data Collected for "Person Entries"

Drivers	Count of Person Enter
Ahmad Hamzan	10
Chong	9
Lee Kheong	5
Mohamad Ali	12
Ramanadass	7
Velloo	9
Grand Total	**53**

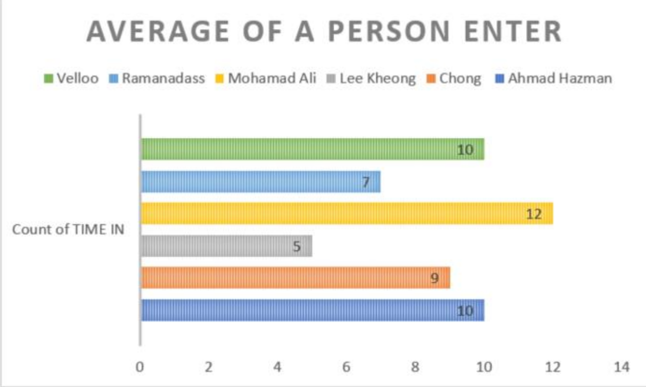

Figure 7. Average of Entries per Person at the Loading Bay

The data obtained for "Time In" at different hours and the corresponding number of truck entries is displayed in Table 3, allowing for an investigation of the peak entry time. Figure 8 illustrates that the peak hour occurred around 5:00 a.m., when the highest number of trucks typically arrived at the loading bay. The least busy hours were at 11:00 a.m., 12:00 p.m., and 11:00 p.m. This analysis allows administrators to predict truck arrivals and take proactive measures to mitigate or prevent congestion during peak hours.

Table 3
Data Collected for "Time In" and Truck Entries

Time In	Sum of Truck In
12 AM	6
1 AM	4
2 AM	3
3 AM	2
4 AM	2
5 AM	7
8 AM	3
10 AM	2
11 AM	1
12 PM	1
3 PM	2
7 PM	2
8 PM	5
9 PM	4
10 PM	5
11 PM	1
Grand Total	**53**

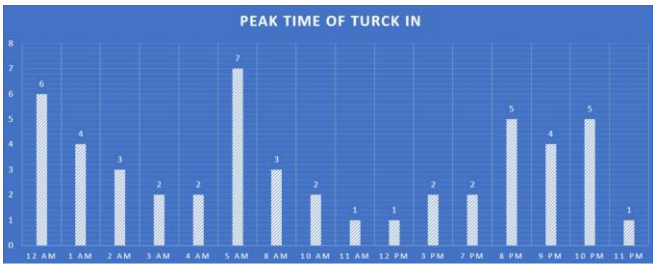

Figure 8. Peak Time of Truck In

The Stopped Truck Analysis in a Loading Process Using GPS Data Tracking was successfully designed and operated effectively, utilizing minimal-cost components and hardware systems. The test results and responses from the experiments conducted demonstrate the performance of the GPS truck tracking system with the Blynk Application interface and the RFID sensor system at the loading bay.

The objectives of this study have been successfully achieved. The GPS truck tracking system effectively monitored truck movements in real time, while the RFID system provided detailed data outputs to support operational decisions. This system allowed administrators to act effectively based on the information collected.

The GPS Truck Tracker prototype was successfully developed and tested to monitor truck movements and notify administrators when a truck stopped. The test results were monitored through the Blynk Application and the laptop's serial monitor. Both systems accurately updated data for latitude, longitude, speed, and timer, with the speed and timer functions successfully detecting when a truck stopped. However, the GPS Truck Tracker experienced signal loss in enclosed areas when it cannot connect to a satellite. This issue could be mitigated using an external antenna.

Additionally,, the RFID system prototype was successfully designed and implemented to track truck entries and exits at the loading bay. Data collected for five days from six individuals enabled detailed analysis. The peak dates and times for truck entries were identified, allowing administrators to take necessary actions to avoid congestion during loading and unloading processes.

V. CONCLUSION

This project successfully integrated environmental protection with sustainable development. By enabling the tracking and monitoring of trucks without interfering with their progress, this eco-friendly solution contributed to reduced fuel consumption and lower air pollution levels. Additionally, it effectively minimized waiting times and operational inefficiencies at loading bays, offering substantial cost savings. Reducing time wastage indirectly addressed increasing workload demands, which might otherwise necessitate additional workers, drivers, or personnel. Moreover, it helped to curb rising vehicle maintenance costs, reinforcing the project's operational and economic benefits.

Although both the GPS Truck Tracker and RFID systems were completed and met the objective requirements, these systems are still not ready for deployment to the market or used by society. Further performance testing under different conditions is required to optimize their functionality. Beyond performance improvements, several new features and upgrades can be explored to enhance the systems. Firstly, incorporating Geo Fencing technology into the GPS Truck Tracker would significantly enhance functionality. Geo Fencing is a software feature that uses GPS or RFID to establish geographical boundaries. These boundaries can dynamically set as a radius around a specific location or configured to match defined areas such as school zones or company premises. Geo Fencing allows administrators to set up triggers or notification that send alerts when a truck enters or exits a predetermined boundary, improving oversight and operational control. Next, upgrade more data information for both GPS and RFID systems. Expanding the data collected for the RFID system could include customer demands, product priorities, expiration dates, and other critical information. This enhancement would enable administrators to prioritize tasks, better manage time, and improve business profitability. For the GPS system, additional data such as the purpose of truck stops and the frequency of stops during a journey could provide deeper insights into operational efficiency and support further optimizations. Finally, further research and analysis are recommended to refine the accuracy and precision of the data analytics produced by both the GPS and RFID systems. These investigations would enhance the reliability and robustness of the systems, ensuring their effectiveness in diverse real-word scenarios.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Universiti Teknikal Malaysia Melaka (UTeM) and the Faculty of Electronic & Computer Technology and Engineering, UTeM for the unwavering support throughout this project.

CONFLICT OF INTEREST

We confirm that this paper is original and has not been published or does not have similarity with other papers. In the case of prior submission, the authors affirm their obligation to disclose this information.

AUTHOR CONTRIBUTION

Khairuddin Osman, Takefumi Kanda (Conceptualization; Formal analysis; Visualisation; Supervision)

Norzahirah Zainuddin, Vishanthini Thangavelloo (Methodology; Data curation; Writing - original draft; Resources).

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