Smart Asset Tracking and Monitoring: A Practical Approach for Resource Optimization

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ABSTRACT

Asset management has significantly evolved with the integration of modern communication technologies and the Internet of Things (IoT). This project aims to enhance asset management by implementing real-time monitoring for predictive maintenance and data-driven decision-making. Through IoT technology, sensors and modules are embedded in physical assets to collect data on their condition, performance, and environment. This data is transmitted via wireless networks to IoT platforms, where it is analysed using cloud-based algorithms and monitoring systems. The insights gained enable organisations to predict failures, optimise resource usage, and reduce downtime and operational costs. The proposed system incorporates cost-effective hardware, including Arduino-based microcontrollers, LoRa transmitters and receivers, and secure data communication protocols. Data analytics tools, using Microsoft Excel, were used to evaluate asset performance and identify trends. The findings demonstrate that integrating IoT with asset management significantly improves operational efficiency, facilitates early fault detection, extends asset lifespan, and enhances overall productivity. In conclusion, this approach offers a comprehensive and scalable solution for managing complex systems, marking a substantial advancement in engineering asset management.

Keywords: IoT; asset management; logistics monitoring; wireless monitoring; maintenance

INTRODUCTION

Asset management is the process of monitoring and optimising resources such as inventory, machinery, and component stocks. In logistics operations, effective asset tracking plays a crucial role in ensuring the timely movement of goods, minimising losses, and maintaining operational efficiency. However, traditional asset management methods often rely on manual processes, including spreadsheets, paper records, or basic digital systems, which are prone to human error and inefficiency.

Such limitations can result in shortages, delivery delays, and inaccurate inventory tracking, all of which negatively affect overall performance in logistics environments. These issues highlight the need for modern, automated solutions that can enhance tracking accuracy, provide real-time visibility, and support data-driven decision-making. The integration of Internet of Things (IoT) technology has emerged as a viable approach to address these challenges. By embedding sensors, GPS modules, and wireless communication systems into physical assets, IoT enables continuous monitoring of asset location, condition, and usage. Real-time data can be transmitted to centralised databases or cloud platforms, allowing for more informed planning, predictive maintenance, and improved resource utilisation. Research has shown that low-cost hardware components such as Arduino microcontrollers, NodeMCU ESP8266 boards, and LoRa-based transceivers can be effectively combined with cloud-based platforms and databases to create scalable and reliable asset tracking systems. These systems offer significant improvements over manual tracking by supporting real-time updates and remote monitoring capabilities.

The goal of implementing an IoT-enabled asset tracking and management system is to improve operational efficiency, optimise resource utilisation, and reduce losses across the logistics supply chain. By integrating real-time monitoring technologies and wireless data transmission, such systems provide a practical and cost-effective solution for enhancing logistics performance and ensuring accurate asset management. Several studies have explored the development and improvement of asset tracking systems in logistics and industrial applications. These works investigate various aspects such as hardware integration, communication protocols, real-time monitoring, and system reliability.

Gurulakshmi et al. (2023) designed a cost-effective tracking device for logistics, highlighting the use of GPS and GSM technology for real-time vehicle tracking. Their system, based on the ESP32 microcontroller and developed using the Arduino IDE, supported both active and passive tracking modes. Active tracking allowed continuous location updates, which is suitable for time-sensitive shipments, while passive tracking reduced energy consumption by updating location data periodically.

Laxmi & Mishra (2018) proposed an IoT-based logistics management system using RFID. Unlike GPS-based tracking, their system utilised Raspberry Pi and RFID modules, with the MQTT protocol for transmitting data. This setup enabled automatic object identification and real-time monitoring through a CloudMQTT broker. Their approach was more suitable for indoor or warehouse settings due to its reliance on short-range RFID technology.

Khalid & Ejaz (2022) introduced a rental asset monitoring system that utilised LoRa and LoRaWAN communication technologies. These low-power, long-range protocols provided efficient tracking over wide areas. Their study also included the use of motion sensors to reduce energy consumption and proposed a wireless power transfer (WPT) solution to eliminate the need for batteries, which is beneficial for remote environments where battery replacement is impractical.

Selvakumar et al. (2023) developed a smart asset management system using multiple IoT sensors such as GPS, temperature, and proximity sensors. The system was tested in a manufacturing setting to monitor both equipment and perishable items. Their approach supported predictive maintenance, just-in-time inventory management, and production planning based on real-time data analysis.

Frankó et al. (2020) investigated asset tracking technologies for Industry 4.0 applications. Their work explored various indoor localisation methods, including ultra-wideband (UWB), RFID, and Bluetooth. They introduced a hybrid positioning system that combined UWB with inertial measurement units (IMU) to improve tracking accuracy. Furthermore, they proposed the use of a permissioned blockchain system called Manu Chain to secure and verify tracking data across different stakeholders in the supply chain.

Comparative analysis of these studies shows a variety of approaches depending on application needs. For instance, GPS and LoRa-based systems used by Gurulakshmi et al. (2023) and Khalid & Ejaz (2022) are suitable for outdoor and long-distance tracking, while RFID-based systems used by Laxmi & Mishra (2018) and Frankó et al. (2020) offer cost-effective solutions for indoor environments. Energy management remains a common concern. While motion-triggered tracking and RF wireless power transfer were proposed inKhalid & Ejaz (2022), smart sensor scheduling was adopted in Selvakumar et al. (2023) to reduce power usage.

The choice of communication protocol also varies. MQTT was used by Laxmi & Mishra (2018) for cloud-based communication, GSM by Gurulakshmi et al. (2023) for real-time tracking, and LoRaWAN by Khalid & Ejaz (2022) for long-range data transmission. Each protocol has trade-offs in terms of power consumption, range, and cost. These previous works provide a strong foundation for the design of asset tracking systems that are tailored to specific operational requirements, whether in logistics, warehousing, or industrial automation.

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METHODOLOGY

The IoT-enabled asset tracking and management system was developed using a combination of low-cost hardware components and open-source software platforms. The overall methodology involved system design, hardware integration, software development, and implementation of data communication between indoor and outdoor tracking modules.

System Overview

The system architecture consists of two main components: an outdoor tracking device and an indoor monitoring and sorting system. Both units communicate with a central monitoring platform through wireless technologies. Real-time data from various sensors are collected and transmitted to a database, where the information is processed and displayed via a web-based interface. Figure 1 presents the overall block diagram of the system, which includes GPS tracking, QR code scanning, data logging, and asset status visualisation.

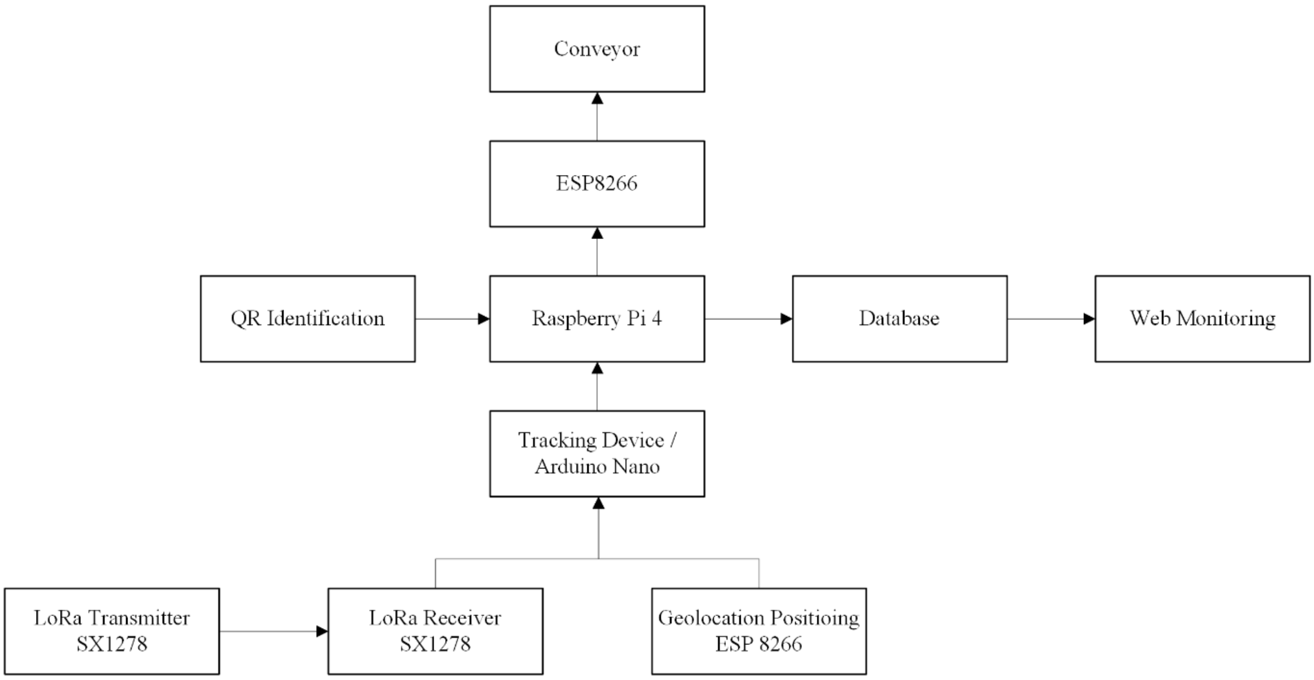


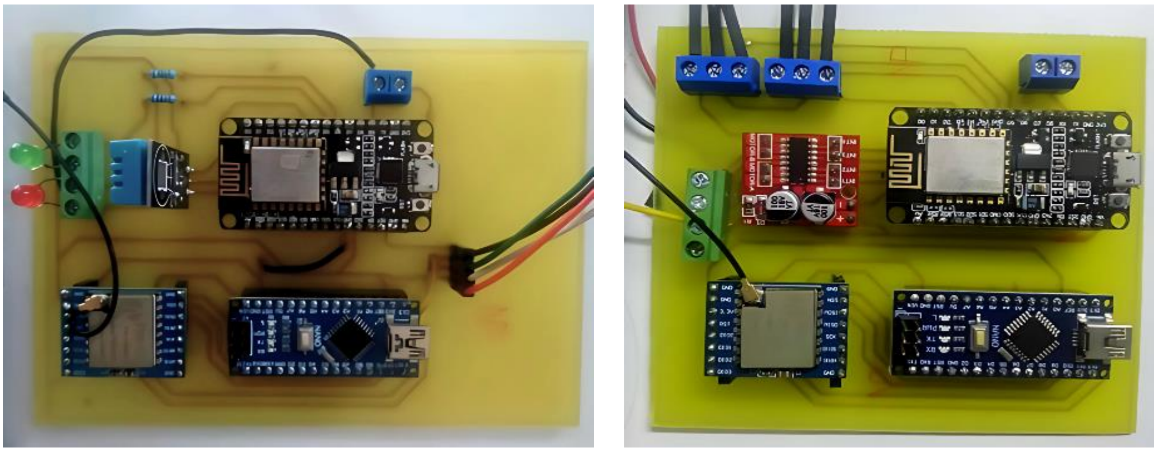
Figure 1 Block Diagram of the System

Hardware Design

The outdoor tracking unit is built using the Arduino Nano microcontroller, integrated with a NEO-6M GPS module and the SX1278 LoRa transceiver. The GPS module continuously captures location data, which is transmitted via LoRa to a receiver node connected to the indoor unit. LoRa was selected due to its long-range communication capability and low power consumption.

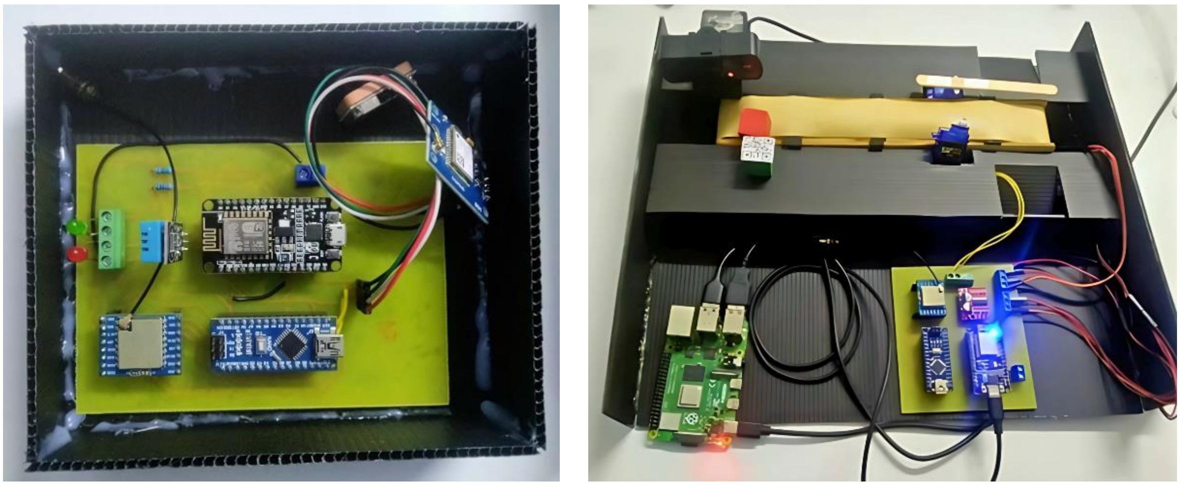
The indoor unit uses a Raspberry Pi 4 Model B as the central controller. It is connected to a camera module for QR code scanning and sorting. The QR codes are printed and attached to assets for identification. The Raspberry Pi processes the captured images using OpenCV and Pyzbar libraries and controls sorting mechanisms based on the decoded asset information. An additional NodeMCU ESP8266 module is used for location tracking via Wi-Fi-based geolocation and for transmitting data to a MySQL database hosted on XAMPP. The system also includes temperature and humidity sensors to monitor environmental conditions.

Printed circuit boards (PCBs) were designed for the microcontroller circuits to ensure compact integration of components as shown in Figure 2. The final prototype as shown in Figure 3 and includes a conveyor belt system for automated sorting and physical demonstration of asset handling.



(a) (b)

Figure 2 PCB Fabrication for (a) outdoor and (b) indoor devices



(a) (b)

Figure 3 Prototype for (a) outdoor and (b) indoor devices

Software Development

The software implementation consists of embedded programming and web development. The Arduino IDE was used to program the microcontrollers. GPS coordinates and asset data are collected and sent over LoRa to the receiver, which forwards the data to the database. Python was used for programming the Raspberry Pi. The software controls the camera module, handles image processing, and integrates with the web interface. Libraries such as OpenCV, Pyzbar, and Picamera were utilised to enable QR code scanning and decoding. For monitoring and data visualisation, a web-based interface was developed using PHP and HTML, connected to a MySQL database. The interface allows users to view asset status, track location data, and monitor inventory in real time via a local IP network.

Data Communication and Monitoring

Data from both indoor and outdoor units are transmitted wirelessly and stored in the database. The ESP8266 module handles the Wi-Fi communication, while LoRa modules manage long-range data transfer. The system supports both GPS-based and Wi-Fi-based geolocation, depending on signal availability and environment. A local monitoring system was implemented by hosting a server using XAMPP, as shown in Figure 4. The web interface displays asset information, including check-in and check-out time, item status, location and environmental data, as shown in Figure 5 and 6. This setup enables users to perform real-time monitoring without the need for external cloud services.

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Figure 4 Web-based monitoring interface on mobile device

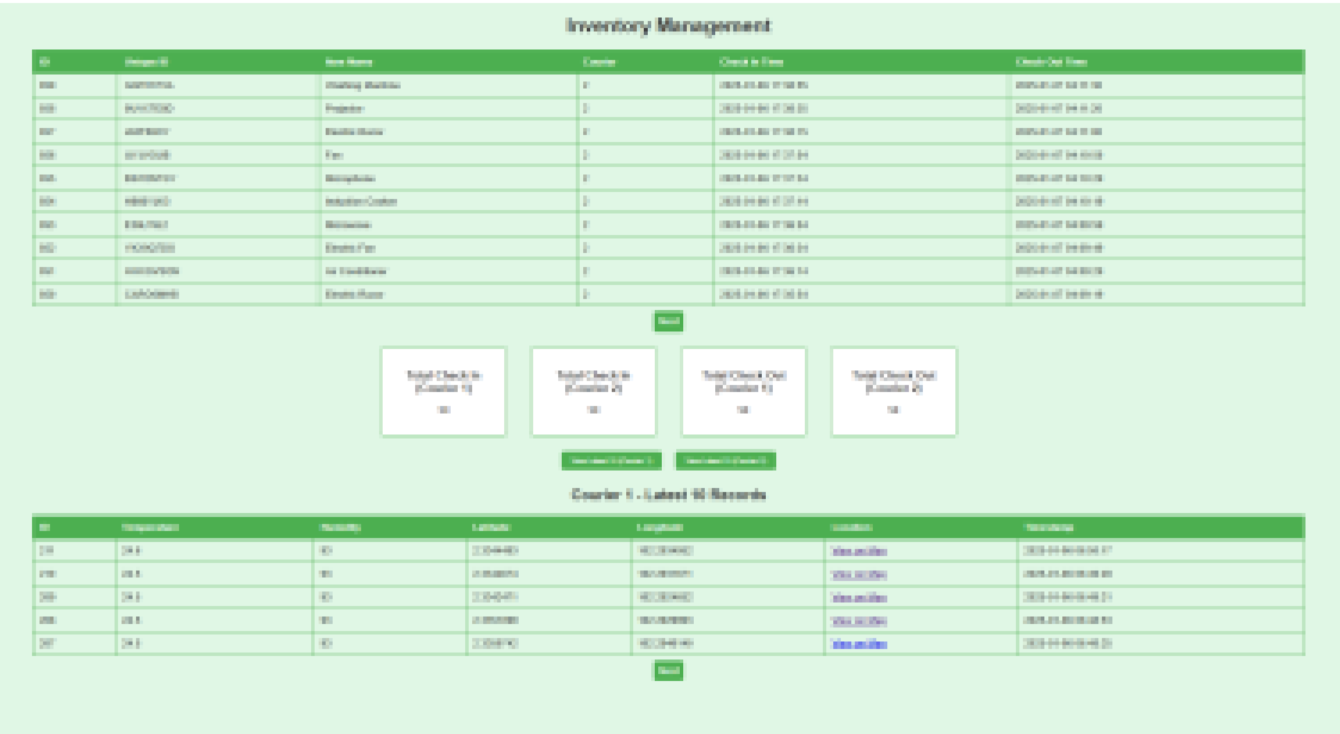

Figure 5 Asset management dashboard

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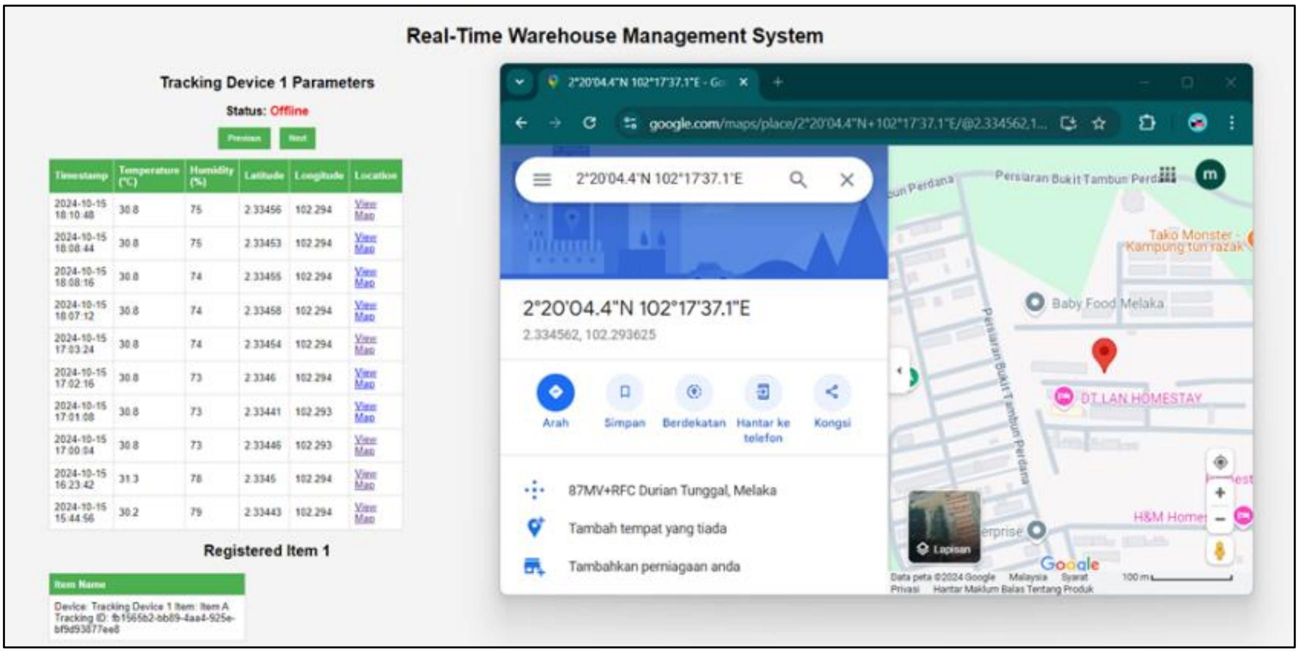

Figure 6 Real-time Management System

System Evaluation and Limitations

The evaluation of the IoT-enabled asset tracking and management system focused on monitoring asset location, identification, and status using RFID and GPS modules. Data were transmitted to the cloud database and accessed through the web interface. The system was tested by tracking multiple assets across defined checkpoints, and its performance was assessed based on the accuracy and consistency of asset identification and data logging. The present work demonstrates the feasibility of automated tracking and monitoring; however, the evaluation was descriptive in nature and relied on real-time observation of system responsiveness and functional correctness. No statistical validation techniques were applied in this study, and the analysis was limited to qualitative interpretation of system outputs. Future work should incorporate quantitative benchmarking, such as accuracy percentages, error rates, and statistical validation, to further strengthen the reliability and credibility of the findings.

RESULTS AND DISCUSSIONS

The performance of the IoT-enabled asset tracking and management system was evaluated through a series of tests that compared traditional and IoT-based tracking methods, analysed camera resolution performance, and assessed geolocation accuracy using GPS and Wi-Fi positioning.

Comparison Between Traditional and IoT-Based Systems

Traditional asset management relies heavily on manual data entry, which is prone to human error and delays. IoT-based asset management automates data collection, enabling real-time monitoring and predictive maintenance. The IoT approach reduces downtime and maintenance costs by identifying potential issues before they occur.

While traditional systems require minimal initial investment, they often incur higher long-term operational costs. In contrast, IoT systems require higher initial investment in hardware and infrastructure but provide cost savings over time through increased efficiency. Scalability is also improved in IoT systems, allowing multiple assets to be tracked across different locations without a proportional increase in labour. Furthermore, IoT systems support environmental monitoring such as temperature and humidity, which is not possible with traditional methods. Figures 7 and 8 show examples of the system's indoor inventory data collection and environmental monitoring.

id	unique_id	item_name	courier_in	check_in_time	check_out_time	courier_out
785	9EGNECFG	Electric Oven	1	1/6/2025 17:14	1/7/2025 3:52	1
786	DYKFU4ND	Air Purifier	1	1/6/2025 17:14	1/7/2025 3:52	1
787	SLYKTQCI	Space Heater	1	1/6/2025 17:14	1/7/2025 3:53	1
788	6RS7KVAD	Smartwatch	1	1/6/2025 17:15	1/7/2025 3:53	NULL
789	ZXRXKJEL	Vacuum Cleaner	1	1/6/2025 17:15	1/7/2025 3:53	1
790	ZRSTGQIT	Speaker	1	1/6/2025 17:15	1/7/2025 3:54	NULL
791	P388PB86	Keyboard	1	1/6/2025 17:16	1/7/2025 3:54	1
792	U7WY2TYV	Keyboard	1	1/6/2025 17:16	1/7/2025 3:54	NULL
793	ZO3C7SF3	Smartwatch	1	1/6/2025 17:16	1/7/2025 3:54	1
794	X62W0SJK	Electric Grill	1	1/6/2025 17:17	1/7/2025 3:55	NULL
795	25DA4IHY	ectric Pressure Cook	1	1/6/2025 17:17	1/7/2025 3:55	1
796	UXTI98A2	Space Heater	1	1/6/2025 17:17	1/7/2025 3:55	NULL
797	9HU5T47A	Webcam	1	1/6/2025 17:18	1/7/2025 3:55	1
798	DARRBY5E	Refrigerator	1	1/6/2025 17:18	1/7/2025 3:56	NULL
799	O1WDNZHZ	Smartwatch	1	1/6/2025 17:18	1/7/2025 3:56	1
800	2HHURRNY	ectric Pressure Cook	1	1/6/2025 17:19	1/7/2025 3:56	NULL
801	YCYFMJPW	Dehumidifier	1	1/6/2025 17:19	1/7/2025 3:56	1
802	KUTTFUUL	Air Purifier	1	1/6/2025 17:19	1/7/2025 3:57	NULL
803	8XXWW6HK	Microwave	1	1/6/2025 17:20	1/7/2025 3:57	1
804	405Q27BH	TV	1	1/6/2025 17:20	1/7/2025 3:57	1
805	OUPNHHMZ	Oven	1	1/6/2025 17:20	1/7/2025 3:57	1
806	095S50LQ	Hair Dryer	1	1/6/2025 17:21	1/7/2025 3:58	NULL
807	NCOAD2OF	Electric Blanket	1	1/6/2025 17:21	1/7/2025 3:58	1
808	TSD8FT3D	Toaster	1	1/6/2025 17:21	1/7/2025 3:58	NULL
809	ULVE5KN9	Refrigerator	1	1/6/2025 17:22	1/7/2025 3:58	1
810	V2X1HAVZ	Smart Thermostat	2	1/6/2025 17:22	1/7/2025 3:59	2
811	2QG68WN9	Tablet	2	1/6/2025 17:22	1/7/2025 3:59	2
812	XCAU8PFN	Toaster	2	1/6/2025 17:23	1/7/2025 3:59	2
813	RZ1PZRTN	Food Processor	2	1/6/2025 17:23	1/7/2025 3:59	NULL
814	ROP9K0RU	Fan	2	1/6/2025 17:23	1/7/2025 4:00	2
815	XZK12PTQ	Cordless Vacuum	2	1/6/2025 17:24	1/7/2025 4:00	2
816	MEOJ8WS7	Electric Grill	2	1/6/2025 17:24	1/7/2025 4:00	2
817	EQVN7KSD	Cordless Vacuum	2	1/6/2025 17:24	1/7/2025 4:00	NULL
818	U1ZYKG56	Speaker	2	1/6/2025 17:25	1/7/2025 4:01	2
819	9T5CG5L7	Space Heater	2	1/6/2025 17:25	1/7/2025 4:01	NULL
820	TL6CC6Q2	Headphones	2	1/6/2025 17:25	1/7/2025 4:01	2
821	OMQZ2I3J	Webcam	2	1/6/2025 17:26	1/7/2025 4:01	NULL
822	N6ZS9MBE	Laptop	2	1/6/2025 17:26	1/7/2025 4:02	2
823	D679QH79	Coffee Maker	2	1/6/2025 17:26	1/7/2025 4:02	NULL
824	S02HYXB0	Vacuum Cleaner	2	1/6/2025 17:27	1/7/2025 4:02	2
825	673EVTH9	Printer	2	1/6/2025 17:27	1/7/2025 4:02	2
826	Q3QIF1JZ	Dehumidifier	2	1/6/2025 17:27	1/7/2025 4:03	2
827	YPCU8PRR	Rice Cooker	2	1/6/2025 17:28	1/7/2025 4:03	NULL
828	GHWNEV3E	Webcam	2	1/6/2025 17:28	1/7/2025 4:03	2
829	0J71Z741	Water Heater	2	1/6/2025 17:28	1/7/2025 4:03	NULL
830	V9QF1X7A	Electric Oven	2	1/6/2025 17:29	1/7/2025 4:04	2
831	IZY9PNH6	Refrigerator	2	1/6/2025 17:29	1/7/2025 4:04	NULL
832	UTN1LWPN	Mouse	2	1/6/2025 17:29	1/7/2025 4:04	2
833	QUEZKXZY	Washing Machine	2	1/6/2025 17:30	1/7/2025 4:04	NULL
834	LZ95R0SZ	Oven	2	1/6/2025 17:30	1/7/2025 4:05	2

Figure 7 Indoor inventory data collection

id	temperature	humidity	latitude	longitude	location	timestamp
225	28.9	85	2.3343868	102.2934723	ww.google.com/maps?q=2.334387,102	1/7/2025 8:15
226	28.9	85	2.3343201	102.2934875	ww.google.com/maps?q=2.334320,102	1/7/2025 8:15
227	28.9	85	2.3339679	102.2936401	ww.google.com/maps?q=2.333968,102	1/7/2025 8:15
228	28.9	85	2.3341074	102.2940063	ww.google.com/maps?q=2.334107,102	1/7/2025 8:15
229	28.9	85	2.3341424	102.2944031	ww.google.com/maps?q=2.334142,102	1/7/2025 8:16
230	28.9	84	2.3339381	102.2956009	ww.google.com/maps?q=2.333938,102	1/7/2025 8:16
231	28.9	84	2.3335166	102.2955475	ww.google.com/maps?q=2.333517,102	1/7/2025 8:16
232	28.9	84	2.3330526	102.2955246	ww.google.com/maps?q=2.333053,102	1/7/2025 8:16
233	28.9	84	2.332715	102.2953033	ww.google.com/maps?q=2.332715,102	1/7/2025 8:16
234	28.9	84	2.3323343	102.2951965	ww.google.com/maps?q=2.332334,102	1/7/2025 8:16
235	28.9	84	2.331574	102.295433	ww.google.com/maps?q=2.331574,102	1/7/2025 8:17
236	28.9	84	2.3306854	102.2955704	ww.google.com/maps?q=2.330685,102	1/7/2025 8:17
237	28.9	84	2.3301871	102.2954483	ww.google.com/maps?q=2.330187,102	1/7/2025 8:17
238	29	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
239	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
240	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:17
241	29.3	84	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
242	29.3	84	2.3283088	102.2939453	ww.google.com/maps?q=2.328309,102	1/7/2025 8:18
243	29.3	83	2.3279812	102.2939606	ww.google.com/maps?q=2.327981,102	1/7/2025 8:18
244	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
245	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
246	29.3	83	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:18
247	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19
248	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19
249	29.3	82	1.4798574	103.7642593	ww.google.com/maps?q=1.479857,103	1/7/2025 8:19

Figure 8 Humidity, temperature, and location data collection

Camera Resolution Performance Analysis

The accuracy and processing time of the QR code scanning system were tested at different camera resolutions. Table 1 summarises the delay time and accuracy for camera identification, and sorting accuracy results.

Table 1 Comparison of delay time versus accuracy for camera identification

Resolution	Constant Delay Time		Accuracy		
	Camera accuracy	Time taken (min)	Camera accuracy	Sorting accuracy	Time taken (min)
240p	90	25	100	98.8	40
360p	98	28	100	100	38
480p	100	26	100	100	33
720p	99	25	100	97.97	33
1080p	99	25	100	77.72	25
2k	100	28	76.2	76.2	25

Figures 9 to 11 illustrate the relationship between camera resolution, processing delay, and accuracy. The results indicate that increasing resolution improves identification accuracy, with 480p and above achieving 100% accuracy. However, higher resolutions such as 1080p and 2K introduced processing delays and reduced sorting accuracy due to the processing limitations of the Raspberry Pi.

At lower resolutions, such as 240p, accuracy was lower and processing time longer due to error correction processes. At higher resolutions, despite clearer images, system overload caused communication errors with the NodeMCU ESP8266, resulting in sorting accuracy drops to approximately 76–78%. These results suggest that resolutions between 480p and 720p provide the best balance between accuracy and processing efficiency.

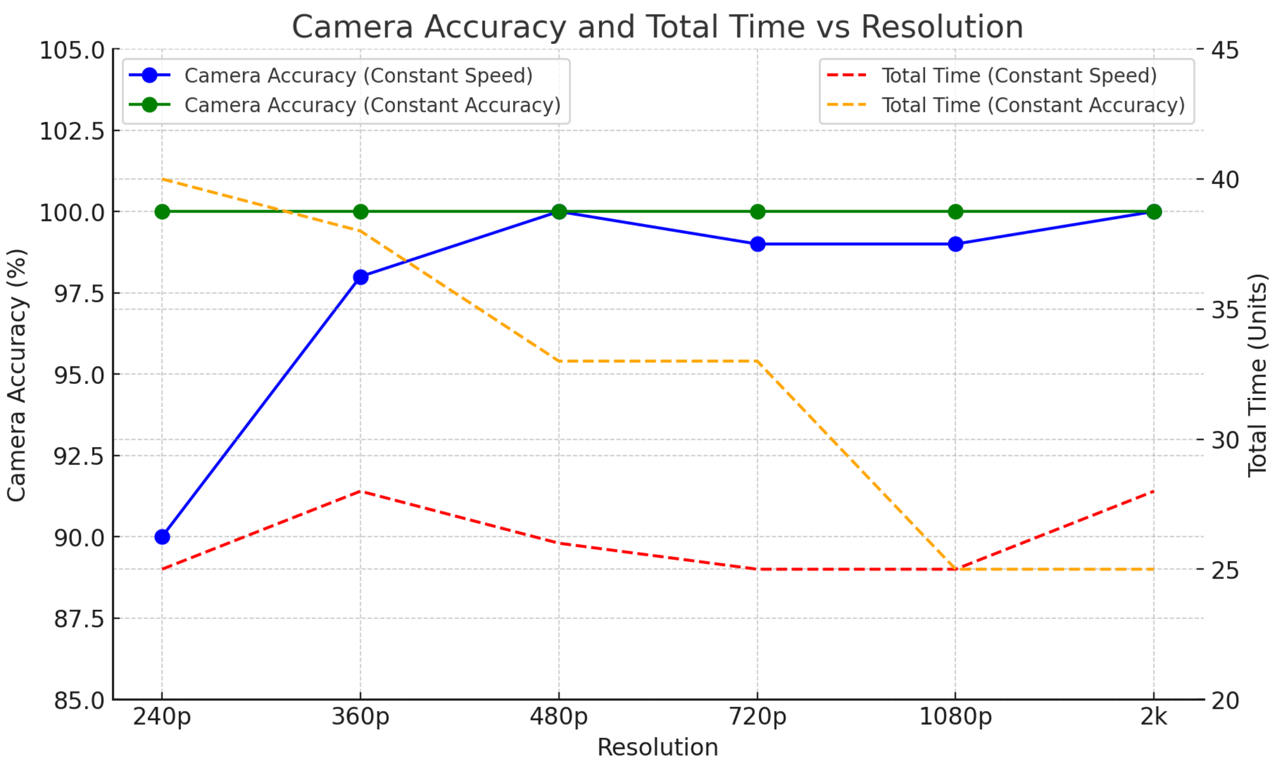

Figure 9 Camera accuracy and total processing time

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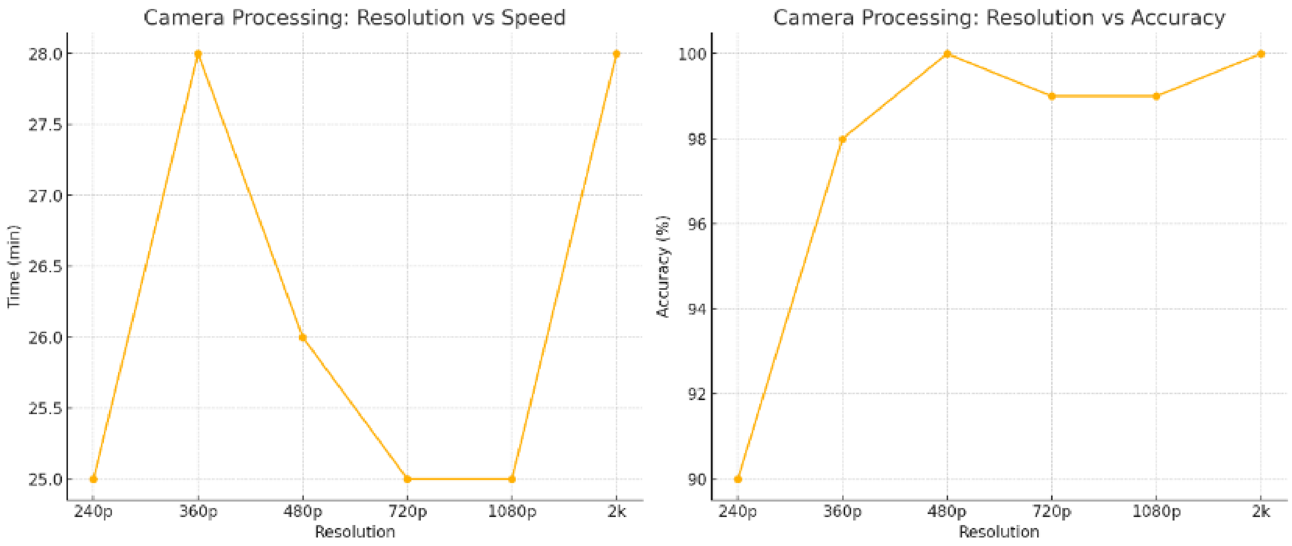

Figure 10 Camera resolution comparison with time delay

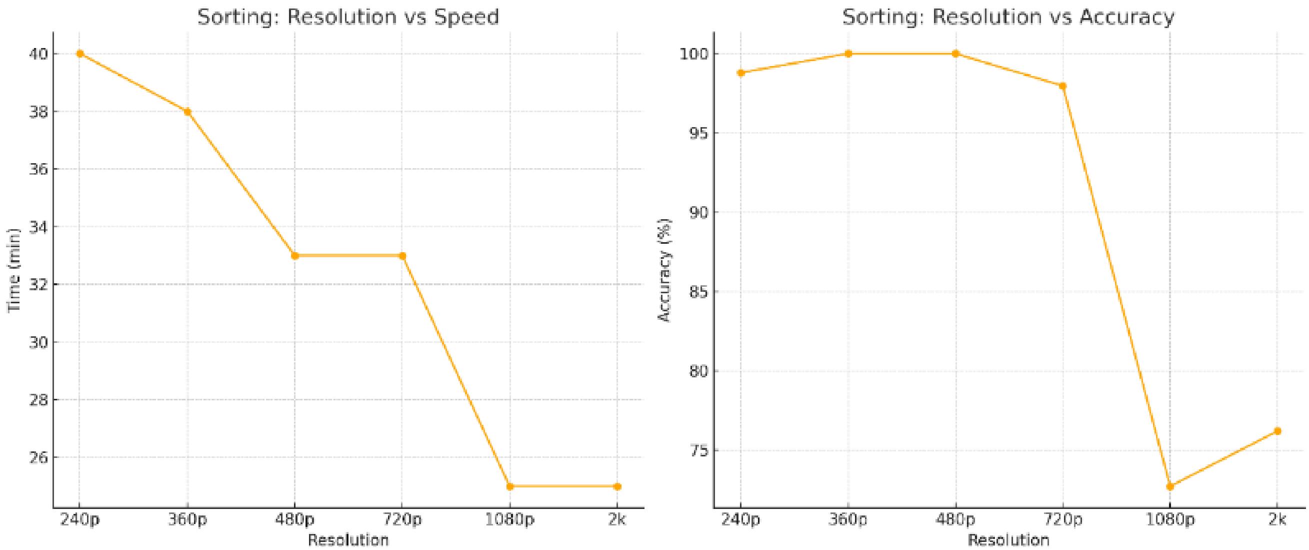

Figure 11 Camera resolution versus sorting accuracy

Geolocation Performance: GPS vs Wi-Fi Positioning

The accuracy of outdoor tracking was compared between GPS (NEO-6M module) and Wi-Fi-based geolocation (NodeMCU ESP8266). Table 2 summarises the main differences between these two methods in terms of plotting frequency, location accuracy, and environmental suitability.

Table 2 Comparison of Wi-Fi-based geolocation and GPS-based positioning.

Feature	**Geolocation API using NodeMCU**	**GPS Module NEO-6M**
Technology	Wi-Fi-based geolocation	Satellite-based GPS positioning
Plotting Points	More frequent plotting points	Fewer plotting points
Location Accuracy	General location, less precise	More precise and accurate location data
Suitability	Suitable for urban areas with dense Wi-Fi networks	Suitable for outdoor environments with clear satellite visibility
Performance Limitations	Lack precision due to Wi-Fi triangulation	Performance degrades in areas with limited satellite visibility (indoors, dense urban environments)

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Wi-Fi-based geolocation provided more frequent plotting points due to the abundance of nearby networks, making it suitable for urban areas with dense Wi-Fi coverage. However, the location accuracy was lower compared to GPS. The GPS module, in contrast, produced more precise coordinates but fewer plotting points, primarily due to its dependency on satellite visibility and acquisition time.

Figure 12 shows the plotted locations generated by the NodeMCU ESP8266 using Wi-Fi-based geolocation. The map contains a high density of plotted points, reflecting frequent updates whenever Wi-Fi networks were detected. This behaviour is advantageous in areas where multiple access points are available but can result in lower coordinate precision due to the nature of Wi-Fi triangulation.

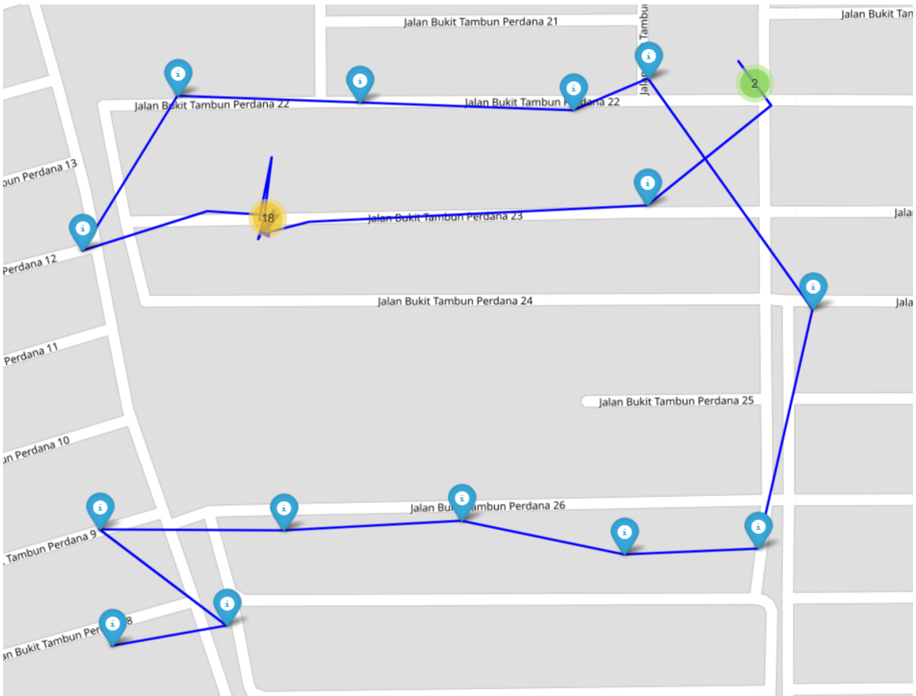

Figure 12: Geolocation ESP8266 NodeMCU maps plotting

Figure 13 illustrates the plotted locations obtained from the GPS module NEO-6M. Compared to Wi-Fi geolocation, the plotting points are fewer but the coordinates are more accurate. The GPS plots are closely aligned with the actual physical locations, which is critical for applications where exact positioning is required.

Figure 13 GPS module NEO-6M maps plotting

Figure 14 depicts the relationship between distance and Received Signal Strength Indicator (RSSI) for both Wi-Fi and GPS positioning. As the distance increased from 1 metre to 10 metres, both technologies experienced a decline in RSSI. Wi-Fi RSSI dropped more sharply, from approximately –32 dBm at 1 metre to –194 dBm at 10 metres. GPS RSSI degraded more gradually, starting at –40 dBm at 1 metre before reaching a similar –194 dBm value at 10 metres. This behaviour indicates that Wi-Fi-based geolocation is more sensitive to signal loss over distance, while GPS signals remain relatively stable up to around 5 metres.

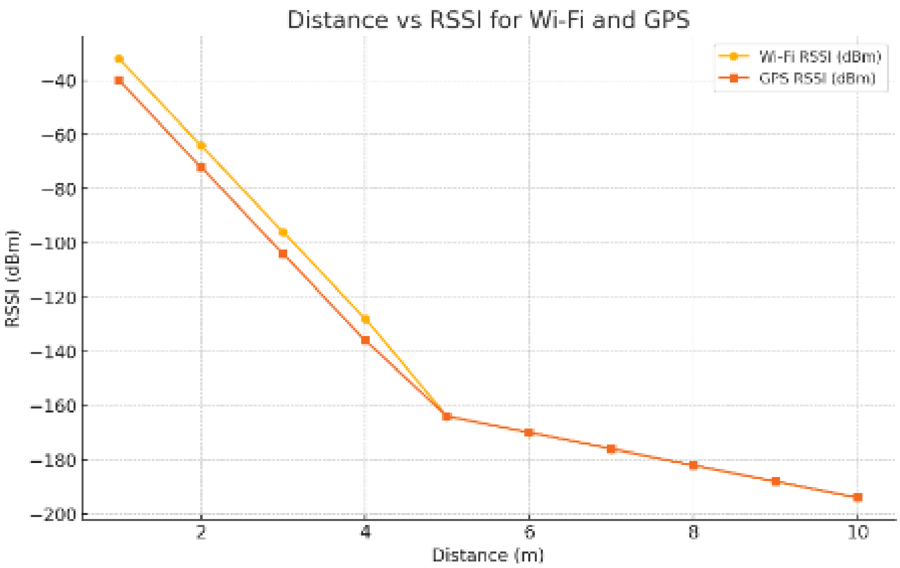

Figure 14: Relationship between distance and RSSI for Wi-Fi and GPS

These findings indicate that Wi-Fi geolocation is suitable for high-frequency updates in network-rich environments, while GPS offers better accuracy in open areas where satellite coverage is strong.

CONCLUSION

The IoT-enabled asset tracking and management system successfully demonstrated the integration of QR code scanning, LoRa-based long-range communication, and GPS tracking for real-time asset monitoring. The system enables efficient tracking of assets, with data visualisation and control provided through a MySQL database and a web-based interface. The use of LoRa technology proved effective for areas with limited Wi-Fi or cellular coverage, ensuring continuous communication between tracking devices and the monitoring platform.

Testing indicated that the system could achieve high detection rates for asset identification and location tracking. However, several limitations were observed. These include processing delays caused by the limited computational capacity of prototype microcontrollers, reduced image recognition speed due to resolution-resource trade-offs in the camera module, and a lack of advanced statistical validation due to the use of basic data analysis tools. Additionally, environmental factors such as signal interference in urban environments impacted tracking consistency.

To address these limitations, future iterations of the system should explore the use of higher-performance edge processors such as Raspberry Pi 4 or ESP32 with AI capability, implement adaptive image resolution based on ambient conditions, and adopt more robust data analytics platforms such as Python or R for quantitative validation and trend forecasting.

The findings highlight the potential of IoT-based asset management to enhance operational efficiency, reduce losses, and support predictive maintenance. The system's modular and cost-effective design makes it adaptable for various logistics and industrial applications. In addition, its capability to integrate environmental monitoring allows assets to be maintained under optimal conditions.

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From a sustainability perspective, the approach contributes to responsible resource management by reducing waste, extending asset lifespan, and enabling more efficient logistics operations. Potential environmental impacts, such as e-waste generation, can be mitigated through the use of recyclable materials and renewable energy sources. With further refinement, IoT-enabled asset management systems can play a significant role in supporting sustainable and efficient operations across multiple sectors.

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REFERENCES

1. Frankó, A., Vida, G., & Varga, P. (2020). Reliable identification schemes for asset and production tracking in industry 4.0. Sensors (Switzerland), 20(13), 1–24. https://doi.org/10.3390/s20133709
2. Gurulakshmi, A. B., Sharma, S., Rajesh, G., Sundar, A., Kumar, A. B., Darshan, D., Chakravarthi, K., & Reddy, D. (2023). Design and Implementation of an Easy-to-Use Tracking Device for Logistic Applications. 4th International Conference on Intelligent Engineering and Management, ICIEM 2023. https://doi.org/10.1109/ ICIEM59379.2023.10167295
3. Khalid, R., & Ejaz, W. (2022). Internet of Things-based On-demand Rental Asset Tracking and Monitoring System. Proceedings - 2022 5th International Conference on Information and Computer Technologies, ICICT 2022, 84–89. https://doi.org/10.1109/ICICT55905.2022.00023
4. Laxmi, A. R., & Mishra, A. (2018). RFID based Logistic Management System using Internet of Things (IoT). Proceedings of the 2nd International Conference on Electronics, Communication and Aerospace Technology, ICECA 2018, 556–559. https://doi.org/10.1109/ICECA.2018.8474721
5. Selvakumar, V., Sivanandan, S., Saillaja, V., & Subbarayudu, A. (2023). Smart Asset Management: Tracking and Optimizing Assets with IoT Sensors. Proceedings of the 2nd International Conference on Edge Computing and Applications, ICECAA 2023, 1354–1358. https://doi.org/10.1109/ICECAA58104.2023.10212115