IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

IOT Enabled School Bus Tracking and Student Monitoring System

Mrs. S.Jancy Sickory Daisy[1], B.Gayathri[2], S.Induja[3]

Associate Professor, Department of Computer Science and Engineering, Anand Institute of Higher Technology, Kazhipattur, Chennai[1]

Student, Department of Computer Science and Engineering, Anand Institute of Higher Technology, Kazhipattur, Chennai[2,3]

Abstract: The Smart School Bus Student Monitoring System enhances student safety and automates attendance using RFID technology**.** A microcontroller like NodeMCU or Arduino processes data, recording attendance and timestamps, which are sent to a central server accessible by school staff and parents. Unlike GPS-based systems, it focuses solely on student tracking. In case of delays, drivers can input reasons, triggering real-time notifications to parents via Telegram chat Bot or SMS. The system is cost-effective, scalable, and offers a modern alternative to traditional school bus monitoring methods.

Keywords: IoT, RFID, Microcontroller, Student Monitoring, School Bus Tracking and safety, Attendance, Real-time Alerts.

I. INTRODUCTION

Ensuring the safety of students during transit is a critical concern for parents, schools, and transportation authorities. Traditional school bus monitoring systems often rely on manual attendance tracking and outdated communication methods, leading to inefficiencies and potential safety risks. To address these challenges, we propose a hardware-based solution that integrates RFID authentication and real-time notification mechanisms.

The core objective of this system is to monitor student attendance through RFID-based authentication while providing real-time updates to parents and school authorities. Unlike conventional manual methods, this approach enhances accuracy, reliability, and efficiency. A NodeMCU-ESP32 microcontroller is utilized to manage data processing and communication between system components and the cloud server.

A key feature of this system is its instant alert mechanism. In the event of emergencies such as bus breakdowns, route changes, or unexpected delays, real-time notifications are sent to parents and school management via the Telegram application. This ensures immediate communication, reducing uncertainty and enhancing parental trust.

By integrating RFID-based attendance, automated real-time updates, and proactive emergency notifications, this system promotes accountability, transparency, and enhanced security in student transportation. It provides an efficient, cost-effective, and user-friendly solution that benefits schools, parents, and students alike, making school transportation smarter and safer.

Beyond attendance tracking and emergency alerts, the system significantly reduces the dependency on manual processes, ensuring greater consistency and accuracy in student monitoring. With RFID-based authentication, each student's entry and exit are automatically recorded, minimizing the chances of missed or incorrect attendance. The seamless integration with the Telegram application ensures that parents remain informed in real-time, fostering a stronger sense of trust and assurance. This automation not only lightens the administrative workload for school staff but also creates a more secure and transparent transportation environment for students.

 This work is licensed under a Creative Commons Attribution 4.0 International License

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

Table 1. Functionalities of an IoT-Enabled School Bus Tracking and Student Monitoring System

Functionality	Description
Real-Time Bus Tracking	Monitors the exact location of the school bus using GPS and IoT sensors for enhanced visibility.
Student Boarding/Exiting Detection	Uses RFID/NFC to track when and where each student boards and exits the bus.
Automated Attendance System	Records student attendance automatically as they enter and leave the bus.
Instant Notifications to Parents	Sends real-time alerts to parents about pickup/drop-off, delays, or emergencies.
Emergency Alert Button (Panic Button)	Allows driver or students to send instant alerts to authorities in case of emergencies.
Data Security and Privacy	Ensures secure handling of student data and prevents unauthorized access.

II. RELATED WORK

Several studies have explored intelligent and technology-driven methods to improve student transportation and safety. [1] introduced an IoT-based bus monitoring system utilizing RFID and cloud technologies to ensure real-time student attendance tracking. [3] implemented microcontroller-based systems for school bus safety, showing how embedded devices like Arduino and NodeMCU can automate the boarding and deboarding process. [5] proposed an RFID-GSM based solution that automatically updates attendance and sends alerts to parents, enhancing communication and reducing manual work.

[6] Demonstrated the integration of IoT and mobile apps for live bus tracking and delay notifications, improving transparency in school transport operations. [8] explored cloud-connected systems for storing and accessing transit data remotely, ensuring availability to school staff and guardians at all times. [10] applied AI models to predict route delays and optimize travel paths, reducing both commute time and operational cost.

[7] Highlighted the use of RFID-based attendance systems within classrooms, validating their high accuracy and scalability, which can be adapted for school bus environments. [12] presented a hybrid system combining manual inputs with automated alerts to manage emergency situations efficiently. [11] introduced App(Telegram Chat bot)-based real-time alerts, offering a simple yet effective communication bridge between drivers, schools, and parents.
Our system builds on these works by removing dependency on GPS and focusing on RFID-based student tracking. It employs a microcontroller to process scan data and uses a server to push real-time alerts and logs. This ensures student safety, minimizes human error in attendance, and enhances operational efficiency through affordable and scalable components.

Building on prior work, our system simplifies school bus monitoring by focusing solely on RFID-based student authentication. It uses a microcontroller to record attendance and trigger real-time alerts via Telegram. This eliminates the need for complex infrastructure like GPS or cloud services. Prior studies [13][14] emphasize low-cost, efficient designs, which align with our approach. The system ensures reliable communication between school authorities and parents. By reducing manual intervention, it enhances safety and operational ease.

Our system builds on these prior works by focusing solely on RFID-based student tracking. The system uses a microcontroller to process scan data and sends real-time alerts and logs to a server, ensuring student safety and minimizing human error. By utilizing low-cost components, our approach offers an affordable and scalable solution for schools of all sizes. Unlike previous systems that rely on complex infrastructure, our system simplifies the setup, reduces operational costs, and fosters more reliable communication between parents, school authorities, and bus drivers. This aligns with the growing trend toward cost-effective, efficient solutions in educational settings.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

III. METHODOLOGY

Table 2. Methodology of IoT-Enabled School Bus Tracking and Student Monitoring System.

Phase	Description
Requirement Analysis	Identified the need for a cost-effective and scalable school bus monitoring system that enhances student safety and automates attendance using RFID technology. Defined key features such as attendance logging, real-time notifications, and delay management.
System Design	Designed the system architecture with a microcontroller (NodeMCU/Arduino) for processing RFID data and recording attendance. Data is sent to a central server for access by school staff and parents. Integrated a Telegram chat bot or SMS for real-time notifications.
Data Collection & Processing	Collected student data via RFID tags as students board or exit the bus. Processed data for attendance logging and timestamp generation. The system then sends this data to a central server, where it is accessible for monitoring.
Implementation	Developed the system components, including RFID-based student tracking, real-time notifications for delays via Telegram or SMS, and a central server interface for administrators and parents. The microcontroller processes the data and triggers notifications.
Testing & Validation	Conducted unit testing on each component (RFID detection, microcontroller data processing, notification system) to ensure accurate attendance logging and reliable real-time notifications. Performed integration testing to ensure data synchronization and system performance.
Deployment & Maintenance	Deployed the system on a cloud server for centralized access and scalability. Monitored system performance through logs and analytics. Periodically updated the system with new features, including enhanced alert mechanisms or improved data management.

IV. EXISTING SYSTEM

The traditional school transportation system lacks an efficient real-time student monitoring and attendance mechanism. In most cases, parents and school authorities rely on manual communication or estimated times, leading to uncertainty and safety concerns. Student attendance on school buses is often recorded manually, making it difficult to ensure that students board and exit at the correct stops. Moreover, there is no automated notification system to instantly inform parents or school authorities about emergencies, delays, or route changes. The absence of a real-time student authentication and alert system increases the risk of errors and reduces overall accountability.

IV.1 System Components:

1.NodeMCU (ESP8266/ESP32): Central microcontroller for processing and cloud communication.
2.RFID Scanner Module: Authenticates student entry/exit using RFID tags.
3.Power Supply: Includes a battery and voltage regulator for mobile, efficient operation.
4.Cloud Platform: Firebase or similar platform used for real-time data storage and updates.
5.Telegram Bot API: Used for sending real-time alerts to parents and school management.

The IoT- Enabled School Bus Tracking and Student Monitoring System is designed to enhance student safety and provide real-time status updates for parents and school authorities. This system leverages RFID technology for accurate student authentication and attendance monitoring. Instead of relying on manual attendance methods or QR code scanning, students scan their RFID cards when boarding and alighting the bus, allowing for automated and reliable attendance recording. Additionally, the system includes an instant notification feature, which sends real-time alerts via Telegram to parents and school authorities in case of bus delays, emergencies, or route changes. A NodeMCU (ESP8266/ESP32) microcontroller is used to efficiently manage data processing, cloud communication, and system operations. Attendance and event data are stored securely on a cloud-based server, allowing easy access for monitoring and reporting. By integrating RFID-based authentication, IoT-enabled communication, and real-time notifications, this system significantly improves accountability, security, and communication, making school transportation smarter and safer.

 This work is licensed under a Creative Commons Attribution 4.0 International License

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

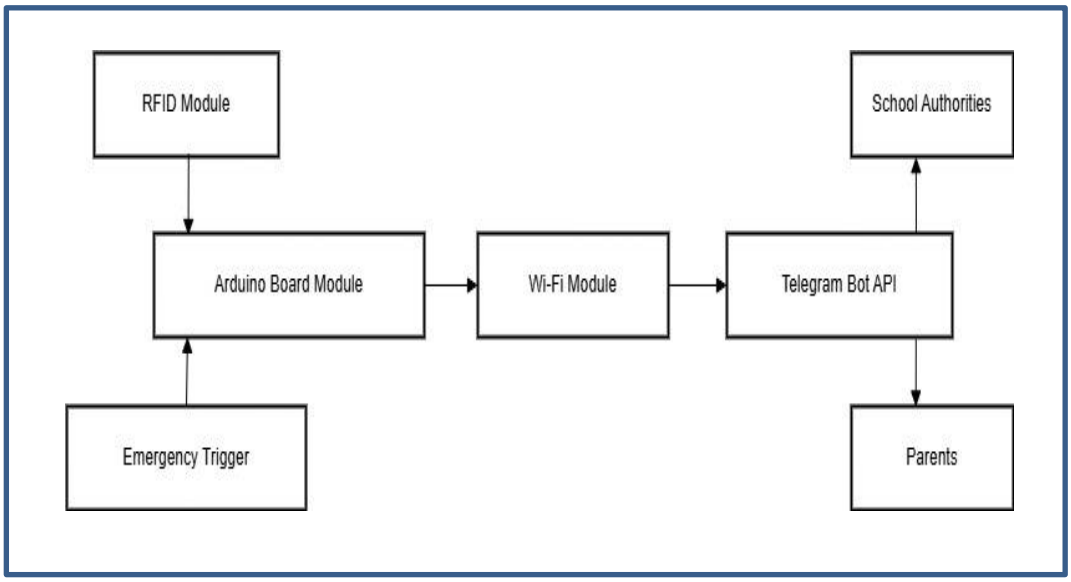
International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

V. PROPOSED SYSTEM

Figure 1: Overall Design of the System



V.1 Modules

A module is a file or a collection of files that contain reusable code, often with a specific purpose. It can encapsulate a set of related functions, classes, or procedures to be imported and used in other parts of a program.

RFID Module:

The RFID Module (RC522) is a key component in the student tracking and attendance system. It works by reading RFID tags assigned to each student, which contain a unique embedded ID. When a student places their tag near the RFID reader, the reader captures the ID and sends it to the microcontroller (such as NodeMCU) using serial communication. The microcontroller then processes this ID, logs it with a timestamp, and determines whether the student is arriving or leaving .The use of RFID technology ensures faster, more accurate attendance without manual input, and helps monitor student location in real time especially useful during emergencies for quick verification and safety response.

Arduino Board Module:

The Arduino board, particularly NodeMCU or ESP8266/ESP32, manages all core functions of the system. It receives data from the RFID reader, processes it to identify the student, and logs the attendance. With built-in Wi-Fi capability, it connects to a mobile hotspot to enable internet access. This connectivity is essential for sending real-time updates and alerts through platforms like Telegram. Additionally, the board handles emergency triggers and ensures smooth communication between hardware modules and cloud-based services.

Wi-Fi Module:

The The Wi-Fi Module, which is built into the NodeMCU or ESP8266/ESP32 boards, plays a crucial role in providing internet connectivity to the system. It connects to a mobile hotspot using the SSID and password specified in the code. This connection enables the system to send real-time data, such as student attendance and emergency alerts, to external services like Telegram. The Wi-Fi module ensures smooth communication between the Arduino board and cloud-based platforms, allowing for instant updates and efficient data transmission, essential for monitoring and emergency response.

Telegram Bot API:

The Telegram Bot API is integral to the system, allowing for real-time communication with parents and school management. Once an RFID card is scanned, the bot automatically sends attendance updates to ensure accurate tracking of student movements. In case of an emergency, the bot quickly sends urgent alerts to both parents and school management, ensuring immediate attention and response. This feature enables real-time notifications, which are crucial for effective monitoring and rapid action, especially during emergencies.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

Emergency Trigger:

The Emergency Trigger, which can be a physical button or a specific RFID card, plays a vital role in detecting and responding to emergencies. When the emergency trigger is activated, the system immediately sends a detailed emergency alert to both parents and school management. This ensures fast communication in critical situations, helping to safeguard student well-being and enabling quick responses from the responsible parties. Together, these features enhance the overall safety and efficiency of the system, ensuring both regular monitoring and emergency preparedness.

Challenges Overcome from the Existing System:

- **Lack of Real-Time Updates** – Parents and school authorities do not receive live updates about bus locations or student status, leading to anxiety and uncertainty.
- **Manual Attendance Recording** – Student attendance on school buses is traditionally recorded manually, increasing the risk of errors and unverified entries.
- **No Instant Emergency Alerts** – In case of emergencies, there is no system in place to quickly alert parents or authorities, delaying response actions.
- **Unverified Boarding/Exiting of Students** – Without real-time monitoring, it's difficult to ensure that students board and exit at the correct stops.
- **Limited Communication with Parents** – Schools rely on manual communication methods for updates, resulting in delayed or missed information delivery.

VI. ANALYSIS

Key Observations and Functional Outcomes:

Real-Time Student Monitoring and Attendance:

The system uses RFID/NFC technology to automatically track when students board and exit the bus, ensuring accurate attendance without manual intervention.

Instant Notifications to Parents and Authorities:

The system sends real-time alerts to parents and school staff when students board or exit the bus, or in case of delays or emergencies, ensuring immediate communication.

Emergency Alert Button:

A panic button feature allows both the driver and students to send immediate alerts to school authorities and parents in case of emergencies, ensuring a rapid response.

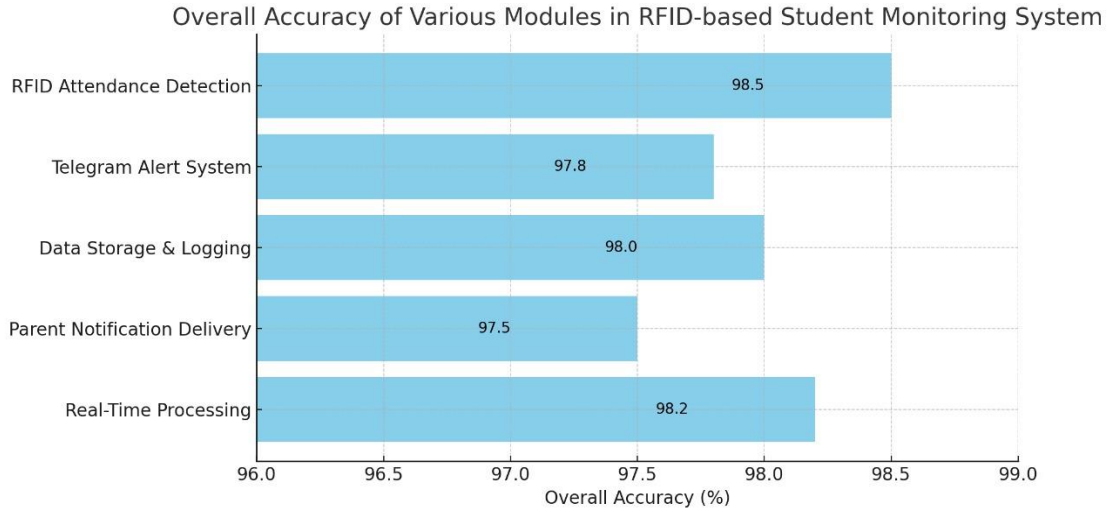
Admin Panel for Efficient Management:

The system provides a secure and user-friendly admin panel, allowing school authorities to manage student data, monitor attendance, and respond to emergencies efficiently.

IoT and Cloud Integration for Real-Time Data:

IoT sensors integrated with cloud services ensure seamless real-time updates across devices, allowing for continuous monitoring and synchronization of data.

Figure 2. Overall Accuracy of various Modules in RFID-based Student Monitoring System



IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 5, May 2025

DOI: 10.17148/IJARCCE.2025.14509

Table 3. Performance of various Metrices

Metric	Definition	Performance	Advantage
Alert Delivery Time	Time between RFID scan and parent alert via Telegram.	Less than 2 seconds	Ensures immediate notification to parents
Attendance Detection Accuracy	Accuracy of student identification and logging through RFID.	99.9% accurate	Reduces false positives and missed scans.
System Load Handling	Number of concurrent RFID scans and data syn the system can handle.	Handles 1000+ students simultaneously	Suitable for large-scale school operations.
Database Query Speed	Efficiency of storing and retrieving data from Firebase.	Real-time synchronization	Enables instant updates in the monitoring system.
Energy Efficiency	Power consumption by hardware (NodeMCU + RFID) during operation	Less than 5% battery/hour	Supports continuous operation with minimal energy usage.
Data Security	Protection of student data and notification access.	Encrypted RFID logs & Telegram bot channels.	Prevents unauthorized data access and enhances parent trust

VII. RESULTS AND DISCUSSION

The implementation of The Smart School Bus and Student Monitoring System performed successfully during both simulation and real-time testing. The RFID module reliably captured student entry and exit data, effectively eliminating manual attendance marking and reducing the risk of errors. Notifications sent via the Telegram platform were delivered almost instantly, keeping parents and school authorities informed about boarding, drop-off, and emergency events. This real-time communication greatly improved transparency and safety. The Node MCU microcontroller efficiently managed data processing and communication between hardware components and the cloud, ensuring smooth operation throughout. The system maintained a stable power supply, supporting uninterrupted performance during transit. While occasional RFID misreads occurred due to improper tag alignment or fast movement, these can be addressed in future improvements by adding visual or audio indicators (like LEDs or buzzers) to confirm successful scans. Overall, the system demonstrated accuracy, reliability, and practical usability for enhancing school transport safety and monitoring.

VIII. CONCLUSION

In conclusion, The IoT-Based Smart School Bus and Student Monitoring System presents a reliable and cost-effective solution to enhance student safety and improve school transportation management. By utilizing RFID technology, the system automates the attendance process by detecting and recording student boarding and alighting events in real time. With Node MCU as the microcontroller, data is processed efficiently and transmitted to a centralized system, while instant alerts are sent to parents and school authorities through the Telegram messaging platform. This real-time communication addresses key issues such as delayed updates, manual attendance errors, and a lack of transparency in student transit. The system has demonstrated reliable RFID detection and prompt Telegram notifications, ensuring accountability and peace of mind for stakeholders. By replacing traditional methods with a smart, IoT-based solution, the project showcases how embedded systems can solve practical safety and communication challenges in the educational sector. In the future, integrating features like mobile app support, biometric verification, and cloud-based analytics can further enhance the system's usability, security, and scalability.

IX. FUTURE ENHANCEMENT

In future , To enhance the current system, a dedicated mobile application can be introduced to provide parents and school staff with features like real-time bus tracking, student attendance logs, and instant push notifications. Biometric authentication such as fingerprint or facial recognition could be implemented to strengthen security and minimize

DOI: 10.17148/IJARCCE.2025.14509

dependence on RFID cards. AI-based route optimization can analyze traffic data to suggest the most efficient routes, reducing delays and fuel consumption. Additional safety features like an onboard voice alert system and an SOS button for students and drivers would enable better communication and emergency response. Geo-fencing could trigger alerts when buses enter or exit specific zones, and driver behavior monitoring would help ensure safe driving practices. Lastly, a cloud-based analytics dashboard would allow administrators to access automated reports and long-term data insights for improved transport planning and management.

REFERENCES

[1] A. Noureldin, A. Osman, and N. El-Sheimy, ‘‘A neuro-wavelet method for multi-sensor system integration for vehicular navigation,’’ Meas. Sci. Technol., vol. 15, no. 2, pp. 404–412, Feb. 2004.
[2] M. R. Islam and J.-M. Kim, ‘‘An effective approach to improving low-cost GPS positioning accuracy in real-time navigation,’’ Sci. World J., vol. 2014, pp. 1–8, Jan. 2014.
[3] M. R. Islam and J.-M. Kim, ‘‘An effective approach to improving low-cost GPS positioning accuracy in real-time navigation,’’ Sci. World J., vol. 2014, pp. 1–8, Jan. 2014.
[4] J.-Y. Huang and C.-H. Tsai, ‘‘Improve GPS positioning accuracy with context awareness,’’ in Proc. 1st IEEE Int. Conf. Ubi-Media Comput., Jul. 2008, pp. 94–99. [Online]. Available: https://ieeexplore. ieee.org/document/4570872.
[5] D. Bhatt, P. Aggarwal, V. Devabhaktuni, and P. Bhattacharya, ‘‘A new source difference artificial neural network for enhanced positioning accuracy,’’ Meas. Sci. Technol., vol. 23, no. 10, Oct. 2012, Art. no. 105101.
[6] J. Li, N. Song, G. Yang, M. Li, and Q. Cai, ‘‘Improving positioning accuracy of vehicular navigation system during GPS outages utilizing ensemble learning algorithm,’’ Inf. Fusion, vol. 35, pp. 1–10, May 2017.
[7] Z. Li, J. Wang, B. Li, J. Gao, and X. Tan, ‘‘GPS/INS/odometer integrated system using fuzzy neural network for land vehicle navigation applications,’’ J. Navigat., vol. 67, no. 6, pp. 967–983, Nov.2014.
[8].X. Chen, C. Shen, W.-B. Zhang, Mka, Y. Xu, and K. Chiu, ‘‘Novel hybrid of strong tracking Kalman filter and wavelet neural network for GPS/INS during GPS outages,’’ Measurement, vol. 46, no. 10, pp. 3847–3854, Dec. 2013.
[9] A. El-Shafie, A. Najah, and O. A. Karim, ‘‘Amplified wavelet-ANFISbased model for GPS/INS integration to enhance vehicular navigation system,’’ Neural Comput. Appl., vol. 24, nos. 7–8, pp. 1905–1916, Jun. 2014.
[10] B. H. Kaygısız, A. M. Erkmen, and İ. Erkmen, ‘‘Enhancing positioning accuracy of GPS/INS system during GPS outages utilizing artificial neural network,’’ Neural Process. Lett., vol. 25, no. 3, pp. 171–186, Jun. 2007

 This work is licensed under a Creative Commons Attribution 4.0 International License