IT4010 Research Project – 2025 July

Topic Assessment Form

Project ID : 25-26J-282

1. Topic (12 words max)

Smart School Bus Safety and Monitoring Ecosystem

2. Research group the project belongs to

AIMS - Autonomous Intelligent Machines and Systems

3. Specialization of the project belongs to

Information Technology (IT)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Ensuring the safety of school children during daily transportation remains a persistent challenge worldwide, particularly in developing countries where monitoring, verification, and safety systems are minimally automated. Traditional school bus systems rely heavily on manual procedures. drivers are not continuously verified, vehicle insurance and safety compliance are not consistently validated, student boarding is recorded manually, and parents receive little to no real time visibility of their child's travel experience. These gaps create significant risks, including student misplacement, unauthorized bus boarding, unsafe driving, and delayed emergency responses.

Sri Lanka faces similar challenges due to the lack of a unified digital transportation safety ecosystem. Problems such as drivers using expired licenses, poorly maintained buses, overloading, students leaning out of windows, footboard travel, harassment incidents, and bus breakdowns often go undetected. Furthermore, most routing systems are static and fail to adapt to daily changes in pickup points or real time traffic delays. Parents and school authorities often receive updates only after an incident has occurred, highlighting the need for a proactive, data driven safety architecture.

Existing solutions in the global market address isolated components, such as GPS tracking or CCTV monitoring, but none provide an end to end trust driven platform integrating identity verification, safety monitoring, predictive analytics, and emergency response.

This research addresses the gap by developing a unified, AI powered school transportation system that combines NFC-based identity validation, driver and vehicle verification, student behavior recognition, GPS routing AI, incident detection, and blockchain backed trust architecture. The proposed solution ensures real time safety, proactive incident prevention, and transparent communication between students, parents, drivers, and school authorities.

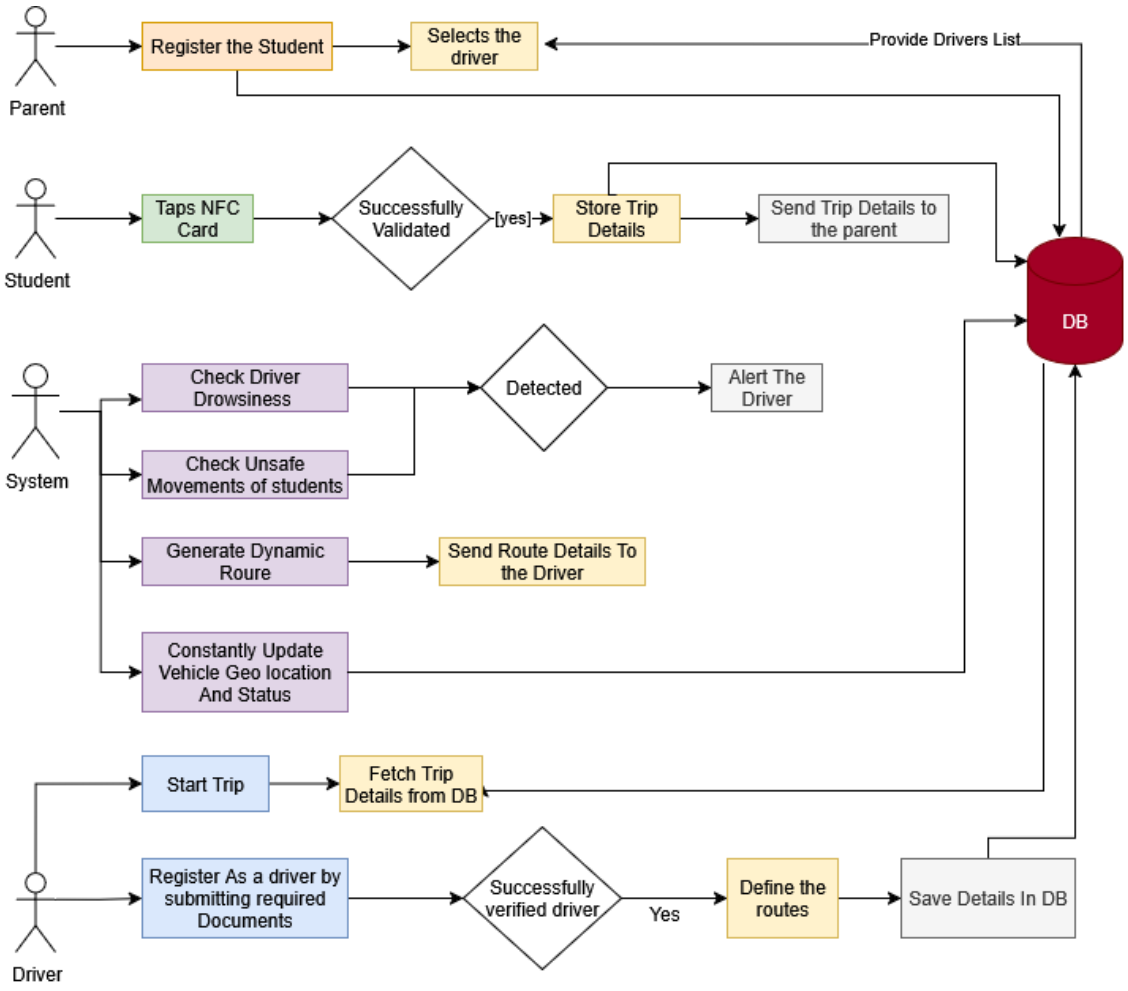
6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

The proposed solution is a fully integrated Smart School Bus Safety, Tracking, and Child Protection Platform built using artificial intelligence, machine learning, computer vision, and blockchain-backed trust infrastructure. The system begins with onboarding and verification, where drivers upload their license and selfie for ML based facial verification, while buses undergo insurance OCR validation and basic safety scoring using uploaded images. Parents register through the mobile application, select recommended buses using driver safety scores, and manage payments through a wallet.

During the trip, students board via NFC card tapping using a PN532 reader, backed by anomaly detection to prevent fraudulent entries. Optional face verification enhances security. In bus cameras continuously analyze student behavior such as falls, unsafe movements, hand out of window actions, crowding, and harassment indicators through CNN and transformer-based models. The “Exit Guardian” monitors leaning, footboard travel, and jump attempts. Driver vigilance is monitored through fatigue detection using side angle optimized ML models deployed on edge devices.

Externally, the system utilizes GPS and IMU sensors to provide real time location tracking, dynamic ETA predictions, and intelligent route adjustments. Crash detection sensors and SOS buttons trigger an emergency pipeline that prioritizes alerts to parent , and authorities based on severity.

All critical events such as boarding, anomalies, violations, and payouts are hashed to a blockchain for tamper proof auditing. This solution ensures a predictive, automated, and high trust transportation ecosystem.



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

This project requires multidisciplinary expertise across machine learning, computer vision, embedded systems, mobile development, network communication, and blockchain technologies. Computer vision expertise is essential for building real time behavior analysis models, including CNN based gesture recognition, fall detection using posture estimation, and transformer based models for detecting unsafe movements or harassment indicators. These models require carefully annotated training datasets of student behavior inside a bus, captured from onboard CCTV cameras.

Driver vigilance monitoring requires domain understanding of fatigue detection, eye blink rate estimation, and distraction recognition, particularly from a side angle camera position. This involves side angle domain adaptation techniques and geometric perspective correction. Embedded systems knowledge is required to deploy ML models efficiently on Jetson Nano or Raspberry Pi with minimal processing latency.

NFC identity verification requires familiarity with PN532 modules, NFC card programming, and secure backend validation. OCR and document verification expertise is essential for extracting and validating expiration dates and plate numbers from vehicle insurance documents. Routing intelligence requires knowledge of GPS, IMU sensors, and algorithms for dynamic route optimization, delay prediction, clustering of student pickup points, and ETA forecasting. The machine learning component uses daily transportation data to predict delays and breakdowns.

Data requirements include images and videos of student activities inside buses, driver facial datasets, license images, insurance documents for OCR training, GPS route history, attendance logs, and daily delay patterns. Privacy and ethical handling of child related data are critical, requiring anonymization methods and secure data storage. Blockchain knowledge is required to implement event hashing for trust-verified logs.

8. Objectives and Novelty

Main Objective

To develop an AI driven school transportation safety ecosystem that integrates student identity validation, driver and vehicle verification, real time behavior monitoring, intelligent routing, and automated emergency response to ensure secure, transparent, and reliable school bus operations.

Member Name with Registration No	Sub Objective	Tasks	Novelty
IT22590312 M.H.S. Akther	Build a complete trust driven transportation platform combining ML based driver/vehicle verification, NFC student validation, blockchain event logging, safety analytics, and parent communication.	• Implement NFC boarding and exit validation using PN532 • Build license + selfie driver verification using face matching ML • Build insurance OCR validation with expiry and plate checks • Train vehicle safety scoring model using uploaded photos • Create ML based anomaly detection for NFC fraud and unsafe travel • Develop parent app (wallet, bus selection, notifications) • Develop driver app (verification, trip handling, safety status) • Build child to parent VoIP communication module. • Integrate blockchain hashing for boarding, drop off, anomalies, driver score, and payouts • Build virtual earnings + payout request workflow • Implement background ML tasks: clustering, forecasting, safety score prediction	A unified trust architecture combining NFC identity, ML verification, and blockchain hashing to create tamper-proof safety records without exposing personal data.
IT22610102 R.I.S.R. Pinto	To ensure passenger safety during disembarkation and monitor driver	• Develop "The Exit Guardian" to detect footboard travel and jump attempts.	The proposed system introduces two key novelties: "The Exit Guardian," a geometric computer vision module that tracks a passenger's Center of Gravity to

	vigilance using real-time computer vision on edge devices	• Implement "AI Co-Pilot" for Driver Distraction (Phone) and Fatigue monitoring. • Optimize Deep Learning models for high-angle A-Pillar deployment. • Develop real-time alert logic for critical fall-risk scenarios.	differentiate between safe standing and critical leaning out, thereby preventing footboard accidents; and a novel "Side-Angle Domain Adaptation" technique, which adapts standard driver monitoring AI models trained on frontal car views to function effectively from the oblique A-Pillar angle of a bus through geometric perspective correction.
IT22600134 A.M.D.C. Kumara	This research develops a smart school bus system that uses daily parent updated present/absent status and pickup/drop off changes to create safe, optimized routes and accurate arrival predictions. It verifies student boarding and drop off; alerts staff about missing students or delays and suggests backup vehicles during breakdowns. Daily operational data trains a machine learning model to	• Build real time face detection & recognition for student exit . • Implement “missing student” detection when expected child does not board • Create optimized routing engine using VRP + traffic aware ETA prediction • Build automatic low risk route selection using hazard and road condition scoring • Develop delay detection module using live GPS, traffic feed, and event triggers • Send real time notifications to parents for ETA, delays, and emergencies • Build backup vehicle recommendation module for bus breakdowns. • Train ML model using daily data to predict late arrivals and congestion patterns • Develop driver app (route guidance , emergency reporting) • Build operations dashboard for staff (live bus tracking, alerts, risk analysis) • Implement automatic reporting: delay	This system provides dynamic, parent driven routing, real time student validation, and AI based delay prediction. It improves school transport safety by generating personalized routes each day, alerting parents to delays, and suggesting backup vehicles during breakdowns. Its predictive analytics make it more intelligent and innovative than traditional fixed-route systems.

	predict future delays and recommend preventive actions, making school transport more automated, reliable, and safety focused.	summary, route performance • Create ML pipelines: clustering, forecasting, risk prediction, anomaly scoring • Build secure cloud backend for student data, trip logs, and route history	
IT22606624 T.A.P.K.Shameera	To design and develop the AI powered child monitoring, behavior analysis, and safety alert subsystem for the smart school transportation platform. This includes real time student behavior recognition, fall/down detection, hand out of window detection, and driver student safety interactions using machine learning and predictive analytics.	• Collect an annotated dataset of student behavior (sitting properly, unsafe movements, hand outside bus, harassment indicators, falls). • A system that automatically alerts parents when the school bus encounters an accident or experiences a technical malfunction, ensuring timely awareness and improved student safety. • Develop CNN based and transformer based models for gesture recognition and safety risk detection. • Implement fall detection and harassment indicator models using posture estimation. • Create the real time ML inference pipeline for bus mounted CCTV/IoT camera streams. • Integrate emergency alerts to parent app and conductor dashboard. • Evaluate model performance with precision, recall, F1-score, and real time processing latency.	System designed to automatically notify parents if the school bus faces an accident, mechanical problem, or unsafe driving conditions such as excessive speeding helping ensure quick awareness, real time monitoring, and better safety for students.

		• Optimize models to run efficiently on the onboard edge device (Raspberry Pi). • Document the AI subsystem and contribute to the final integration with backend + parent app.	

9. Individual component description of how it is complied with the specialization.

Member Name with Registration No	Description
IT22590312 M.H.S. Akther	This component aligns with the IT specialization by integrating secure identity verification, backend service orchestration, and trust driven data management. It applies NFC based student validation, ML based driver and vehicle verification, and blockchain-backed event hashing to ensure secure and tamper-proof operations. The module incorporates mobile application development, anomaly detection, OCR processing, and digital wallet workflows, demonstrating practical use of distributed systems, machine learning, and secure system design within modern IT ecosystems.
IT22610102 R.I.S.R. Pinto	This component aligns with the IT specialization by applying computer vision and real-time edge processing to enhance passenger safety and driver monitoring. It uses geometric vision techniques, fatigue and distraction detection, and optimized deep learning models deployed on embedded devices. The module demonstrates expertise in image processing, real-time inference, IoT enabled safety systems, and the application of intelligent computing to reduce disembarkation and driving risks.
IT22600134 A.M.D.C. Kumara	This component aligns with the IT specialization through the development of intelligent routing, predictive analytics, and real-time transport management. It applies data structures, GPS/IMU integration, ETA prediction, delay analysis, and emergency rerouting algorithms to optimize daily school transportation. The use of machine learning for delay prediction and backend-engineered routing logic demonstrates applied data science, systems engineering, and practical IT-based problem solving.
IT22606624 T.A.P.K. Shameera	This component aligns with the information technology specialization by integrating advanced computer vision, machine learning, and real-time safety analytics to enhance child protection during school transportation. It applies AI based behavior recognition, fall and unsafe movement detection, and predictive risk analysis to identify potential safety threats inside the bus. The subsystem utilizes CNN and transformer models, posture estimation algorithms, and edge based inference to generate immediate alerts and improve student safety, demonstrating strong practical application of IT, AI, and IoT.

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor				
Co-Supervisor				
External Supervisor				
Summary of external supervisor's (if any) experience and expertise				

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Staff members.</u>

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes		No	

b) Does the proposed topic exhibit novelty?

Yes		No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes		No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes		No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

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Topic Assessment Form

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

Staff Member's Name	Signature

*__Important__:

1. According to the comments given by the evaluator, make the necessary modifications and get the approval by the **Evaluator**.
2. If the project topic is rejected, identify a new topic, and request the RP Team for a new topic assessment.