Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

A mobile GIS framework for improving the security of school vehicles

Archita Chakraborty[a], Arindam Dasgupta[b], Prashant Prasad[c], Soumya K Ghosh[d], Bhargab Maitra[e]*

[a]*MS Research scholar, RCG School of Infrastructure Design and Management, Indian Institute of Technology, Kharagpur-721302, India*
[b]*Research scholar, Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur, Kharagpur-721302, India*
[c]*Research scholar, RCG School of Infrastructure Design and Management, Indian Institute of Technology, Kharagpur, Kharagpur-721302, India*
[d]*Professor, Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur, Kharagpur-721302, India*
[e]*Professor, Department of civil engineering, Indian Institute of Technology, Kharagpur, Kharagpur-721302, India*

Abstract

A secured transportation system is one of the most important factors for the socioeconomic growth of a country. Every day millions of children undertake school trips using different modes of transportation. The parents rely mostly on using private vehicles for transferring their children, due to lack of reliability and safety-security issues associated with the shared modes of school transport. Also, limited road capacity and increment of vehicular volume always act as significant reasons for traffic congestion. Therefore, the use of shared modes such as school bus and shared cab for school trips is being encouraged. On the other hand, security while using shared modes is a major concern with the absence of any mechanism to monitor the vehicle and share information with their parents. The aim of the present study is to design a system to monitor school children while commuting in school vehicles and to update parents and concerned authorities in real time. In this regards, a radio frequency-based technology along with GPS system is utilized to develop the desired framework. Moreover, the system is designed to track the travelled path of the vehicle and send the map to parent's mobile phone, respective school, and local police station. This can also send out SMS to concerned parents with real-time information regarding child's boarding and alight time and location. Thus the system developed in the present study is expected to address security concerns of parents with regards to shared school vehicles and thereby encourage them to use these modes.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Safe Transportation; RFID ; School children; GPS; School vehicle monitoring

* Corresponding author. Tel.: +91-943-404-0738.
E-mail address: bhargab@civil.iitkgp.ac.in

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

1. Introduction

The rapid urbanization (MHA, 2011; MoRTH, 2013) and associated externalities such as traffic congestion, vehicular emission, issues related to safety-security, are major concerns for transportation planners across the globe. Owing to the limited physical space, the augmentation of road capacity is often restricted in developing countries such as India (Chandra et al., 2003). Use of public transportation is considered as one of the solutions to the increasing congestion in urban areas (Maitra et al., 2014, Maitra et al., 2013; Prasad et al., Working paper). School trips in urban areas are one of the major contributors to traffic during peak hours. In this regard, the use of shared modes of transportation, such as school buses and shared cabs is likely to reduce congestion. However, due to the lack of safety and security in the shared modes of school transportation, and increased affordability and aspiration to own car among the young population, private cars are presently gaining popularity for school trips. According to a recent study carried out in the Indian metropolitan city Kolkata, safety and security has emerged as the major concerns for parents while sending their children by shared modes of transportation (Prasad et al., working paper).

The two predominant shared modes for school trips, school-bus and shared-cab, face several security issues such as children getting locked in the vehicle at parking, children missing during the trip, boarding wrong vehicle, or alighting at wrong stop, etc., with no method to track them (Shaaban et al., 2013). Also, there is no mechanism for parents to know if and when their child has reached the school safely. This generated the necessity for a system to monitor the school vehicles and keep the school authority, as well as, parents informed of the real-time status of the children while commuting in the school vehicles.

The present work aims to develop a system to keep track of school children while commuting in school vehicles and to update parents and concerned authorities in real time. Several existing technologies are combined in the system to (i) track the boarding and alighting data of children along with their location and time and then transfer the data to parents and concerned authorities in real time with the use of Radio-Frequency Identification (RFID) and Global Positioning System (GPS) , (ii) use of Short Message Service (SMS) to inform parents of the boarding and alighting of their child in real time, and (iii) real-time storage of the data in a central server for future investigation.

The remainder of the paper is organized into four sections. A review of presently available technology for enhancing security is discussed briefly in section 2 along with a brief discussion on the technology adopted for the present work. Section 3 articulates the system architecture. The implementation of the system with a case study and results are presented in section 4. Section 5 discusses the conclusions of the present study and scope for future work. Technology for Enhancing Security

2. Technology for Enhancing Security

The existing technology used for the security of the school vehicle and other related transportation and their findings are discussed below. The main objective and the technology used for the proposed system is also illustrated in the current section.

2.1. Existing technology for enhancing safety

RFID technology is a reliable and smartly utilizable technique which can ensure safety and security of an item on which it is attached. The stable and dependable feature of RFID made it a popular technology in present times through many interventions such as tracking by means of physical-layer fingerprints etc. (Zanetti et al., 2011). It gave acceptable privacy protection and integrity assurance (Jules, 2006) and it is cost effective too (Nath et al., 2006). The technology is used in healthcare services to improve safety of patients and achieve operational efficiency (Yao et al., 2010). A real-time vehicle monitoring system for hazardous goods is developed by using RFID and Global Positioning System (GPS) technology by Yu et al., (2012). The functions of data acquisition in real time, positioning, tracking and monitoring of transportation are included here.

Several researchers worked on the secured transportation of school children as it is a very crucial and emerging issue (Committee on Injury, Violence, and Poison Prevention, 2007; Rhoulac, 2005). An IoT (Internet of Things) based school bus monitoring system is developed with using Message Queuing Telemetry Transport (MQTT) connectivity protocol where the internet is expanded to reach the location and speed sensors connected to it, so that

they can transmit the location and speed of school transportation (Zambada et al., 2015). Sanam et al., (2016) illustrates a safety system for the school bus, which monitors the time of boarding and alighting of every child in a school bus and allows only authenticated person inside the bus. In another work, firstly the safest routes are considered for children to reach the bus stop. Then this work used alert light on arrival and departure of the children to the bus stop (Ramachandran et al., 2016). Again, one more set up is found in a system where a passive or active tracking device with GPS is used to hold GPS receiver with an SD card holder which stores GPS location, speed and time. (Kamaraj et al., 2016).

All the above discussed systems require a complex set up for monitoring a school vehicle. These studies also indicate that only few vehicles can be monitored through their proposed frameworks. However, in the case of school vehicle monitoring a large number of children traveling in several vehicles need to be monitored simultaneously. As the number of school going children are likely to increase over the years, a porting and robust system for computing and providing useful results to the end users should be developed to take care of any number of students. The present paper demonstrates a simple and easily implementable system architecture which is capable of real-time tracking of large number of students individually and storing all the related information in a server for future observation.

2.2. Objective

The main objective of the proposed system is to build a framework which would provide security to the school vehicles and the children. This will be done by monitoring the vehicles on the transit time of the children during boarding and alighting. This system also intends to inform the parents through SMS and show the travelled path of the vehicle using GPS. Another objective is to use simple and easily available technologies such as mobile, GPS data, Bluetooth etc. for framing the system.

2.3. Technology used for the proposed system

The following three existing technologies are combined to develop the proposed system, (i) RFID reader, (ii) GPS tracker, and (iii) Bluetooth device and SIM/WI-FI based communication system.

RFID reader

A Radio-Frequency Identification (RFID) system is made up of two parts: a tag or label and a reader. RFID tags or labels are embedded with a transmitter and a receiver. The RFID component on the tags has two parts: a microchip that stores and processes information, and an antenna to receive and transmit a signal (Source: https://www.epc-rfid.info/rfid). The tag is programmed with information which is to be read by a two-way radio transmitter-receiver called an interrogator or reader. This reader emits a signal to the tag using an antenna. The tag responds with the information written in its memory bank. The interrogator will then transmit the read results to an RFID computer program (Source: http://www.byte-technologies.com/rfid.html). The RFID technology uses radio waves to read and capture information stored on a tag (RFID tags). RFID tags are intelligent barcodes that can talk to a networked system to track any object on which it is attached to. In the present context it is used to track children in school vehicles. Fig 1(a) shows the RFID tag and fig 1(b) shows the configuration of RFID.

a b

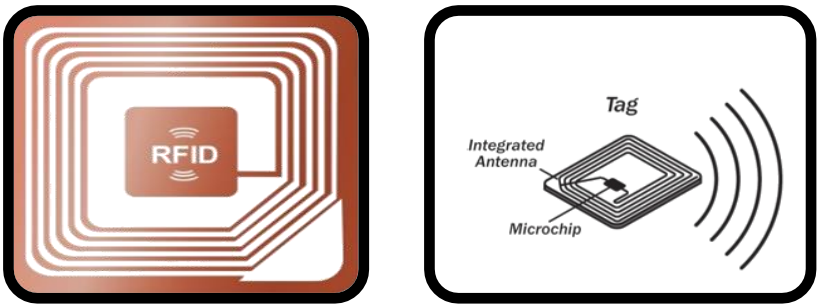


Fig. 1. (a) RFID tag; (b) RFID Configuration

GPS tracker

GPS tracker is a navigation device, normally carried by a moving vehicle or person that uses the Global Positioning System (GPS) to track the device's movements and determine its location. The recorded location data can either be stored within the tracking unit or transmitted to an Internet-connected device using the cellular (GPRS or SMS), radio, or satellite modem embedded in the unit. The location of the object is displayed against a map in backdrop either in real-time or when observing the data later.

Bluetooth device and SIM/WI-FI based communication system

Bluetooth is a short-range wireless communications technology standard for exchanging data over short distances using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz from fixed and mobile phone devices, and building personal area networks (PANs).

SIM/ Wi-Fi-based data communication is used for sending the location related information to the server. Here SIM900 is used. It is an ultra-compact, reliable, wireless, and complete Quad-band GSM/GPRS module in a SMT type and is designed with a very powerful single-chip processor integrating AMR926EJ-S core module. It allows us to benefit from small dimensions and cost-effective solutions and supports performance for voice, SMS, Data, and Fax in a small form factor with low power consumption. It needs a very tiny space configuration of 24mm x 24mm x 3 mm for which it can fit almost all the space requirements, especially for slim and compact demands of design.

3. System Architecture

The architecture is designed for the present study to store the information related to the transit of the school vehicle comprises of a server which is a system controller, databases, monitoring system, and decision maker. Fig 2 illustrates the components of the setup.

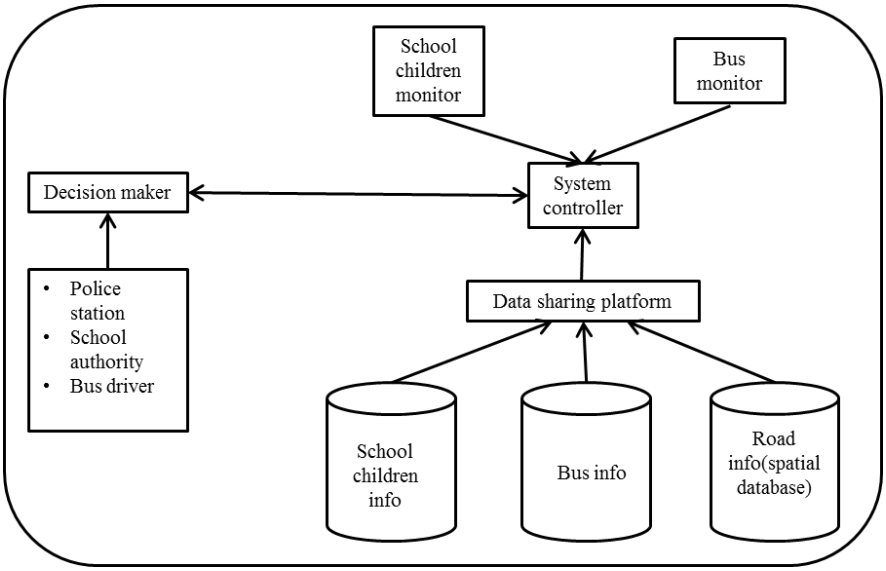


Fig. 2. System architecture of the framework

The following components are used for the system:

System controller

System controller is the unit which acts as the main server of the setup. Data from various components such as school children monitor, bus monitor, data sharing platform, decision maker are sent to the system controller. The server stores and computes the data and reflects it on the website and the mobile phone.

School children monitor

The school children are monitored through their RFID based ID card. The children tapped their ID cards while boarding on the bus and RFID no. are sent to the android app installed in a mobile phone located on the bus. Then the app starts sending the location of the student to the server. Again, when children tapped their ID cards at the time of alighting from the bus, the server stops tracking the location.

Bus monitor

This component is responsible for extracting GPS value and to transfer it to the data server. It continuously checks the GPS value and if it changes from its predefined value then the updated value will be transferred.

Decision maker

A decision maker is either equipped with a mobile device or a desktop monitor. This device extracts the location of the vehicle during transportation. The extracted data is reflected in the server for the local traffic police department and school authority to monitor the vehicle. In addition, if any uneven situation is detected by the system controller, then the system generates alert message and the location of the vehicle is sent to the traffic police department. The predefined alert messages are linked with various complex situations such as traffic congestion, over speed, adverse environment etc. Further, if a child wishes to get off the bus in an unusual location then the system immediately sends a message to the parents and school authority. In this case, the child would wait for the

message from both school authority and parents. The child will be allowed to alight from the vehicle only after receiving a confirmation message from his/her parent.

Databases

In this work, a database schema is developed to capture children's security-related information. It stores the location information of the vehicles and students during their transit time. It also stores different predefining text messages which would be activated if any uneven condition arises. The following table schemas are used in the database.

- Sms in (Id, Sms Text, Sender Number, Sent Date)
- Admin Info (Username, Password, Security Ques, Security Ans)
- Bus Logger (Log Id, Bus Regn No, Latitude, Longitude, Location Name, Date Time)
- Tb Check In (Rf Id, Check In Date Time, Check In Place, Check Out Date Time, Check Out Place, Bus Regn No)
- Student Info (Rf Id, Student Id, Password, Student Name, Guardian Name, Mobile, Email, Reporting Bus Stop)
- Message (Message Id, Message Type, Message Text)

All the data retrieved from the databases are integrated at the data sharing platform and sent to the server.

4. Implementation

The components used for the proposed system are described below.

4.1. Experimental set-up

A child has to register on the website by giving all required information including guardian's mobile phone number. The website is accessible only by the administration that could be an authorized person from the school and the police station. The android app is used for connecting the RFID via Bluetooth which is located on the bus. Also, the driver is able to check the current location of the school bus from the map within the app. The time interval of sending SMS notification to parent's cellphone can be set from the website. The Fig 3 shows the data transfer among all the components in the system.

Fig. 3 Data Transfer from RFID card to Server

4.2. Working principle of the set up

This application tracks the school children during their travel by school vehicle. Each child carries an RFID attached Identity card with them. The child touches his/her identity card to the RFID Reader which is located on the vehicle while boarding. The Bluetooth enabled RFID reader sends the RFID number to the registered mobile phone through Bluetooth. The mobile phone which is located on the vehicle send the RFID number to the server through GPS. The server receives the RFID number and maps it with the database. The server then starts to track the location of the child until he/she touches the IDENTITY CARD to the RFID reader again on the time of alighting. When the child touches the identity card to the RFID reader again, the server stops tracking the location of the child. All location points travelled by the child are recorded on the server along with date and time. During the transit time, the parent, as well as the school authority and police station is aware of the current location along with date and time of the child by using SMS facility or by seeing the location in the map or from the desktop by using the website.

4.3. Case study

For studying the system in real life scenario, a case study was carried out by considering the buses of a few schools located within the Indian Institute of Technology Kharagpur, India campus. The app was installed on a mobile phone and located on the bus which was transferring students from their bus stops to the school. Each of the students were given RFID tagged ID card and were instructed to tap their ID cards while boarding and alighting the bus. Their locations were sent to the server and analyzed. SMSs were sent by the server to the registered mobile phone numbers against each ID card at the time of boarding and alighting from the bus. Also, SMSs were sent in a regular time interval which was predefined from the server. The location was updated in the smartphone app as well as in the server and the website. Fig 4 shows the student registration form and the android app.

Fig. 4. (a) Student registration form in the website; (b) Android app to be installed in the bus

4.4. Experimental result

The overall set up used for this prototype was very easily maintainable by all the users such as the children, parents, schools, and police. Moreover, all the components used were cost effective and easily available. By installing some simple set up, school administration and the police could see the current location of each and every student on the bus. If the police notice the vehicle standing in an unusual location for a long time then they may investigate about the vehicle and the students. Parents got a notification through SMS containing the current location of their children and a hyperlink by clicking which the location can be seen on the map. They also knew if their children got down from the bus in an unusual location. The travelled path was stored in the server with date and time for future study purpose. Fig 5 and Fig 6 illustrates the website interface of tracking the vehicle and how the bus information is stored on the server respectively.

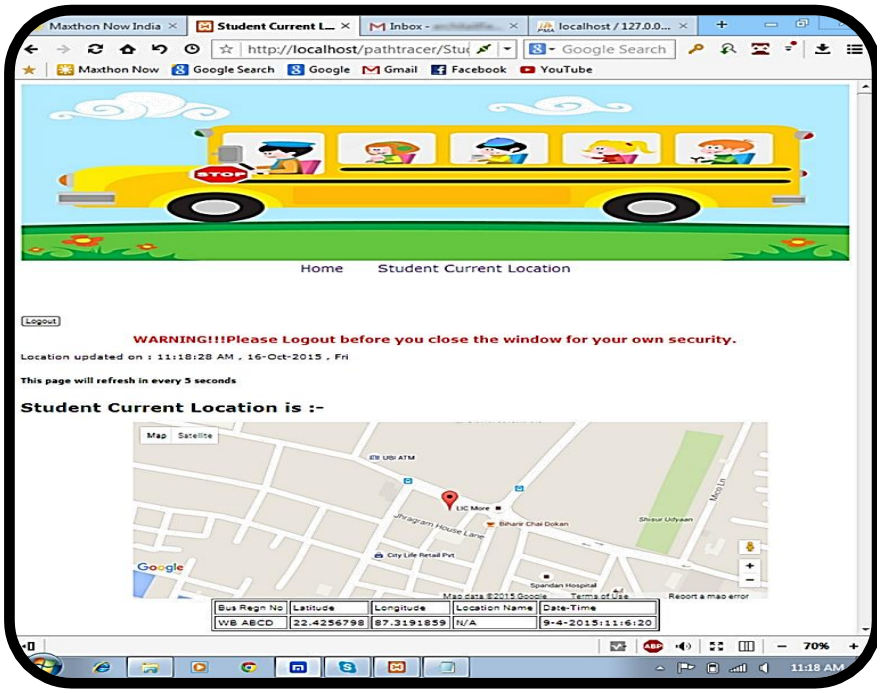
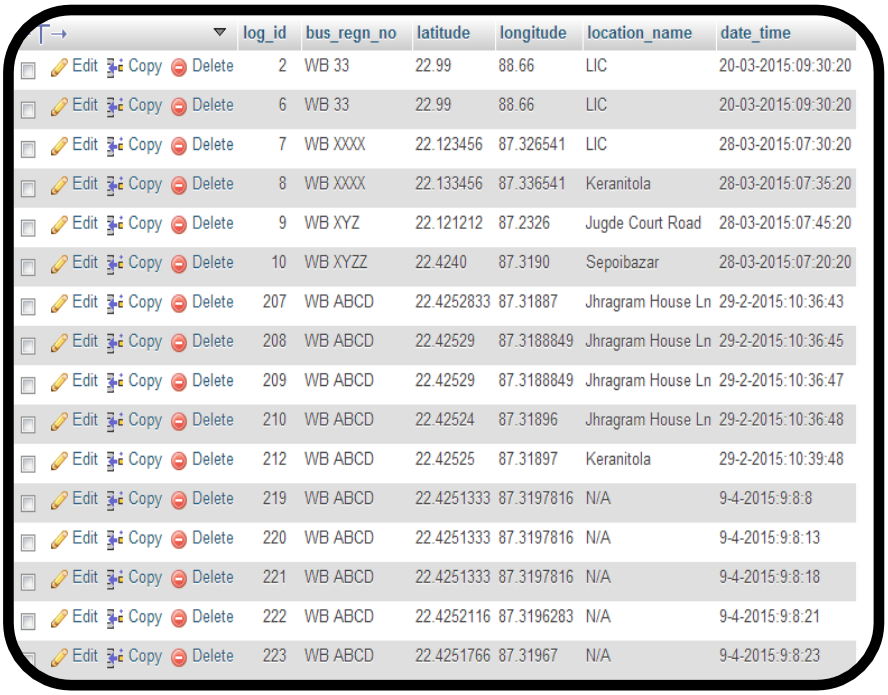


Fig 5. Tracking website interface



	log_id	bus_regn_no	latitude	longitude	location_name	date_time
Edit Copy Delete	2	WB 33	22.99	88.66	LIC	20-03-2015:09:30:20
Edit Copy Delete	6	WB 33	22.99	88.66	LIC	20-03-2015:09:30:20
Edit Copy Delete	7	WB XXXX	22.123456	87.326541	LIC	28-03-2015:07:30:20
Edit Copy Delete	8	WB XXXX	22.133456	87.336541	Keranitola	28-03-2015:07:35:20
Edit Copy Delete	9	WB XYZ	22.121212	87.2326	Jugde Court Road	28-03-2015:07:45:20
Edit Copy Delete	10	WB XYZZ	22.4240	87.3190	Sepoibazar	28-03-2015:07:20:20
Edit Copy Delete	207	WB ABCD	22.4252833	87.31887	Jhragram House Ln	29-2-2015:10:36:43
Edit Copy Delete	208	WB ABCD	22.42529	87.3188849	Jhragram House Ln	29-2-2015:10:36:45
Edit Copy Delete	209	WB ABCD	22.42529	87.3188849	Jhragram House Ln	29-2-2015:10:36:47
Edit Copy Delete	210	WB ABCD	22.42524	87.31896	Jhragram House Ln	29-2-2015:10:36:48
Edit Copy Delete	212	WB ABCD	22.42525	87.31897	Keranitola	29-2-2015:10:39:48
Edit Copy Delete	219	WB ABCD	22.4251333	87.3197816	N/A	9-4-2015:9:8:8
Edit Copy Delete	220	WB ABCD	22.4251333	87.3197816	N/A	9-4-2015:9:8:13
Edit Copy Delete	221	WB ABCD	22.4251333	87.3197816	N/A	9-4-2015:9:8:18
Edit Copy Delete	222	WB ABCD	22.4252116	87.3196283	N/A	9-4-2015:9:8:21
Edit Copy Delete	223	WB ABCD	22.4251766	87.31967	N/A	9-4-2015:9:8:23

Fig 6. Bus logger table in the server

5. Conclusion

The present paper discussed several technologies used to enhance the safety and security of commuters. A few existing technologies were used advantageously to enhance the security of school children in shared modes of school transport (i.e. school bus and shared cab). A tracking system was developed using RFID, GPS, and Bluetooth device & SIM/WI-FI based communication. The implementation/ installation of the proposed setup is simple and it was demonstrated successfully in a school bus. Furthermore, the system works in real-time providing a higher sense of security and satisfaction to the parents. The proposed tracking system is implemented on a case study basis to present a successful demonstration. The outcomes of the present paper is expected improve the security of school vehicles and emphasize the use of shared modes for transfer of school children in order to minimize vehicular congestion and emission.

The finding and recommendations from the present work would help to improve the attractiveness of school-bus and shared-cab for school trips. However, it will be necessary to carry out further investigation to understand the willingness to pay for the proposed system and the impact of improvement on mode share for the school bus and shared cab. Furthermore, a system to alert the driver about poor fitness level of vehicles, probably near miss traffic incidents due to other vehicles nearby, etc. may be developed in continuation of the proposed framework. Although the proposed system tracks school vehicle and children, the similar framework may be applied in other fields of transportation to track vehicles and use the information advantageously for other users.

6. Acknowledgements

The authors would like to acknowledge the Ministry of Human Resource Development (MHRD), Government of India, for partially funding this research work.

References

Chandra, S., Kumar, U., 2003. Effect of lane width on capacity under mixed traffic conditions in India. Journal of transportation engineering, 129.2, pp.155-160.

Committee on Injury, Violence, Poison Prevention, 2007. School transportation safety. Pediatrics, 120.1, pp.213-220.

Juels, A., 2006. RFID security and privacy: A research survey. IEEE journal on selected areas in communications, 24.2, pp.381-394.

Kamaraj, A., Radha, K., Priyanka, M., Punitha, M., 2016, March. Intelligent transport system using integrated GPS optimized reader. In Science Technology Engineering and Management (ICONSTEM), Second International Conference on IEEE, pp. 332-336.

Maitra, B., Dandapat, S., Chintakayala, P., 2014. Differences between the perceptions of captive and choice riders toward bus service attributes and the need for segmentation of bus services in urban India. Journal of Urban Planning and Development, 141.2, p. 04014018.

Ministry of Home Affairs, 2011-2012.

Ministry of Road Transport & Highways, 2013.

Nath, B., Reynolds, F., Want, R., 2006. RFID technology and applications. IEEE Pervasive Computing, 1, pp.22-24.

Prasad, P., Cheranchery, M.F., Maitra, B., (working paper). Identifying Strategies for Encouraging the Use of Shared Modes for School Trips, (No. 18-02695).

Ramachandran, M., Sahandi, R., Prakoonwit, S., Khan, W., 2016, August. Intelligent Safety Transport Framework for Schools: A Review of Route Planning and Tracking Systems. MATEC Web of Conferences.

Rhoulac, T., 2005. Bus or car?: The classic choice in school transportation. Transportation Research Record: Journal of the Transportation Research Board, (1922), pp.98-104.

Sanam, A.M. , Sawant, S.D., 2016, August. Safety system for school children transportation. In Inventive Computation Technologies (ICICT), International Conference on IEEE, Vol. 1, pp. 1-5.

Shaaban, K., Bekkali, A., Hamida, E.B., Kadri, A., 2013. Smart Tracking system for school buses using passive RFID technology to enhance child safety. Journal of Traffic and Logistics Engineering, 1.2, pp.191-196.

Yao, W., Chu, C.H., Li, Z., 2010, June. The use of RFID in healthcare: Benefits and barriers. In RFID-Technology and Applications (RFID-TA), IEEE International Conference, IEEE, pp. 128-134.

Yu, M., Deng, T., Fu, J., 2012, June. Application of RFID and GPS technology in transportation vehicles monitoring system for dangerous goods. In Remote Sensing, Environment and Transportation Engineering (RSETE), 2nd International Conference on IEEE, pp. 1-4.

Zambada, J., Quintero, R., Isijara, R., Galeana, R., Santillan, L., 2015, October. An IoT based scholar bus monitoring system. In Smart Cities Conference (ISC2), IEEE First International, IEEE, pp. 1-6.

Zanetti, D., Sachs, P., Capkun, S., 2011, July. On the practicality of uhf rfid fingerprinting: how real is the rfid tracking problem?. In International Symposium on Privacy Enhancing Technologies Symposium, pp. 97-116, Springer, Berlin, Heidelberg.

Maitra, B., Sadhukhan, S., 2013. Urban public transportation system in the context of climate change mitigation: Emerging issues and research needs in India. In Mitigating climate change, pp. 75-91. Springer, Berlin, Heidelberg.