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Review Article

Smart School Bus Monitoring and Notification System using Rfid and Gps

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ABSTRACT

The Internet of Things (IOT) as a paradigm promises to make things including consumer electronic devices or home appliances such as medical devices, fridges, cameras, and sensors part of the internet environment. Within this paper, the design of an IOT-based solution of smart school bus monitoring that provides SMS notification in real-time has been proposed together with its prototype development. The system allows parents and schools to track the condition and safety of children by using a combination of Radio Frequency Identification (RFID) and Global Position System (GPS) technologies connected to a remote server using GSM/GPRS technologies through Arduino Uno and Arduino IDE. This resulted in a Smart School Bus (SSB) system consisted of six main components and seven sub-components to solve one of the key challenges in the City of Kigali with no trustworthy system in place that can monitor school buses and be able to provide real-time information for children's locations while commuting to school. The practice of diverse devices, communication rules for software features, and security instruments was a hard encounter which SSB system faces and should balance to provide its features and ensure responsive services.

Keywords: RFID; GPS; Bus monitoring; IOT; Internet of things

INTRODUCTION

Every day millions of children need to travel from home to school and vice versa. For parents to obtain safer transport for their children is sometimes a critical issue. Crime against children is increasing every day, especially in developed countries [1]. Children in the world employ an excessive time travelling to and from school. In the United States of America, more than 25 school bus tracking apps are in place in 2019 [2], to help concerned parents about their children to know where their children are located. Those platforms provide school bus information of their children to parents: a bus is running late, to get an estimated time of its arrival, bus map location, notification if it is behind the schedule, and alert in case of emergency [3]. With specialized trackers, all children transport stakeholders could continuously see where their children are non-violent, and so on. As an alternative to providing the information just to parents, these apps offer services to school administration of keeping track of their students, and bus companies use them to expand their safety and to provide better service.

In South Africa, vehicle tracking services represent a multimillion-rand industry including solutions for tracking children to school [4]. "TrackSchoolBus" is one of them and is currently used. The platform has a parent app with the following key features: School bus attendance to view complete and precise school bus attendance of the children anytime from anywhere without contacting authorities. Real-time location and notifications help you to pick the children from their respective bus stops at right time and generates complete details of the school bus journey of the children. Leave management to apply leave for the children if needed without contacting school management. View schedule route to visualize the detailed view of the scheduled route of the school bus trip and receive a notification of any changes or updates in the scheduled route. Bus stops re-assignment to change the pickup/drop-down point of the children *via* an app without much hassle if any relocation is needed. Lastly provides communication with school management and drivers *via* an app [5].

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In East African region, specifically in Tanzania solution like School bus tracker is in place. Children's whereabouts at your fingertips provide child safety as a top priority to any concerned parent. Parents need to know their children are safe while in transit to and from their respective schools. It makes sense to have a GPS vehicle tracking system installed in school buses to ensure the safety of children to add value to education services [6]. In Rwanda, during school time every day children risk many challenges like extended travel times, overloaded buses, long bus stop waiting times, late arrival and departure, taking the wrong bus, get out to the wrong bus stop, etc. These challenges faced by children during their trip to and from school result in a problem for many parents due to the lack of enough information on their school bus system. The only solution parents have for those challenges is to make calls to different individuals like a bus driver, teacher, school administration, other parents, neighbors, or doing nothing and wait until the children returned home safely in the evening. In some cases, this can result in blaming children when they are late yet it is not their fault, while in some cases they have waked up early. Such a situation is one of the factors that can affect the performance of students and leads to the poor quality of education in general.

Some parents prefer to use their cars to take their children to/from school but this also is a delinquent to them as they are mostly late to their office or to take their children from school [7]. Some private companies or individuals and/or schools tried to respond to children's transport problem within Kigali by providing colored yellow school buses to indicate that they are dedicated to school transport only, however, issues persisted as no system provides information in real-time to allow parents to track where their children are located during the school time. Another challenge of children transport within Kigali city is its topology that affects at large the way of going and coming of children to and from school definitely, as it is difficult to track school bus due to traffic jam caused by limited and small roads. According to Smart City Rwanda Master Plan [8], an integrated transport app will help to enhance the reliability of public transport including children transport's while also acting as a strategic tool for designing routes and intervals to assist in children's safety.

The Internet of things (IoT) as a paradigm promises to make things including consumer electronic devices or home appliances such as medical devices, fridges, cameras, and sensors part of the internet environment. This paradigm opens doors to innovations that will build a novel type of interactions among things and humans and enables the realization of smart cities, infrastructures, and services for enhancing the quality of life and utilization of resources [9]. IoT can be used in many applications, but in this research, the focus is on monitoring children's location during their trips to and from school.

This paper aims to design and develop a prototype for an IoT-based monitoring system to enable all concerned bodies to have a reliable and secure school transport service to guarantee the security of the children. The system tracks children's locations among the following locations: home, bus stop, inside the bus, and school. It combines RFID and GPS technologies and connects them to a remote server using a GSM/GPRS module and their technologies and provides real-time notification. Different reports showing attendance, incident, pickup time and location, etc. may be generated by the system from the real-time data and make them available through a system to schools, parents, and other stakeholders who are concerned for bus comfort, safety, and attendance, toward providing complete visibility into conditions from home, inside school bus up to school and the way back to school. The system intends to monitor the children's location and provide related information by sending notifications through emails and/or SMSs to different bodies per demand by default and automated notifications as optional.

The scope of the work is to design a hybrid IoT multimodal and simulate or develop its prototype system that can track the movements of a child and keep monitoring his or her location to respond to the parents' concerns after sending their children to school. The system should be able to send a notification to parents and school administration per demand *via* an SMS with the option of automated notification. It has been shown by [1]. that the use of the applicability of RFID technology for tracking and monitoring children during their trip to and from school in school buses, considering its advantage of efficient tracking capabilities, low cost, and easy maintenance can contribute in identifying the presence of children at school. Then that information could be communicated to the parent and school *via* the GSM module. The system does not cover the distance from home to a bus stop.

Children tracking systems are currently adopted in different places worldwide. A system that allows the parents to be notified when their ward alights or boards the bus is developed by Raj and Sankar [10]. The developers made use of RFID and GPS technologies to identify each student and locate a vehicle respectively and connect them to a remote server over Wi-Fi using an ESP8266 microcontroller. The information can be accessed by the parents through a mobile application and this helps parents track their wards effectively. The school administration can also access the application to ensure student safety and contact a driver or a parent. However, the system does not consider child safety between home and bus stops.

The big challenge for parents and different stakeholders concerning children's safety while to and from school is tracing where they are whenever they are not with them. Therefore, considering the local context specifically in the urban area of the City of Kigali, the standalone solution to the above problem is calling individuals or moving to school to inquire about their children's conditions. This is not a viable solution with the current advanced technology as instead, it is time and money-consuming. But so far, there is no other solution. To solve this problem, it needs to provide an adequate real- time platform in Kigali City that can generate information for all those concerned about children's safety while commuting to/from school.

It is in this line, to address the above issue, a solution should be designed as an IoT based smart school bus monitoring and notification system that tracks children from their home to school and the way back and be able to send information about the location of children to all concerned bodies given local context.

context. The system should be able to communicate in real- time *via* SMS in both directions between the system and parents or school administration or bus driver or any other entity concerned. This interaction can be considered as the advantage of the proposed system.

LITERATURE REVIEW

Introduced a system with the use of RFIDs to track children, but the information from RFID cannot provide information on the dangerous situation of the children inside the bus [1]. The platform devised a method to identify the student by using a combination of RFID and GPS technology to track the student locations and alert parents with sent notifications *via* SMS. System notifications are set to be sent automatically which may be a challenge due to the many notifications received nowadays. Presented a system that provides the relevant information about bus numbers from users' source and destination along with the route details and real-time location [11]. Their system used GPS attached to the bus. In their project, UNO is used to program with a Real-Time Clock (RTC), and all information related to the bus (source and destination), can be accessed by users through the android application. Their system could be only consumed by children who know how to use the information generated by the system.

Proposed a similar system "IoT based school bus tracking and monitoring system" where each school bus contains a variety of modules including an On-Board Diagnosis-II (OBD) Module, an RFID Module, and an RFID for each child, DHT22 and a smartphone that acts as a mobile hotspot [12]. This system uses publish/subscribe mechanism. A parent to benefit from it, needs to subscribe each time they want to use the system feature of the publishing/subscribe mechanism, which can be considered as a limitation for some parents, it is not user-friendly.

Developed a school bus monitoring system capable of tracking students in a school bus using a combination of RFID/GPS/GSM and GPRS technologies [13]. In addition to the tracking, a prediction algorithm is implemented for the computation of the arrival time of the school bus. Through an Android application, parents can monitor the bus route and forecast arrival time for the bus. This system did not consider the safety of students between the bus and home.

proposed a system that provides real-time information about various parameters of the vehicle like the location, the route, the speed, the list of passengers, the adherence of drivers to schedule, and much more [10]. The system further allows the parents to be notified when their ward alights or boards the bus. In this system, they made use of RFID and GPS technologies and connected them to a remote server over Wi-Fi using an ESP8266 microcontroller. This system starts counting when passengers enter into the bus, out of the bus it is not its business. introduced a novel multimodal representation learning-based model (MRLM) with two closely related modules trained simultaneously. The global feature representation learning and multimodal feature representation learning. After MRLM is converged, items' multimodal features could be used to calculate users' preferences on items *via* cosine similarity. Through extensive experiments on two real-world datasets, MRLM remarkably improved the recommendation effectiveness in IoT [14].

Introduced Device Profile for Web Simulation (DPWSim), a simulation toolkit to support the development of service-oriented and event-driven IoT applications on top of devices with secure Web services capabilities and seamless integration into the existing World Wide Web. DPWSim allows developers to prototype, develop and test IoT applications using the Device Profile for Web Service (DPWS) technology without the presence of physical devices. It also can be used for collaboration among manufacturers, developers, and designers during the new product development process [15].

Project aims and objectives

The project aims to design a hybrid IoT multimodal system of RFID and GPS technologies connected to the remote server (cloud) and develop its prototype. The system should be able to allow all concerned bodies especially parents to have information related to the location of their children when they commute to and from school in a real-time manner.

Overview of the system

To design an IoT multimodal different hardware and software modules were required. These include the RFID and GPS sensors, GSM/GPRS module, Arduino UNO microcontroller, Arduino IDE, and cloud platform enabled architecture as data. The above-mentioned modules being hardware or software were tested before being used. An IoT system architecture approach specifically a three-layered system architecture was adopted for the realization of the project. RFID and GPS sensors are located at the perception layer and serve as data collection for the system. RFID with its technology for child identification using RFID tag and RFID reader installed in different locations along the way the child passes.

GPS sensor installed in the bus, with its technology, generated the coordinates for each school bus location. GSM/GPRS module was used positioned at the network layer and its role was to send the collected data to the remote server for further processing and send SMSs. Arduino UNO microcontroller integrated all system components being components at the perception layer, at the network layer, and an application layer. The work of the Arduino UNO microcontroller together with Arduino IDE is executed at application layers to serve the system purpose. After gathering all required information for the proposed system design, the work proceeded in the IoT prototype development concerning the three-layered IoT system architecture.

System architecture

The system architecture of the proposed system is composed of 6 main units: Child unit, Home unit, School bus unit, School unit, Cloud unit, and Parent unit (Figure 1).

Child unit: Consisted of the child with his/her RFID card: A card with RFID embedded technology that serves to identify the child. Each child wears his or her card in a manner it can serve its purpose.

Home unit: Consisted of RFID reader and connectivity to a remote server. This unit serves to read the RFID tag on a child while he leaves home and returns back home.

Bus unit: Consisted of a GPS sensor to track the movement of the bus and the speed limit and a GSM/GPRS module to provide a connection to the remote server for GPS and RFID reader and a mobile app of the driver for interact with the application.

School unit: Consisted of RFID reader to read the RFID tag on a child while enters and exits the school premises and connectivity to a remote server, mobile app, and web application for communication and management with the system.

Cloud unit: data engine of the system that provides cloud services such as data storage, security, privacy, and execution of an instruction. It gives the view of data to end-users.

Parent unit: Contained a mobile app and/or a web application connected to the remote Server through the internet to allow a parent to use the application.

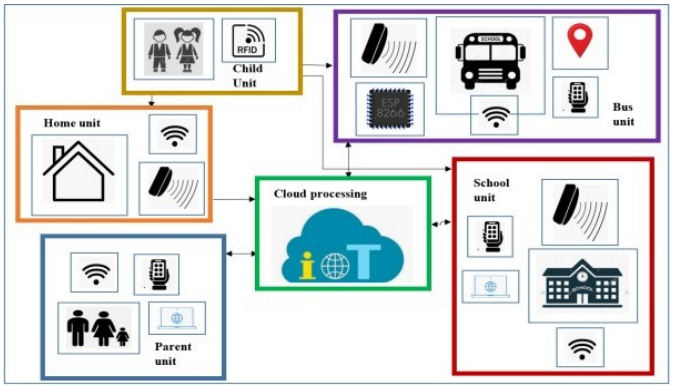

Figure 1: The proposed system architecture.

DISCUSSION

System design

The system combines different components with different technologies; therefore, the system design adopted the multimodal IoT system design which consists of linking different devices, protocols, applications, and platforms. This provided the required interoperability, data privacy, security, interfaces of those different components of the system. The design defined all requirements of the system such as data type to be collected, how the communication among all system's components and system management.

The system design defined the process specifications that the system followed and the information model used by the system. The system design also defined the services of the monitoring system: service types, service inputs/outputs, service endpoints, service schedules, service preconditions, and service effects. The system design defined which IoT level is suitable for the proposed system.

Initially, the system initiated two modules: RFID and GPS modules when it starts, and puts ON GPS inside the bus and activates all RFID readers to be ready to communicate with the server. For the RFID module, the system created encrypted data of the children in the database to identify each child and generated code for each child. The encrypted data is then written to the tag that is carried by the children (the portable card to each child for his/her identification). The RFID module also verified the value on the tag until all tags are successfully encrypted. Once the tag approaches the RFID reader, it compares the card information to the data stored in the database.

This happens when a child passes his or her card to an RFID reader. At that stage, two services are executed, either the tag's value matches with one from the database, then the child is identified and the system recognizes the action and sends the information to the remote server and goes to the next tag, or the tag value is not recognized and the RFID reader notifies the system and the card's owner that the wrong tag is used and go to the next tag. All communications are done through the Arduino microcontroller and GSM/GPRS module or Wi-Fi. All information is stored and executed to the remote server where notification is generated if requested.

For the GPS module, once the GPS is ON, it calculates the location by using the triangulation technique and then sends the information about the bus (location, the engine starts or shut down, speed limit) to the server through the connectivity from GSM/GPRS module or Wi-Fi if the bus has Wi-Fi inside. From the server side, the notification module with its capabilities sends a notification to the dedicated destination when requested.

System algorithm

The system has the objective of monitoring the children while commuting to and from school and send a notification message containing the child's location. To achieve the system target, the system needs to perform three main tasks: identify the child, track the location of the child and send a notification. To realize the purpose of the system, the three main modules are integrated into one microcontroller before sending all data to the server: RFID module for child identification, GPS module for bus tracking, and GSM/GPRS module to provide connectivity.

RFID module uses two objects; RFID tag for child identification and RFID reader to read the data from the tag and send them to the server. The RFID tag is configured with encrypted data in such a way the system recognizes it through an RFID reader. If the tag used is not from the system, the RFID reader should be able to provide a notification of a not recognized tag if else it reads the information and sends it to the remote server through connectivity (Figure 2).

GPS module uses GPS sensor to track bus location and GSM/GPRS module to send location data to the server. Once the bus engine turns on, immediately the GPS starts to calculate the bus

coordinates and the status of the bus engine (engine starts or shut down) and speed limit then sends the information to the remote server.

On a remote server, the application was designed to run all types of instructions/commands from the system's components. If a child's location is requested, the application compares the identification of the child's location request in the database and provides the feedback accordingly.

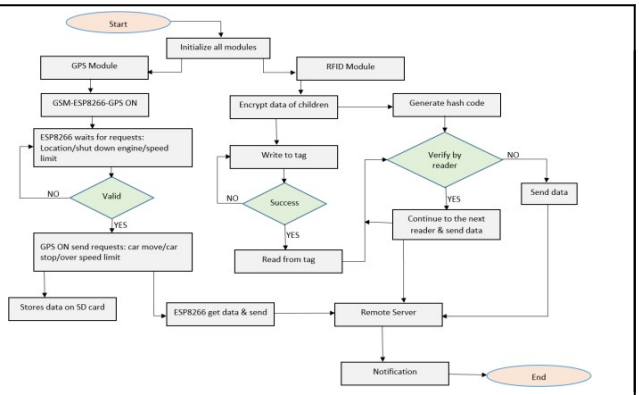

Figure 2: The proposed system algorithm.

System prototype development

One of the specific objectives of this work is to develop the system prototype. The prototype developed consisted of the following IoT components: The RC522 RFID module, NEO-6M-0-001 GPS module, SIM800L EVB, and Arduino Uno microprocessor. The prototype development was based on the system architecture, system design, and algorithm.

The potential impact of the project

Knowing where your beloved ones are located is essential especially when it is done in real-time and links parents and their children. The notification sent to parents will positively affect parents as they can obtain real-time information related to their children's location. School management gains the capability of monitoring and tracking the buses and bus drivers, and this can contribute to large children's safety while they go and come to and from school. Data generated by the system would contribute to further studies or/and future researches. School bus transportation system is improved towards Smart transport which is a component of Smart Kigali the vision of our capital city.

CONCLUSION

The commute of children from home to school and back has always been a source of concern for parents. Bus drivers may not be able to identify all children and do not know in time if any child is missing. In the local context, parents have no way of knowing if their ward is safe until the evening when the bus returns. The project ensures always responsive services to the end-users. The presented SSB system is an answer addressing the communication and interactions among all stakeholders involved in the school bus system with the help of IoT provision automation solutions. The SSB feature serves the possibility of monitoring the children using a school bus from home to school by notifying primarily their parent or anyone else with the permission per request and automatically as an option.

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