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Smart IoT-Enabled Efficient Child Pickup Notifications for Effortless Traffic Flow

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ABSTRACT

Schools and parents are increasingly worried about the safety of school children, both during transportation and elsewhere. Parental delays in picking up kids often lead to extended waits outside school. With no real-time tracking, parents can't monitor their children's movements or receive alerts when they leave safe zones, like school and home. Children might not notice parents' arrivals, worsening traffic and hindering evacuations during emergencies. Parents spend time searching, causing congestion and inefficiency. To tackle this, the Smart Child Pickup Notifications system has been introduced. Using IoT technology, it alerts children when parents arrive, smoothing procedures, possibly easing congestion, and boosting child security. This solution offers a comprehensive solution, addressing safety concerns, refining traffic management, and optimizing child pickups.

Keywords:

Pick-up notification; Child tracking; Notification app; IoT

1. Introduction

Child kidnapping, missing child and child harassment are the world-wide problem related with child safety [1-4]. Children are often targeted as objects of crime in terms of kidnapping, violence, and abuse. So, school-age children, especially early childhood education, are vulnerable to becoming victims [5].

Recently, all over the world, crimes against children are increasing at higher rates and many cases of missing children are reported. Parents are always worried about the possibility of kidnapping their children [6]. Children are often targeted as objects of crime in terms of kidnapping, violence, and abuse. So, school-age children, especially early childhood education, are vulnerable to becoming victims [4,5]. Globally, around 8 million kids disappear each year [5]. Between 2020 and early 2022, 1,509 children in Malaysia were reported missing, with 1,424 eventually found. The others remain either missing or were found dead [7].

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The public schools in Malaysia have the single and double session. The single session school has a morning session, while the double session school has morning and afternoon session. School start time and end time are varying for each school. According to Osman, S. [8], typically, the morning session runs from 7.30am to 1pm while the afternoon session lasts from 1.15pm to 6.45pm. Students and teachers may also attend school on Saturdays for co-curricular activities. Usually, the school kids inform their parent that when is the time of the school is over and their parent drives the vehicle to go pick up them at that time.

Nowadays, the schools and the parents are very much worried about their school children for school transport and other places [9]. Parent might late to pick up their kid at the school which cause the kid to wait longer outside the school. Parents were unable to track the whereabout of their children and even get the notification when their children exit the safe place, particularly their school and home [10].

Sometimes, the kid is not alerted and realized when the parent is arrived to fetch them. The child pick-up behaviour of parents during an emergency can cause heavy traffic congestion and failing to evacuate an affected area successfully [11]. Parent might need to spend time to look for the kid. Both situations can cause traffic congestion in the school area, besides wasting time waiting and searching for the kid.

Internet of Things (IoT) is one of the keys for IR4.0 which uses a network of interconnected devices to deliver data via the Internet [12]. This revolutionary concept involves linking everyday objects to the internet, enabling them to interact and perform various tasks [13]. Recognizing the need for Smart Child Pickup Notifications to address child missing issues and enhance traffic management [14], a Smart IoT-Enabled Efficient Child Pickup Notifications system is introduced. This system aims to notify children when their parents arrive, streamlining the pickup procedure and potentially contributing to a reduction in traffic congestion, while also mitigating concerns related to children's security.

2. Related Works

This project involves a children's security and tracking system that utilizes Bluetooth and GPS technology. The purpose of this device is to assist parents in locating their children, especially in cases of their whereabouts being unknown. The device is designed to trigger an alarm notification on the connected smartphone when the Bluetooth connection is disrupted. Through the GPS module, the device retrieves its coordinates and transmits them to the smartphone for monitoring [15].

The E-Monitoring application was designed to facilitate child tracking through a mobile tracking system. When children venture outside their homes, they are provided with a mobile device that utilizes satellite tracking via GPS. This application is designed to retrieve and utilize latitude and longitude coordinates to determine the child's location and enhance their safety [16].

This system involves two primary actors: parents and children. They are linked together using a smartwatch and smartphone. Children utilize the smartwatch while parents use the smartphone. Both devices are internet-connected, facilitating the real-time transmission of tracking data between them. This linkage ensures synchronized data exchange [17]. This child monitoring application with geofence facilities was built using the unified software development process (USDP) method. USDP is divided into 4 stages, namely Inception, Elaboration, Construction, and Transition. This application is designed to assist parents in monitoring children's movements in real-time.

The system is built on Arduino and uses a commercial GPS receiver to compute the position of the child continuously. The child's position information is periodically sent through GSM to the parent's smart phone. This can help the parents and the school authorities to monitor the children when they leave the school or they go missing [18].

A child tracking system has been created by integrating various technologies into a hip belt worn by the child. This system enables parents to track their child regularly using their mobile phones. The tracking functionality extends up to a range of 50 meters. The system has undergone successful testing, demonstrating proper signal channel functionality [19].

A modern solution employs GSM technology to protect children, addressing social concerns without making them feel abandoned. This approach integrates GSM, sensors, and a panic button into a wearable IoT device, offering genuine benefits for children's safety. The proposed IoT device connects to a mobile app, allowing parents to set up a Geo-fence around the child's location. With a built-in GPS module, parents can monitor the child's position in real-time. If the child crosses the Geo-fence, an instant notification alerts the parents [20].

This system is constructed through an Android-based application that interfaces with the smartphone's GPS sensor, enabling teachers to track parents' locations on maps. The core of the system is an Android application named "Child Pick Up (CPU)," where the initial screen upon logging in is the login page. This page offers the functionality to create a new parent account. Subsequently, daycare teachers can validate these accounts. The "CPU" application is designed to dispatch two distinct notifications: one when parents activate the pickup button and another when parents approach within 100 meters of the daycare [21].

The assessed strategies [15-21] are capable of tracking the children's locations. In some cases, children are required to have smartphones with them [15-18,21,22], while in other cases, wearable IoT devices are employed [17,19,20,23]. Nevertheless, none of these methods fully resolve the issue of notifying children when their parents arrive. This notification process aims to streamline pickups, potentially alleviate traffic congestion, and address child security concerns.

3. Proposed Solution

The proposed design consists of 2 main parts. One is for the smart notification application for parents and another one is the notification device for children. The architecture design of Smart child pickup notification is shown in Figure 1.

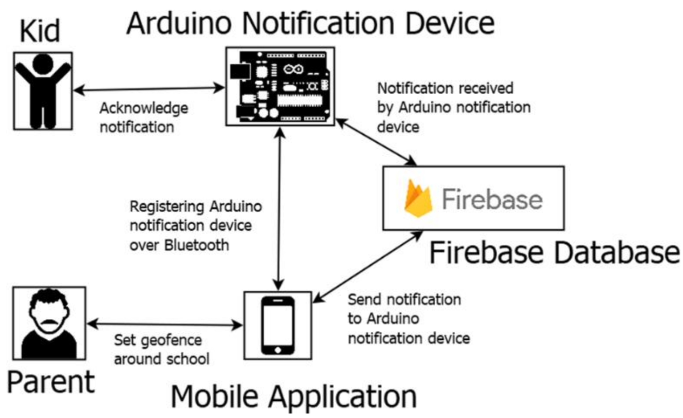

Fig. 1. The architecture design of the proposed solution

Initially, the mobile application needs to establish a connection with the Arduino notification device via Bluetooth. A configuration file containing the Firebase token is then transmitted to the device, enabling it to access the Firebase database. Consequently, once the parent finishes setting up the geofence and commences the route to the designated area, the act of entering the geofenced zone prompts the mobile application to dispatch a notification to the Firebase database.

Subsequently, the Arduino notification device is alerted in case a pending notification exists within the Firebase database. The Arduino device retrieves the notification from the database and initiates the alert process, notifying the child through visual display and vibration. The child acknowledges the notification by pressing a button on the Arduino notification device. The flowchart of the smart child pickup notification app is shown in Figure 2

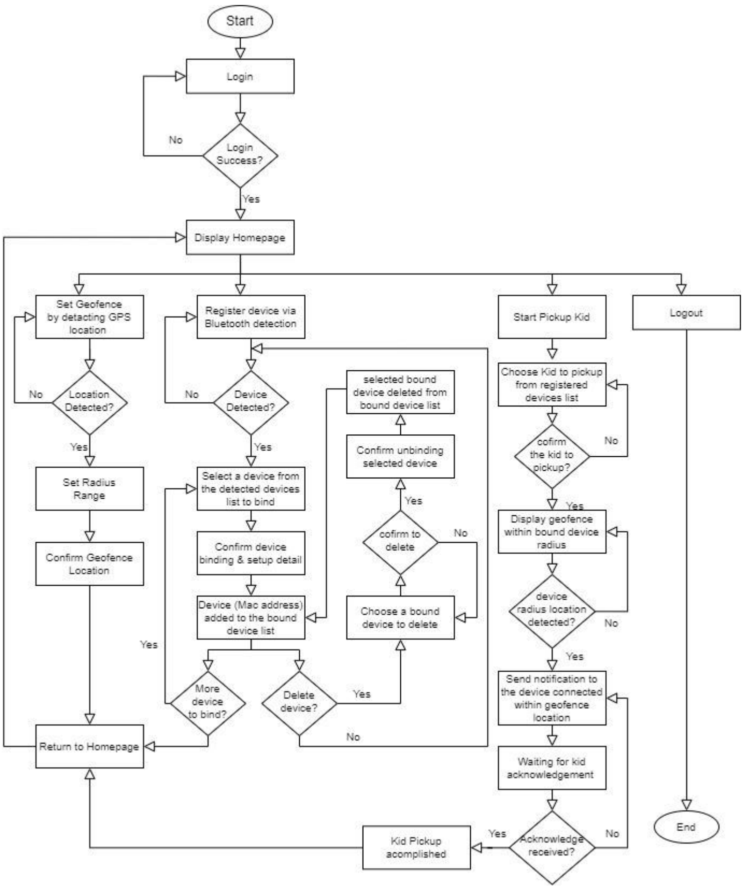

Fig. 2. Flowchart of kid pickup notification system

3.1 Notification App

Upon app launch, the login page appears first. Users can sign in using their Google account or choose to add another account. After successful login, they are directed to the home page as shown in Figure 3.

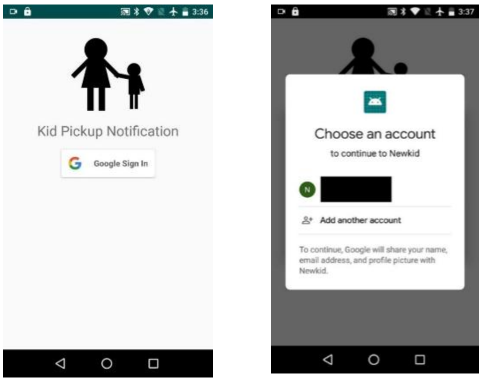

Fig. 3. Login page of the app

The Figure 4 represents the app's home page, showcasing its key functionalities: setting geofences, device management, and child pickup.

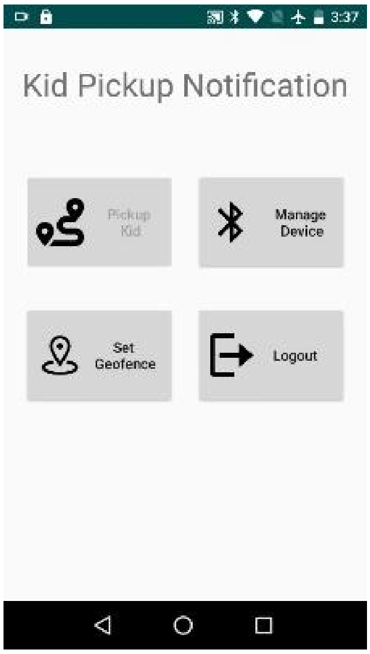

Fig. 4. Home page of the app

3.1.1 Set geofence

Upon entering this page, the app automatically identifies and zooms in on the user's location. A preview of the geofence's appearance prior to user configuration is available. The user has the option to select the radius from a dropdown menu, ranging from 1 to 7 kilometres. Additionally, users can manipulate the map by employing gestures to relocate, zoom in, and zoom out, thus identifying the ideal geofence location. Once content with the designated geofence, the user can finalize the process by pressing the "set geofence" button. Figure 5 shown the Set geofence page of the app.

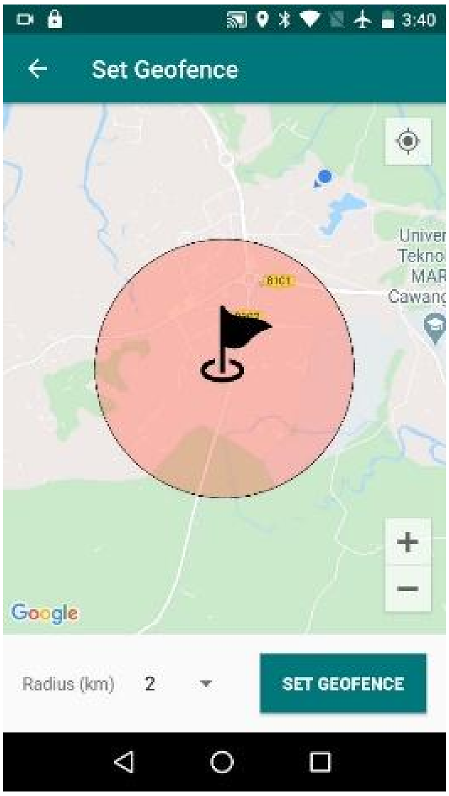

Fig. 5. Set geofence page of the app

3.1.2 Device management

The notification devices that have been connected are displayed, as presented in the Figure 6. Each device is associated with its corresponding image and name. Deleting a notification device is accomplished by clicking the designated delete button, resulting in the device becoming unlinked from the account.

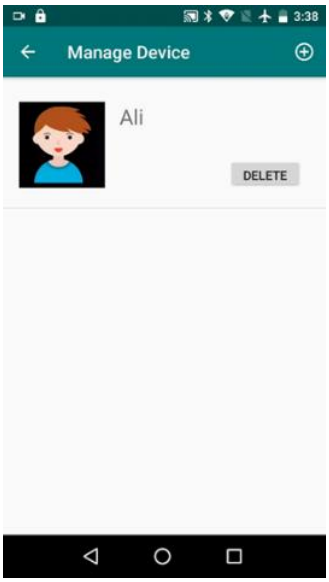

Fig. 6. Manage device page of the app

Adding a new notification device involves clicking the "+" icon situated in the top right corner. This action redirects the user to the device search page, illustrated in the Figure 7.

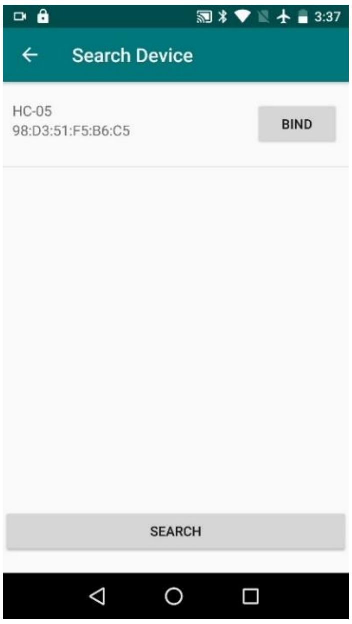

Fig. 7. Search page of the app

Once the user initiates the search by clicking the search button, the app commences the Bluetooth-based search for notification devices. Upon detecting any such devices, the app displays the device's name and MAC address. To establish a connection, the user can select the "bind" button, enabling the notification device to be successfully paired.

Upon activation, a dialog box appears as shown in Figure 8. Within this dialog, users can opt for an image and assign a name to the notification device. Once the "OK" button is pressed, the chosen image and name are stored in the Firebase Database. Simultaneously, the user's ID is transmitted to the notification device via Bluetooth.

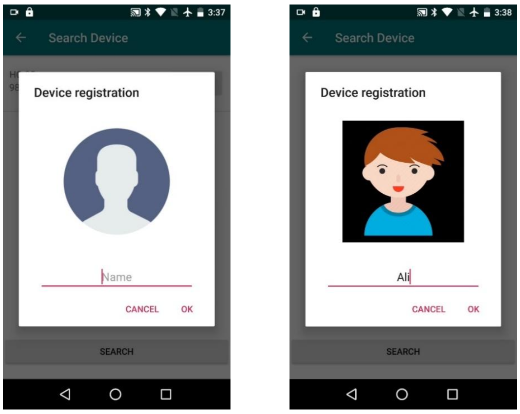

Fig. 8. Binding the notification device

3.1.3 Child pickup

The Figure 9 illustrates the "pickup kid" page, which becomes accessible once the user has successfully bound the device and established a geofence. The application automatically identifies and zooms in on the user's current location. Initiating the pickup process involves the user clicking the "start" button. A confirmation dialog displaying the name and picture subsequently appears, seeking user verification for commencing the pickup procedure.

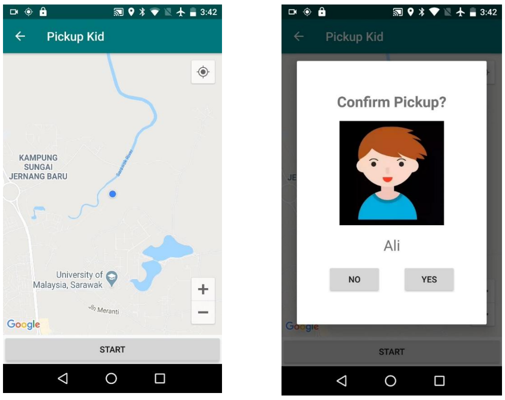

Fig. 9. Pickup kid page of the app

As depicted in Figure 10, a line is drawn from the user's present location to the designated geofence location. Upon the user's entry into the geofence, which is indicated by the red coloration, a notification is dispatched to the connected notification device.

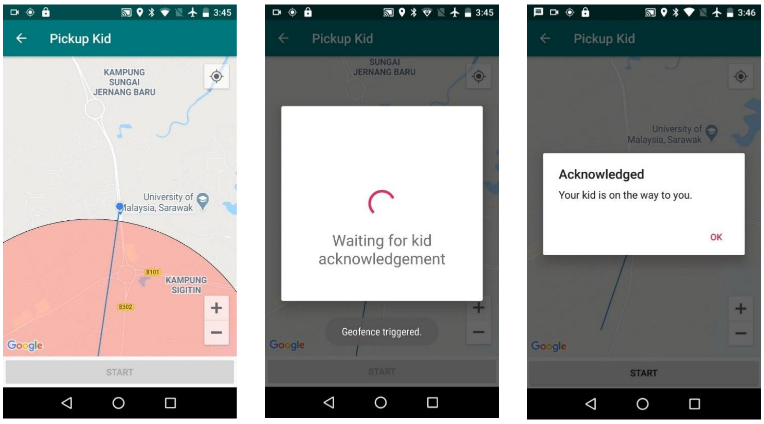

Fig. 10. Triggering geofence

This mechanism is apparent in the code snippet presented in Figure 11. In this code, the app recognizes the user's entrance into the geofence and updates the "status" values to 3. When the "status" value reaches 3, it acts as a trigger for the notification device to initiate an alert and display the notification.

Subsequent to this, a dialog emerges, indicating that the app is awaiting acknowledgment from the child. Once the acknowledgment is received, the initial dialog is dismissed, and a new dialog promptly appears, notifying the user of the child's acknowledgment.

```
@Override
public void onReceive(Context context, Intent intent) {
    // TODO: This method is called when the BroadcastReceiver is receiving
    // an Intent broadcast.
    Toast.makeText(context, "Geofence triggered.", Toast.LENGTH_LONG).show();

    GeofencingEvent geofencingEvent = GeofencingEvent.fromIntent(intent);
    int transitionType = geofencingEvent.getGeofenceTransition();

    switch (transitionType) {
        case Geofence.GEOFENCE_TRANSITION_ENTER:
            DatabaseReference ref = FirebaseDatabase.getInstance()
                    .getReference()
                    .child("users")
                    .child(FirebaseAuth.getInstance().getUid())
                    .child("status");
            ref.setValue(Constants.DeviceStatusCode.THREE_WAIT_FOR_ACKNOWLEDGEMENT);
            PickupKidHelper.GetInstanceOrNull().removeAllGeofences();
            break;
    }
}
```

Fig. 11. Source code of updating firebase database to send notification

3.2 Notification Device

The Figure 12 shows how all the components are connected for notification device. In the actual implementation, a power bank that can supply 5V voltage through USB cables is used instead of AAA batteries. The power bank supply dedicated power to the GPRS module and Arduino Uno R3. The rest of the components draws power directly from the Arduino Uno R3.

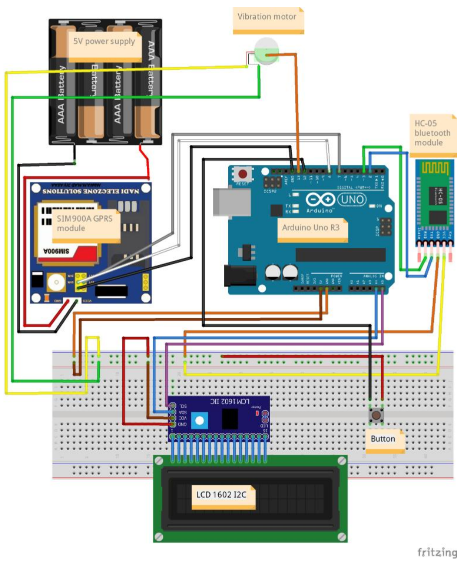

Fig. 12. Hardware schematic of Arduino notification device

Ardunino Uno R3 connects all the hardware components. Button enables the user to acknowledge the notification by pressing it. HC-05 Bluetooth module uses to bind Arduino notification device to the android smartphone. LCD1602 module with I2C displays the notification to the user. Rechargeable 9V battery powers up all the components. SIM900A GSM/GPRS module provides internet access for the device. Vibration motor module provides vibration feedback to the user that notification has arrived.

The Arduino notification device consists of Arduino Uno R3, SIM900A GPRS module, HC-05 Bluetooth module, LCD 1602 with I2C, vibration motor, and a button as shown in Figure 13. Power bank (not shown in the figure) with two USB 5V outputs are used to power up the notification device, where the Arduino Uno R3 and SIM900A need a dedicated power supply.

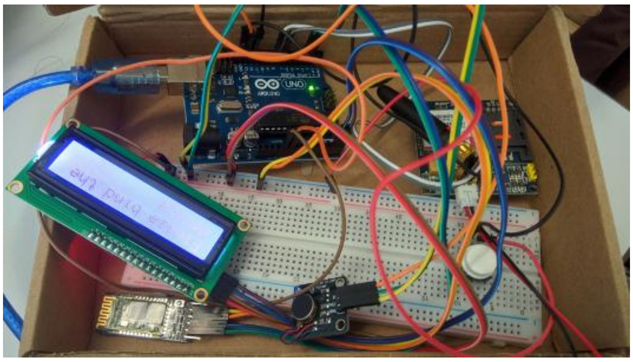

Fig. 13. Implementation of the notification device

When the device is starting up without any GPRS initialization error, the device is ready to be bound with the smartphone over Bluetooth. As shown in Figure above, before binding the device, the device will display "please bind the device". After binding the device, it will display "device is binded successfully" as show in Figure 14

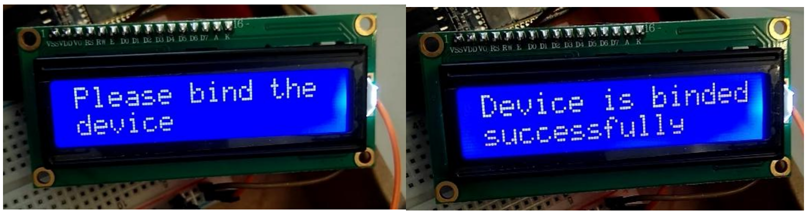

Fig. 14. Before binding device (left) and after binding device (right)

The notification device is now at standby mode. Every 10 seconds or more, it will check the Firebase database by sending an HTTP request. As shown in Figure 15, depending on the return values of the HTTP request, the notification device can be still in standby mode, show notification and alert the kid, or hard reset itself. The checking notification algorithms is shown in Figure 16.

Fig. 15. Notification device in standby mode

```
if (actionState == AS_DO_FIREBASE_LOOKUP)
{
  // Make a GET petition to the server
  if ( SIM900->Get( "fyp2.tk", "", ("p.php?u=" + uid).c_str(), httpCodeResponse, bodyResponse ))
  {
    int val = atoi(bodyResponse);
    if (val == X_NO_ACTION || val == X_PARENT_ON_THE_WAY)
    {
      lcd.clear();
      lcd.print("Standby");
      delay(2000);
    }
    else if (val == X_PARENT_IN_GEOFENCE)
    {
      actionState = AS_WAIT_BUTTON_PRESS;
      lcd.clear();
      lcd.print("Your parent is ");
      lcd.setCursor(0,1);
      lcd.print("almost here");
    }
    else if (val == X_HARD_RESET_DEVICE)
    {
      hardReset();
    }
    delay(2000);
  }
}
```

Fig. 16. Algorithms for checking notification

When the parent starts the pickup process, and he/she enters the geofence, the app sends a notification to the notification device. The notification device displays a notification that is “you parent almost here” as shown in Figure 17. The vibration motor is also vibrating to alerts the kid.

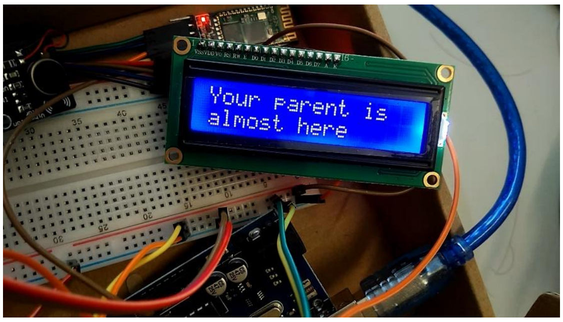

Fig. 17. Notification device shows notification

The kid needs to press the white button on the notification device to silent the vibration and sending an acknowledgement to the parent as shown in Figure 18. After this is done, the notification device goes into standby mode again.

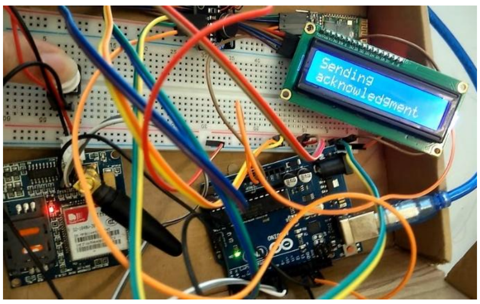

Fig. 18. Sending acknowledgment from notification device

3.3 Proxy Server

The SIM900A GPRS module that is used in this project does not support HTTPS. It only supports HTTP with GET and POST requests. HTTPS support is needed to access the Firebase database REST API. HTTPS GET request is used for reading data, while HTTPS PUT request is for writing data into Firebase database. To overcome this limitation, a proxy server is setup to forward the HTTP request from the GPRS module to the Firebase database.

4. Results

After the design of the device is complete, the next step is to check, test and measure the device. This stage aims to check the overall function and performance of the device and also user satisfaction.

4.1 Unit Testing

The main purpose of unit testing is to segregate the application into a smaller part of the function. Each of the functions is tested separately to ensure each of it is performed as its designs. Test case for login, manage device, search device, set geofence, pickup kid has been carried out with 30 respondents. All test cases were passed.

4.2 Performance Testing

Pick up kid device is carried out by 40 respondents to complete the task given. This system test aims to test the performance of the pickup kid device with the smart notification app. With this testing, the performance of the device is achieved 97% of successful rate by the expected design.

4.3 Notification Testing

Children with Notification device will receive two notifications from the system application, (1) notification when parents send the notification and children receive signal of 'standby", and, (2) count down for 10seconds before arrive and (3) notification when parents are arrived.

4.3 Usability Testing

The main purpose is to have a better understanding of how real users interact with the application created and improve the design based on the given set of test tasks. The usability test result is shown in Table 1 where most of the respondents are satisfied with the proposed solution.

Table 1
Usability Testing Evaluation Result

Ratings / Questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The system is easy to learn.	0	0	8	22	15
The system is easy to use.	0	0	7	19	19
The system is user friendly.	0	0	7	18	20
The system is useful.	0	0	8	15	22
Overall is satisfied.	0	0	8	17	20

5. Conclusions

In conclusion, this paper has introduced the Smart Child Pickup Notifications App with IoT Devices. This solution has the potential to alleviate traffic congestion around schools and pickup locations. Parents receiving instant notifications can time their arrival more accurately, reducing the instances of vehicles idling or circling around waiting for their children. This, in turn, contributes to a more streamlined traffic flow, benefiting both parents and the surrounding community. Besides, its heightened emphasis on child security.

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References

[1] Pramkeaw, Patiyuth, Thittaporn Ganokratanaa, Thidarat Pinthong, and Napathsorn Kitprasert. "Alert system with IoT Techniques for Stray Children." In *2023 IEEE International Conference on Cybernetics and Innovations (ICCI)*, pp. 1-6. IEEE, 2023. https://doi.org/10.1109/ICCI57424.2023.10112468
[2] Karunya, S. "A creative approach for recent advancements in tracking system for women and children by using wi-fi technology." In *2022 International Conference on Applied Artificial Intelligence and Computing (ICAAIC)*, pp. 910-915. IEEE, 2022. https://doi.org/10.1109/ICAAIC53929.2022.9793292
[3] Isa, Mohammad Zulhafiz Md, Muhammad Mahadi Abdul Jamil, Tengku Nadzlin Tengku Ibrahim, Muhammad Shukri Ahmad, Nur Adilah Abd Rahman, and Mohamad Nazib Adon. "Children security and tracking system using bluetooth and gps technology." In *2019 9th IEEE International Conference on Control System, Computing and Engineering (ICCSCE)*, pp. 184-187. IEEE, 2019.
[4] Branka, V. "30 Scary Kidnapping Statistics You Can't Afford To Ignore." https://legaljobs.io/blog/kidnapping-statistics
[5] Walters, Glenn D. "Weak parental supervision and lack of child remorse as predictors of proximal crime continuity in early-to-mid adolescent delinquents." *Journal of criminal psychology* 11, no. 1 (2021): 59-71. https://doi.org/10.1108/JCP-10-2020-0043
[6] Chaudhary, Harshal, Ranjana Zinjore, and Varsha Pathak. "Parent-hook: a child tracking system based on cloud url." In *2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC)*, pp. 219-224. IEEE, 2020. https://doi.org/10.1109/ICSIDEMPC49020.2020.9299610
[7] Noel Wong. "Without a trace: 5 cases of missing children in Malaysia." (2022). https://www.freemalaysiatoday.com/category/leisure/2022/09/28/without-a-trace-4-cases-of-missing-children-in-malaysia
[8] Sharifah Osman. https://people.utm.my/sharifah/files/2018/07/page-176-1.pdf#:~:text=Typically%2C%20the%20morning%20session%20runs%20from%207.30am%20to,the%20afternoon%20session%20lasts%20from%201.15pm%20to%206.45pm
[9] Poonkuzhlai, P., R. Aarthi, and Yaazhini VM. "Child monitoring and safety system using WSN and IoT technology." *Annals of the Romanian Society for Cell Biology* (2021): 10839-10847.
[10] Jaya, M. Izham, Goh Xin Tong, Mohd Faizal Ab Razak, Azlee Zabidi, and Syifak Izhar Hisham. "Geofence Alerts Application With GPS Tracking For Children Monitoring (CTS)." In *2021 International Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM)*, pp. 222-226. IEEE, 2021. https://doi.org/10.1109/ICSECS52883.2021.00047
[11] Jang, Sang Hoon, Ha Hwang, and Ji-Bum Chung. "Effects of child pick-up behavior on emergency evacuations." *Nuclear Engineering and Technology* 54, no. 7 (2022): 2519-2528. https://doi.org/10.1016/j.net.2022.01.035
[12] Zainal, Salbiah, Rasimah Che Mohd Yusoff, Hafiza Abas, Suraya Yaacub, and Norziha Megat Zainuddin. "Review of design thinking approach in learning IoT programming." *International Journal of Advanced Research in Future Ready Learning and Education* 24, no. 1 (2021): 28-38.

[13] Nuwair S.N., Nurshafinaz M.M., Mohamad F.H., Ahmad F.M., Farah M.R.& Shanir M.Y. "Strategies In Harvesting Wind Energy From Flow-Induced Vibration For IoT Applications." *Journal of Advanced Research in Computing and Applications* Vol. 30 No. 1: (2023).

[14] Isa, Mohammad Zulhafiz Md, Muhammad Mahadi Abdul Jamil, Tengku Nadzlin Tengku Ibrahim, Muhammad Shukri Ahmad, Nur Adilah Abd Rahman, and Mohamad Nazib Adon. "Children security and tracking system using bluetooth and gps technology." In *2019 9th IEEE International Conference on Control System, Computing and Engineering (ICCSCE)*, pp. 184-187. IEEE, 2019.

[15] Tärnfalk, Michael, and Charlotte Alm. "Social worker motivations and organisational prerequisites for care of children who commit crimes–the best interests of the child or the protection of society?." *European Journal of Social Work* 24, no. 1 (2021): 21-33. https://doi.org/10.1080/13691457.2019.1585334

[16] Roopesh P, Sas Prashanth Ch, Sivakumar K. "Child Monitoring System, International Research." *Journal of Engineering and Technology (IRJET)*, Vol. 7(6), (2020): 4050-4055.

[17] Indrayana, I. N. E., P. Sutawinaya, Ni Made Wirasyanti Dwi Pratiwi, Putu Manik Prihatini, and Sri Andriati Asri. "Android-based child monitoring application using a smartwatch and geofence service." In *Journal of Physics: Conference Series*, vol. 1803, no. 1, p. 012024. IOP Publishing, 2021. https://doi.org/10.1088/1742-6596/1803/1/012024

[18] Poonkuzhlai, P., R. Aarthi, and Yaazhini VM. "Child monitoring and safety system using WSN and IoT technology." *Annals of the Romanian Society for Cell Biology* (2021): 10839-10847.

[19] Sari, Marti Widya, Desinta Ningrum Belsa Putri, and Banu Santoso. "Design Of Android Based On Children Tracking Location Monitoring System." *METHODS* 13 (2020): 14.

[20] Thamaraimanalan, T., R. Pathmavasan, T. R. Pradeep, N. Praveen, and R. Srija. "IoT based Safety Gadget for Child Monitoring and Notification." In *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)*, vol. 1, pp. 783-786. IEEE, 2023. https://doi.org/10.1109/ICACCS57279.2023.10112699

[21] Aisuwarya, Ratna, Tati Erlina, and Syafajar Ahmad Sabyl. "Notification System and GPS Position Tracking as a Security Feature for Child Pick Up At Daycare." In *2022 International Symposium on Information Technology and Digital Innovation (ISITDI)*, pp. 55-58. IEEE, 2022. https://doi.org/10.1109/ISITDI55734.2022.9944503

[22] Al-Mazloum, A., E. Omer, and M. F. A. Abdullah. "GPS and SMS-based child tracking system using smart phone." *International Journal of Electronics and Communication Engineering* 7, no. 2 (2014): 238-241.

[23] Benisha, M., R. Thandaiah Prabu, M. Gowri, K. Vishali, M. Anisha, Ponmozhi Chezhiyan, and C. Jim Elliot. "Design of wearable device for child safety." In *2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)*, pp. 1076-1080. IEEE, 2021. https://doi.org/10.1109/ICICV50876.2021.9388592