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Implementation of an Intelligent Automatic Notification System Based on Bluetooth Beacons and Smart Phones

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Abstract

In this study, we aim to implement an intelligent automatic notification system based on Bluetooth beacons and smartphones to prevent accidents caused by children being left in vehicles while commuting to school during summer or winter. This is a problem that is emerging as safety accidents occur owing to negligence in vehicles. Although teachers solutions, such as checking children's attendance, safety accidents occur frequently every year. Because the continuous occurrence of safety accidents, parents' anxiety about accidents is increasing, and various accident prevention measures are being developed to solve this problem. However, these methods are difficult to implement as teachers have to manage a large number of children. To solve this problem, this study implements an intelligent automatic notification system based on Bluetooth beacons and smartphones. This notification system attaches a relatively low-power Bluetooth beacon to the child's belongings to recognize boarding and disembarking using the teacher's smartphone, and sends a message to the parent's smartphone.

Index Terms: Bluetooth Beacon, Smart Phones, Automatic Notification, Signal Strength

I. INTRODUCTION

Every year, problems arise when children are left unattended in vehicles. This is not a problem in seasons when the outside temperature is cool. However, in summer, this is a serious problem that can lead to heat exhaustion and even death in children. To solve this problem, local governments and companies have devised various policies and products to prevent accidents, such as the neglect of children, through in-vehicle behavior detectors and separate vehicle modifications. However, in reality, separate costs are required to implement this function in vehicles and it is not readily available. Furthermore, when safety inspections are conducted, it is difficult to verify whether the modifications have been implemented [5-6].

In most cases, separate vehicle installations are difficult, and in such cases, inspection is not easy. As an increasing number of requirements are being placed on instructors to prevent vehicle neglect, this burden increases. It is difficult for parents to contact their children because they do not have smartphones or work, and it is even more difficult to check on them every day. These factors increase anxiety, and each time we hear news of safety accidents through various media, anxiety rises [7-8].

This study, in particular, aims to address the problem of safety accidents due to neglect in vehicles. To solve this problem, we implemented a Bluetooth beacon and smartphone-based intelligent automatic notification system that is easy to check and can be used without modifications to the vehicle. By applying it to the system, the goal is to reduce the burden on instructors, safety accidents, and reduce parents' anxiety. In Korea, children frequently use various types of vehicles to attend school. They come in various sizes, and representative examples include H Automobile's Starex,

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Bongo, and County Bus. Although these vehicles are used for commuting to school, they are not actually owned by the facility; rather, they are owned personally by the director and facility managers, and safety facilities and training are lacking. The omission of such safety checks often leads to accidents [9-10].

In addition, a boarding and disembarking notification system must be implemented using only Bluetooth beacons and smartphones to solve safety accidents such as children being left unattended in the vehicle, and how to manage the signal strength for each vehicle to recognize boarding and alighting. Through experiments, we plan to implement the boarding and disembarking notification systems for each vehicle.

II. RELATED RESEARCH

A. Bluetooth Beacon

Beacons have been developed using Bluetooth Low Energy (BLE) since Bluetooth 4.0. These are Bluetooth Classic, Bluetooth Smart Ready, and Bluetooth Smart. Bluetooth Classic supports only existing Bluetooth functions;, Bluetooth Smart Ready supports both existing Bluetooth and BLE functions;, and Bluetooth Smart supports only BLE functions. BLE was developed under the name Wibree; however, it is better known as BLE, and beacons use this method. A Bluetooth beacon is a BLE beacon. These beacons have two communication functions. Advertise and, Connection Mode. The Advertise Mode is the process of sending a packet to the surrounding area without a designated destination and having someone find and connect to it. The Connection Mode is characterized by sending and receiving data at the right time by generating packets only for those previously connected to the Advertise Mode [1]. The system is configured and operated as shown in Fig. 1.

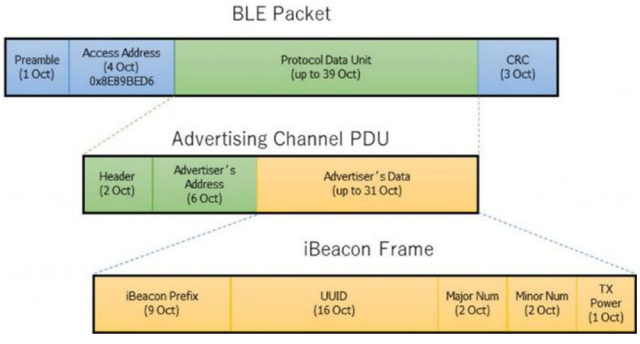

Fig. 1. BLE iBeacon packet element

B. RSSI

The received signal strength indicator (RSSI) is an indication of the received signal strength in communication, and is the current value of the received wireless signal. It is expressed as a negative value using dbm and is related to the strength of the transmitted signal. The closer the number is to 0, the stronger the signal. If the number is smaller than -100, it means that the signal quality is very poor. The RSSI is calculated by considering the beacon transmission signal, presence of obstacles, and environment. Furthermore, and it becomes more vulnerable to environmental influences as the distance increases. In the graph, the RSSI is proportional to the distance; however, there is noise, and therefore, the deviation is large. To overcome vulnerability to variables, use multiple units, such as the trilateration technique, fingerprinting, and Kalman filter, or use a smoothing method considering the standard deviation to preprocess the RSSI and use it more accurately [2].

$$RSSI = -10n\log_{10}(d) + \alpha$$

Fig. 2. RSSI calculation method

The RSSI calculation method considers each environmental variable. n is determined depending on whether there are obstacles and ranges from two to four, increasing to two if there are no obstacles and up to four depending on the number of obstacles. α is the beacon transmission signal and means Txpower. d is a constant representing distance and uses the beacon transmission signal, RSSI. To find the distance of the beacon, Txpower, the transmitted signal, is used as α, RSSI is used, and the final RSSI is derived in the same way, as shown in Fig. 2.

C. Trilateration

The trilateration technique determines the distance between the coordinates of a point using the properties of a triangle. Although it is one of the most precise techniques, it is not commonly used, except for long-distance measurements because it requires multiple units, and has the disadvantage of being complicated because it requires many calculation formulas and conditions.

To calculate the current location of the beacon, each RSSI is received from P1, P2, and P3, and the calculation is performed using the properties of a triangle. The disadvantage is that more than three units are required and the calculation is complicated and time-consuming. However, this method has the advantage of obtaining more accurate values even over long distances as shown in Fig. 3 [3].

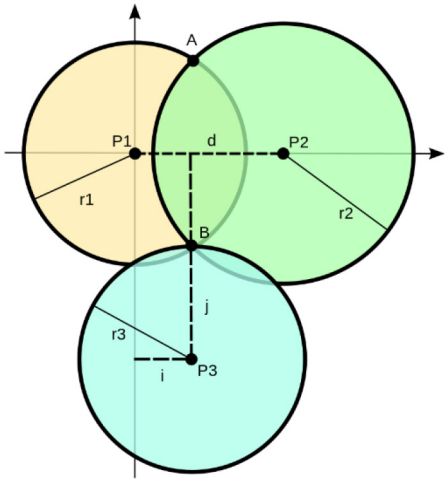

Fig. 3. Trilateration technique

D. Kalman filter

The Kalman filter generates an estimated value by considering variables in the continuously measured RSSI. The calculation process is simple and fast, and simple calculation formulas are used. This is very useful for processing signals and predicting values in linear systems where noise exists. In the Kalman filtering process, the purple and green solid lines represent the prediction and correction steps, respectively. In the equation for estimating the predicted value of the RSSI, 'st is the previously measured RSSI and mt is the currently measured RSSI. It is calculated using Kt (Kalman gain) along with the two RSSI values. The Kalman gain is a variable that determines where the weight will be assigned among the measured RSSI. The part shown in green in the image above is performed recursively as shown in Fig. 4.

There are various RSSI utilization techniques. Although they are helpful for actual distance determination, they have the disadvantage of being difficult to use in this study, where the recognition and non-recognition stages are mainly used. This is because they may be recognized as normal values when errors occur. In future research, it is expected that a more accurate environment can be constructed if a filtering process is added owing to changes in the unit environment [4].

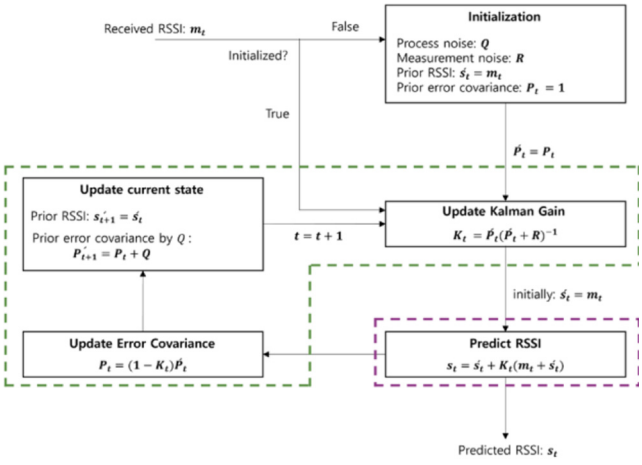

Fig. 4. RSSI filtering process in PFIPS

III. SYSTEM DESIGN AND IMPLEMENTATION

A. Design of Intelligent automatic notification system

Fig. 5 shows the design of the intelligent automatic notification system module. Each module of the boarding and disembarking notification system operates stepwise. ① The beacon- signal stage transmits the BLE beacon signal to the parent application. ② The transmitting information to children step is where the information entered into the parent application is transmitted to the database. ③ In the transferring student information step, the student information entered into the database is transmitted to the teacher application. ④ The beacon signal stage moves on to the ⑤ student boarding and disembarking information transmission stage when the beacon signal of the student is transmitted between boarding and disembarking recognition, and the student's information is updated in the database. ⑥ The stage of transmitting student boarding and disembarking information and push messages was designed to deliver the student's boarding and disembarking notification and information to the parent application based on the updated student information.

Fig. 6 shows the intelligent automatic notification system processing algorithm. This is the design of a process in which two modules − an application for parents and an application for teachers − deliver boarding and disembarking notifications through a database. When entering the student's infor-

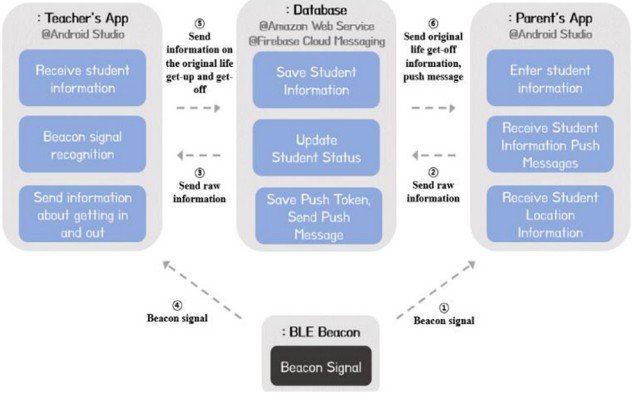

Fig. 5. Intelligent automatic notification system module design

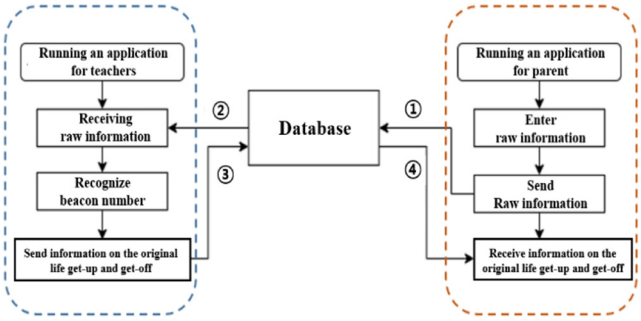

Fig. 6. Intelligent automatic notification system processing algorithm

mation into the parent application, the information is transmitted through ① Transfer of student information. ② is the step of transferring the student's information from the database to the teacher application. ③ is the step of updating the student's boarding and disembarking information in the database, and ④ is the step of sending the student's boarding and disembarking information from the database to the parent application to end the boarding and disembarking notification system. Using this design, a boarding and disembarking notification system was developed to update graduate students' boarding and disembarking information.

B. Implementation of Intelligent automatic notification system

Fig. 7 shows the configuration diagram of the intelligent automatic notification system. It can be observed that the AWS and FCM are used in the database to update the information of the boarding and disembarking notification systems and to deliver notifications. In the parent application, one can input the student's information, receive the student's boarding and disembarking information through a push message, and check the information. The role of the teacher application is to receive student information in the form of a list, recognize beacon signals based on the list, upload

Fig. 7. Intelligent automatic notification system configuration diagram

boarding and disembarking information to the database, and deliver boarding and alighting notifications to the parent application through FCM according to the update status. A boarding and disembarking notification system was designed using the systems for each of these roles.

The operation of intelligent automatic notification system. ① Parents enter students' information directly and upload it to the server. ② The graduate student information list receives graduate student information in the form of a list from the teacher application. It is designed to update the graduate students' information using two processes. ③ Beacon signal recognition recognizes the beacon signal in the teacher application when the student gets on or off the train. ④ The student's boarding and disembarking information recognizes the beacon signal, updates the student's status as boarding or disembarking, and uploads it to the server. ⑤ The student boarding and disembarking information is delivered to parents based on the updated information on the server, and the operation system of the boarding and disembarking notification system was designed using these five steps.

IV. CONCLUSIONS

In this study, we implemented an intelligent automatic notification system based on Bluetooth beacons and smartphones to prevent safety accidents that can occur when students use vehicles to commute to and from small academies and schools. To use the boarding and disembarking notification system more efficiently, an experiment was conducted to individually apply the RSSI, the standard signal for boarding and disembarking the boarding and disembarking notification system, to the most commonly used vehicles in Korea. It was based on the Android environment and uses Android Studio as an IDE to implement the pick-up and drop-off notification system. It is implemented using BLE Beacons and smartphones to achieve low power consumption and cost. Each student has a unique BLE beacon, and the student's information and BLE beacon tokens we are input from the parent's smartphone and uploaded to the server. On the instructor's smartphone, the student's stored information can be retrieved, and a list that manages whether the student can board or disembark can be checked.

When a student boards a vehicle with a BLE beacon, the instructor's smartphone recognizes the RSSI. If the value of the recognized RSSI is greater than the standard RSSI for boarding, it is recognized as boarding. If it is recognized as being within the range of the standard RSSI for getting off, it is continuously recognized as a ride. If it falls outside the range of the RSSI standard for getting off, it is recognized as getting off. When boarding and disembarking are recognized, parents receive a push message through Firebase so

that they can receive the student's boarding and disembarking information even when the application is inactive for the efficiency of smart devices. After receiving the push message, the application was activated, and a notification system was implemented so that the student could directly check the location and time of the drop-off using the map.

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REFERENCES

[1] S. B. Nam, E. H. Park, J. C. Parko and N. H. Kim, "Indoor location detection algorithm performance evaluation using the BLE Beacon," *Proceedings of the Korean Society of Computer Information Conference*, vol. 24, no. 2, pp. 187-188, 2016.

[2] W. C. Kim, C. G. Lee and H. Y. Kwak, "RSSI Stabilization for Measuring Position using Beacon," *Proceedings of the Korean Society of Computer Information Conference*, vol. 27, no. 1, pp. 13-14, 2019.

[3] J. H. Sohn, and G, H. Hwang, , "Development of position awareness algorithm using improved trilateration measurement method," *Journal of the Korea Institute of Information and Communication Engineering*, vol. 17, no. 2, pp. 473-480, 2013.

[4] Y. Sung, "RSSI-based distance estimation framework using a kalman filter for sustainable indoor computing environments", Sustainability, vol. 8, no. 11, pp. 1136, 2016. https://doi.org/10.3390/su8111136.

[5] K. Echizennya and K. Kondo, "Estimation of indoor position and motion direction for smartphones using DNN to BLE beacon signal strength," *2020 IEEE International Conference on Consumer Electronics -Taiwan*, pp. 1-2, 2020. DOI: 10.1109/ICCE-Taiwan49838.2020.9258282.

[6] X. Guangyong, L. Shizhen, and Z. Dongyao, "A hybrid model of regional path loss of wireless signals through the wall," *KSII Transactions on Internet and Information Systems*, vol. 16, no. 9, pp. 3194-3210, 2022. https://doi.org/10.3837/tiis.2022.09.020.

[7] Y. Shen, B. Hwang, and J. P. Jeong, "Particle filtering-based indoor positioning system for beacon tag tracking," *IEEE Access*, vol. 8, pp. 226445-226460, 2020. DOI: 10.1109/ACCESS.2020.3045610.

[8] A. Bbosale, G. Benny, R. Jaison, A. Kbot and S. Pati, "Indoor Navigation System using BLE Beacons," *2019 International Conference on Nascent Technologies in Engineering*, pp. 1-6, 2019. DOI: 10.1109/ICNTE44896.2019.8945881.

[9] K. E. Jeon, J. She, P. Soonsawad and P. C. Ng, "BLE beacons for internet of things applications: survey, challenges, and opportunities," *IEEE Internet of Things Journal*, vol. 5, no. 2, pp. 811-828, 2018. DOI: 10.1109/JIOT.2017.2788449.

[10] A. Ito, F. Xiang, H. Hatano and H. Uchiyama, "A study on observing a lost child using BLE beacons," *2018 Sixth International Symposium on Computing and Networking Workshops*, pp. 67-70, 2018. DOI: 10.1109/CANDARW.2018.00021.

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