International Journal of Recent Innovations in Academic Research
E-ISSN: 2635-3040; P-ISSN: 2659-1561
Homepage: https://www.ijriar.com/
Volume-8, Issue-10, October-2024: 54-65

Research Article

Internet-of-Things-based Smart Bus Detection Platform for the Visually Impaired

***[a]Steve Rho and [b]Albert Rho**

[a&b]Independent Researcher, Seoul Innovation Research Institution, South Korea
*Corresponding Author Email: steve.rho5235@gmail.com

Received: September 21, 2024 **Accepted:** October 10, 2024 **Published:** October 18, 2024

Abstract
Visually impaired individuals face various commuting challenges, including limited bus accessibility and safety risks. This study proposes a smart bus detection system (SBDS), comprising a radio frequency identification (RFID) sensor, beacon, cloud-computing web server, and iOS application. Leveraging the Internet of Things (IoT) and cloud computing technology, SBDS achieves real-time bus tracking. After installing and testing at multiple bus stations, the SBDS proved reliable for live bus monitoring and assisting visually impaired riders. The web server allows administrators to monitor the system and view bus arrival and departure times, with data for quality assurance. An application was created to provide information in an accessible format, including text for non-visually impaired users and voice announcements for visually impaired users. The result confirms the system's value for visually impaired bus riders, demonstrating the feasibility of an IoT-based bus detection platform to enhance smart bus services and safety.
Keywords: Beacons, Cloud Computing, Internet of Things, RFID, Smart Bus Station.

Introduction

In 2021, 284 million people worldwide suffered from vision impairment, out of which 39 million suffered from severe vision impairment that caused blindness [1]. Owing to their disabilities, most, if not all, people suffering from such conditions are unable to drive their vehicles [2, 3] and are left to use public transportation or walk to arrive at their destinations. Public transportation has low operational costs. Buses are typically cheaper and have lower transportation costs [4, 5].

Visually impaired people face other commuting problems in addition to limited bus accessibility. In Korea, 58% of people with visual impairment involved in a survey answered that buses were the most difficult mode of public transportation when it came to usage [6].

Some visually impaired people become involved in accidents because they either do not notice a bus arriving or miss the boarding time [7, 8]. Many of these accidents could easily be prevented with a better information communication system for the visually impaired.

In recent years, the integration of technologies, such as the Internet of Things (IoT) and cloud computing, has emerged as a transformative force in real-time monitoring across various fields [9–11]. Previous studies primarily explored the integration of IoT platforms for real-time monitoring of health systems, smart cities, and general maintenance [12, 13]. However, studies on leveraging these technologies to improve smart bus systems for the visually impaired are limited.

Existing systems, such as artificial intelligence (AI)-based prediction of bus arrival time [14, 15] and global positioning system (GPS)-incorporated systems, provide live positions of buses tracked by the user [16, 17]. Other studies have incorporated algorithms and RFID sensors to predict the arrival time of buses [18-20] or focused on ticketing systems [21-23]. However, these systems can be improved in terms of their accessibility features for the visually impaired. For example, providing audio feedback would be beneficial to the visually impaired who cannot access the regular features of these systems. Features, such as arrival announcements, bus proximity announcements, and other auditory accessibility enable better and more comfortable bus experiences for users [24-26].

To address this problem, this study proposes an IoT-based smart bus system that provides audio feedback to users, called the smart bus detection system (SBDS). The system aims to improve the accessibility options available using radio frequency identification (RFID) sensors mounted on the bus and near the station to read data and using cloud computing and web server technology to disseminate that information to visually impaired individuals.

Materials

The most important factor in the proposed system is its ability to provide accurate and timely data to servers and users. Thus, the important specifications and factors considered in choosing each equipment in the system.

Microcontroller

A Raspberry Pi microcontroller is a single-board computer suitable for the proposed system considering its specifications [27]. Its ability to process input using its 4-core central processing unit (CPU) and random-access memory (RAM) capacity of 1 GB running at 900 MHz and the various slots for modification were appropriate for the proposed system.

Table 1. Raspberry Pi 2 model B specifications.

Specifications	**Values**
Instruction set	ARMv7-A (32-bit)
CPU	4 × Cortex-A7
Memory	1 GB
SoC	Broadcom BCM 2836
Weight	45 g
Size	85.6 mm × 56.5mm

RFID Reader

The RFID sensor used in the system was a CF-RA5006 from Chafon [28]. Table 2 lists the RFID specifications. This sensor was selected owing to its range and use in other systems with similar objectives. Its 902–928 MHz frequency allows frequency variations to tune the readers and taggers.

Table 2. CF-RA5006 reader specifications.

Specifications	**Values**
Frequency	902–928 MHz
Gain	5 dBi
Size	133 mm × 133 mm × 21 mm
VSWR	≤1.3
Maximum power	50 W

RFID Tag

The RFID tag used in the proposed system was an active EPC C1G2 [29]. The RFID tag specifications allow its use on buses moving at high speeds to transfer information from the tag to the reader accurately. Its frequency range of 860–960 MHz, as shown in Table 3, falls within the range of the CF-RA5006, allowing its use with the RFID reader.

Table 3. EPC C1G2 tag specifications.

Chip	**Alien H3**
Frequency	860–960 MHz
Material	ABS + PA
Size	248 mm × 28 mm × 8 mm
Working temperature	-20–65 °C

Beacon

A HyconN HRD-Net beacon was used in the proposed system to check whether the user is onboarding or has already boarded the target bus. Table 4 lists the specifications of the beacon [30].

Table 4. Beacon specifications.

Beacon type	**Version 5.1**
Beacon mode	Peripheral
CPU core	ARM Cortex -M0 32 bit 16Mhz
Radio frequency	2.45 GHz GFSK
Beacon distance	50 m

Gateway

The LTE model allows communication between the main board and the web server. The model uses an LG U+ LTE B5/B7 FDD Cat.4 to communicate with the servers, as shown in Table 5 [31]. Its input voltage allowed the effective use of the modem in coordination with a Raspberry Pi microcontroller.

Table 5. LTE model specifications.

Properties	**RCU890L LTE module**
Communication method	LG U+ LTE B5/B7 FDD Cat.4
Interface	DB9 RS-232, RJ-45 Ethernet, GPIO
Band	LTE FDD 850 MHz (B5)/2.6 GHz (B7)
Data speed	150 Mbps DL/50 Mbps UL
Input voltage	4.5 V to 5.5 V

Web Server

The primary part of the presentation layer of this system is the Amazon Web Services (AWS) cloud server. The AWS cloud server enables the system to transfer data quickly and efficiently to users. Its low cost and large virtual CPU and memory capacity make it an optimal choice, providing two virtual CPUs with a 3.3 GHz clock speed and 4 GiB memory capacity, as mentioned in Table 6.

Table 6. Specifications of the instance for AWS.

Properties	**t2.medium**
vCPUs	2
Memory (GiB)	4
Clock speed (GHz)	Maximum 3.3
Networking performance	Low to medium

IoT-based Smart Bus Platform

The IoT-based smart bus platform is primarily divided into two parts (Figure 2): "SBDS" and web server. The SBDS comprises an RFID sensor, RFID tag, and beacon. The RFID sensor receives signals from the RFID tag. The signal from each device is then transmitted to the web server, which processes the data and pushes it to the user. The web server uses cloud computing, which provides higher speed and flexibility than non-cloud-computing web servers. These information systems need to provide a fast method for processing and outputting data without a physical server.

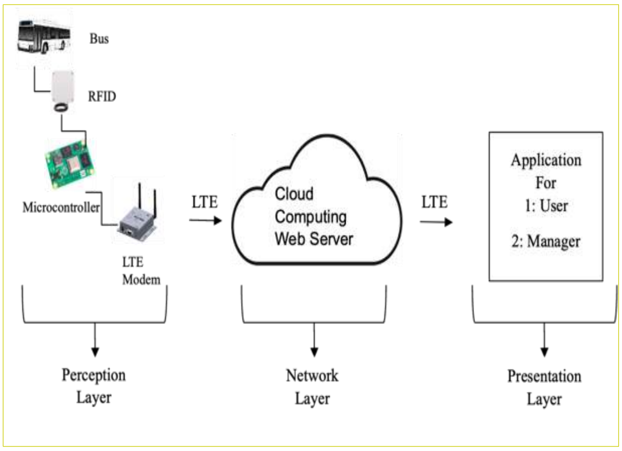

Figure 1. Internet of things diagram of the SBDS platform.

Other benefits include but are not limited to, easy access from various modes of the internet and application systems that allow simple but effective monitoring and the ability to rapidly process large amounts of data, making it a vital aspect of a monitoring system. In this research, the AWS, developed by Amazon, was used to process, organize, and present data to users. In addition, a mobile application for iOS developed by Apple was used to visualize and present the data on the bus position and arrival with the web server for "anywhere, anytime" access in real-time.

IoT systems comprise three layers: the perception, network, and presentation. The perception layer involves sensors and other data, which are collected and then transmitted to the network layer using a wireless network module. All processed data are visually presented in the presentation layer, typically as alerts, graphs, or maps [32-35], as shown in Figure 1.

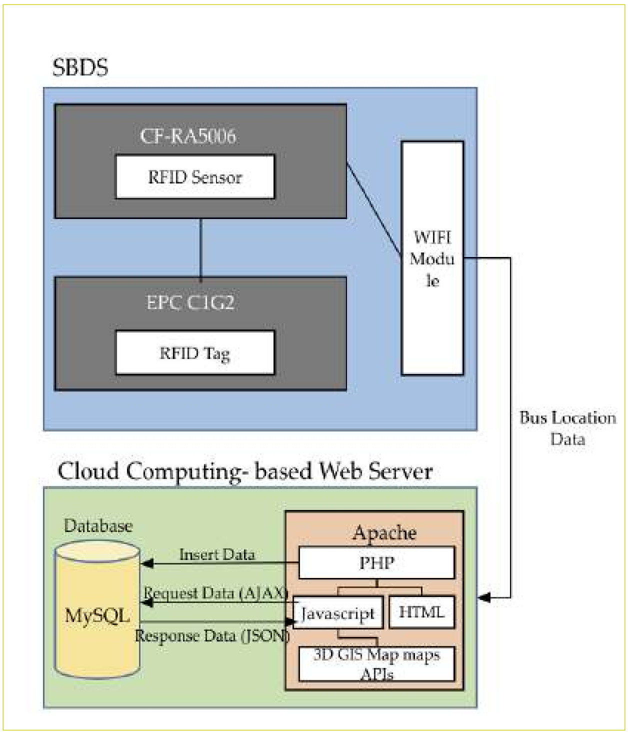

Figure 2. Configuration diagram of the SBDS.

Figure 2 shows the specific parts of the SBDS. The perception layer comprises multiple RFID sensors and tags used to track the arrival and departure of buses at the station. The LTE modem, the main component of the network layer mounted onto the microcontroller with the RFID sensor, is used to send signals to the presentation layer, which comprises a cloud-computing-based web server and the application. The calculations and processing of the input data are handled on the web server, and the results are sent to the application. The application then displays where the bus is located relative to the user's position using audio cues, such as direction and distance, and whether the bus has arrived at the station.

This application was developed for iOS systems [36] to incorporate the needs of the visually impaired. The application requires the ability to communicate through audio and deliver messages quickly to provide live updates. However, to diversify the purpose of the application, diagrams of the relative bus locations were incorporated such that non-visually impaired people can use it conveniently. The application can handle multiple locations simultaneously owing to the use of cloud-computing-based web servers. Users can input the number of buses that they want to track in both writing and voice.

SBDS

The RFID tag was attached to the front, inside the driver's seat, to check for bus arrivals or departures. When a bus equipped with a tag approaches a station and crosses the preplaced RFID sensor, the microcontroller detects it and sends the data to the web server via an LTE modem. When the bus leaves the station, the RFID sensor detects this change and sends a signal to the LTE modem. In addition, a beacon was attached to each bus to allow users to check whether they had boarded the correct bus. To assist the visually impaired in verifying whether they have boarded the correct bus, the beacon announces when the user enters the bus and whether it is the correct bus.

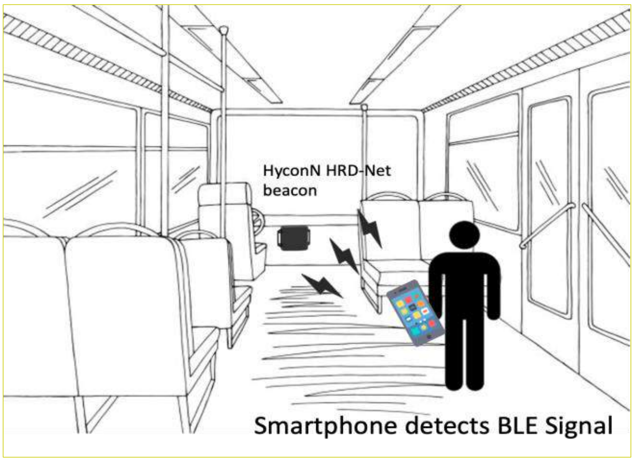

Figure 3. Beacon and smartphone diagram inside the bus.

Figure 3 shows the basic algorithm of the system. The algorithm is a subset of the SBDS that detects the arrival and departure of a bus. Each SBDS was tuned using this algorithm and RFID tags corresponding to their number.

The algorithm is used to properly and efficiently sort bus arrivals and correctly process and display the data in the user's application. For bus arrival, the algorithm uses two loops that constantly cycle to check for bus arrival and departure, each with a different RFID sensor.

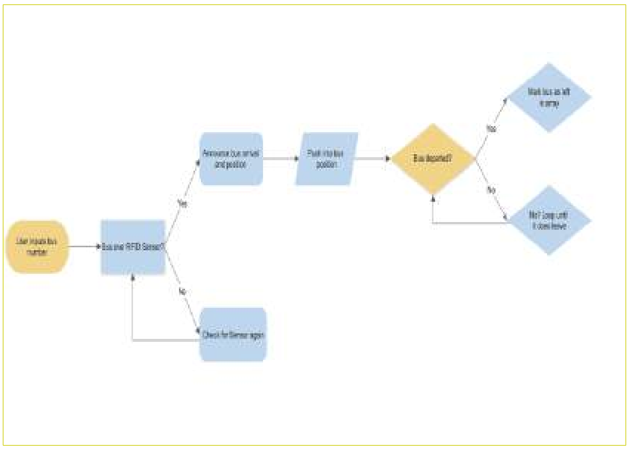

Figure 4. Algorithm diagram of the SBDS.

Another algorithm was used to check whether the user entered the correct bus using the beacon sensors. The beacon was selected owing to its ability to provide accurate location data. The algorithm first calls a beacon signal to verify whether the user has entered the correct bus. The web server then pushes the notification if the number matches the user's pre-input number. This is to let the bus user know whether they boarded the correct bus or not, as some visually impaired users might be unable to identify the bus they are on and whether it is the correct bus. Figure 4 shows a diagram of this subsystem.

IoT Network

A wireless sensor network based on cloud computing is vital to the SBDS because the system requires simultaneous monitoring of many systems. The SBDS uses a microcontroller as the IoT gateway to send and receive data from and to a web server. Each SBDS is equipped with its own microcontroller and LTE modem. The data are transferred in TCP/IP packets [37] from the microcontrollers to the web server via LTE. The data are then processed by web servers for later visualization and pushed to the user's application.

Cloud-Computing-Based Web Server

As mentioned previously, the server processes the data received from the RFID sensors and evaluates the location of the bus and its position in the queue. The server then visualizes the data and sends it to the user, informing the user of the position of the target buses anytime and anywhere. In addition, data are saved into a database for quality maintenance and live monitoring in case problems arise. The primary purpose of the cloud-computing-based web server in this system is to monitor many SBDSs simultaneously, as monitoring large amounts of data is key to the success of this system. In addition, a notification system was attached to the webserver to enable contact with the application to push updates on the bus arrival and departure. The web server is shown in Figure 5.

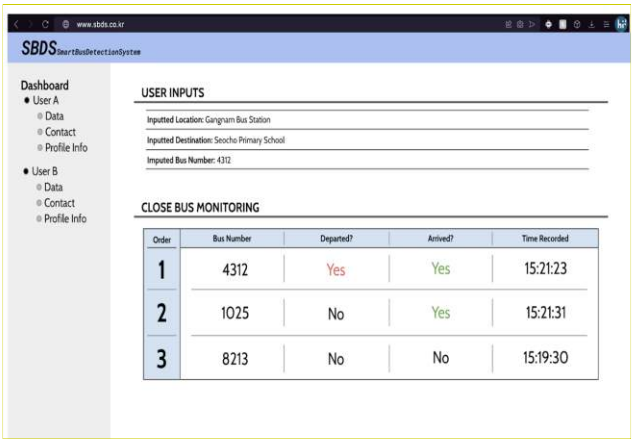

Figure 5. Web server for the SBDS platform.

Application

For commuters to use the SBDS, an iOS application was developed to present the processed data in viewable and audible formats. Data could not be shown to the user in its raw form, either because of its probable ineffectiveness or because of the target audience (the visually impaired). The user inputs the number of target buses. In addition, the application was paired with a voice announcement system to effectively display the data processed through the web server. The bus positions are displayed graphically, as shown in Figure 6.

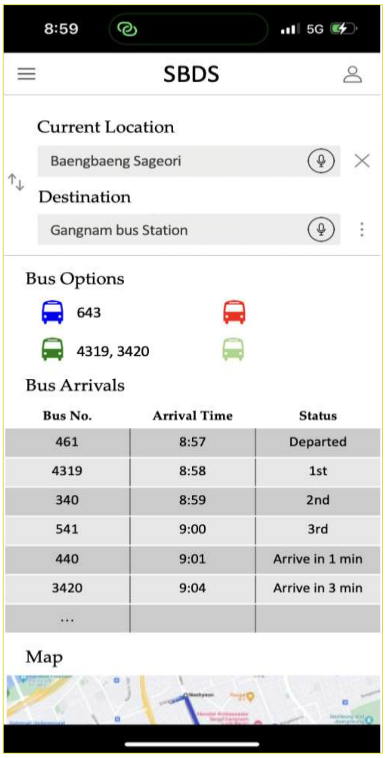

Figure 6. SBDS application.

Voice Announcement System

Auditory features and visual aids are necessary because the system was designed for the visually impaired. One aspect integrated into this system is an arrival announcement message. As the bus nears a station, the application makes a voice announcement regarding the position of the bus in the queue and its number, such that the user knows exactly where to ride the bus. In addition, when the user enters the target bus, the system checks if it aligns with the bus information that the user has inputted previously and lets the user know whether it is the correct bus using the beacon attached inside the bus.

Experimental Testing

Because reliability is key to this system, experiments were performed to check the accuracy and practicality of the IoT-based bus arrival monitoring system. To test the reliability of the system, multiple SBDS device sets were installed at bus stations around Seoul, including Seocho Station and Baengbaeng Sageori Station. The system comprised the SBDS, a microcontroller, an LTE modem, a cloud-computing-based web server, and an iOS application.

Installation

Two SBDS devices were installed to provide information to the visually impaired and test the SBDS. They were installed at bus stations around Seoul. The first RFID sensor was attached approximately 20 m from the station, and one was placed at the end of the station. Figure 7 shows photographs of the sensor installation locations. The RFID reader was strategically placed 20 meters ahead of the bus stop to provide early detection and ample time for visually impaired individuals to be notified about the approaching bus. This distance allows the system to recognize the bus and relay the information to the individual promptly, giving them sufficient time to prepare and position themselves safely for boarding. Furthermore, this setup reduces the risk of last-minute confusion or rush, improving both safety and accessibility. It also helps avoid interference with other RFID signals that might occur if the reader was placed too close to the bus stop, ensuring a more reliable and effective recognition process.

In addition, the device was tested at two different stations, a roofed station, and a pole station, to ensure that the system could operate in both conditions. As the components of the SBDS were designed to be functional in extreme temperatures (>-20, <60) and varying humidity, the SBDS could endure conditions that the system would usually face [27, 28]. According to some papers, in rainy conditions, the system could maintain a high level of accuracy in recognizing buses, as the RFID technology used is not significantly affected by water. For extreme temperatures, both hot and cold, the RFID components continued to operate within the specified temperature range without a noticeable decline in performance.

(a) (b) (c)

Figure 7. Installation of RFID sensors in (a) Baengbaeng Sageori station, (b) Beacon in a bus, and (c) Seocho station.

Web Server

After installing the SBDS at the two locations, the web server and website were launched to enable system monitoring, detect bus arrivals, and process the mass data received from the system. Figure 4 shows illustrates the web server. It comprises the monitored sensor, which detects bus arrival, and beacons, which monitor whether a person enters the bus or not. The server shows a datasheet of Boolean and user values to show these data, with the time the data were received shown next to the values. If any errors arise, the manager or user can act to mitigate them.

Application

The application was designed to provide users with easy access to information from the web server. The application displays the user's data and their current location. In addition, the application displays the user's selected location and number of buses tracked by the SBDS. The estimated arrival time of the target bus is also determined. All information can be announced vocally by clicking on a button next to the text. In addition, the application periodically announces the estimated arrival time of the bus and whether the bus has arrived at its destination.

User Testing

The user testing process consisted of active testing of 10 individuals, composed of 4 visually impaired people and 6 blindfolded people. The 4 visually impaired people were chosen by volunteering, while the 6 blindfolded people were also chosen by volunteering, however, were chosen with the condition of having experienced vision problems in the past to some extent. The age range of the individuals were between 30 to 50, with half of each group (visually impaired/blindfolded) being male and the other being female. The 10 individuals installed the SBDS and were led to a bus station by a guardian. All participants were instructed to ride the bus while using the application. After the testing, users were required to take a survey with a series of questions, rating their answers on a scale of 1 to 10; one of the questions had to replied with a yes or no.

Results

The experiment was performed as an initial implementation of the proposed system for monitoring bus arrivals and departures for the visually impaired. Smart bus detection devices wirelessly transfer data from preselected buses. The data were then compiled to monitor bus arrival and departure and users boarding the buses. The experiment demonstrated that the system effectively informed users of bus arrival and departure through voice messages. In addition, the beacon correctly detected whether the user had entered the correct bus by checking the beacon information of the bus and comparing it with that inputted by the user, as shown in Figure 8. In addition, the web server correctly displayed the status of the buses and the time at which the data were received.

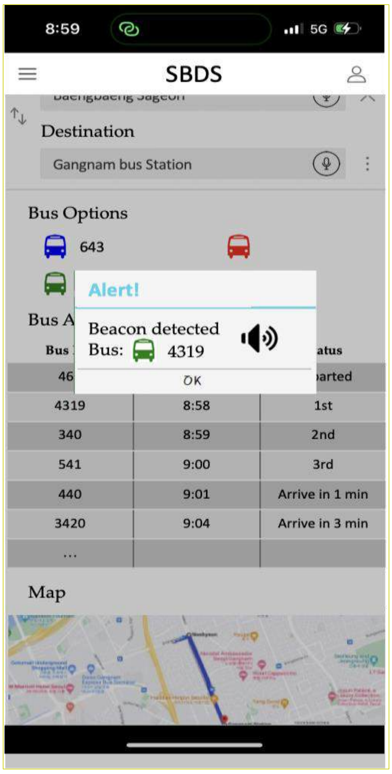

Figure 8. Pop-up and voice notifications when a user enters the bus.

Because the system was designed to improve the bus commuting experience of the visually impaired, interviews with users were conducted to collect data for a qualitative analysis of the effectiveness of the system. The interviews involved people with and without visual impairment, as the application was designed for both types of users. People without visual impairments were satisfied with the integrated Google Maps showing the location of the bus and the convenience of being notified of the arrival of their target bus. The visually impaired were also extremely satisfied with the application, as they were able to receive prompt notifications of the bus arrival and check whether they boarded the correct bus.

The feedback from the 10 users revealed that all users agreed that the device did have a positive impact on their bus-riding experience (all answers to all questions had a rating above 5). However, the most positive response was for question number 9B (all responses had a rating of 7 or above). The lower response rate to question 9A could be explained by the traffic present when the users tested the system. Heavy traffic could have led to inaccuracies in the system and a more crowded line, which would have inconvenienced the user. The congestion could have resulted in sensors being inaccurate, as the buses might have been in one place for a while. Meanwhile, as shown in Figure 10A, all the users agreed that the app must be further developed to assist the visually impaired. Most of the users responded favorably to using the app after its release (Question 10B), indicating the effectiveness of the app in providing accessibility to the visually impaired.

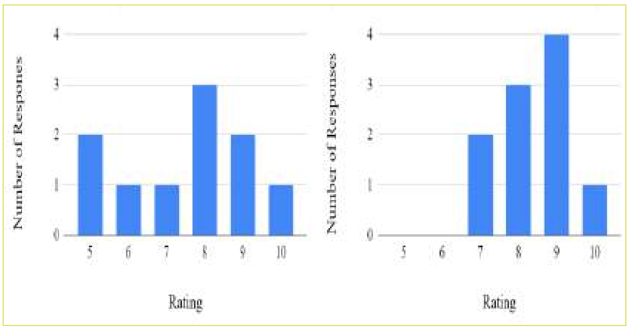

Figure 9. Survey test results for (a) riding experiences and (b) ease of use.

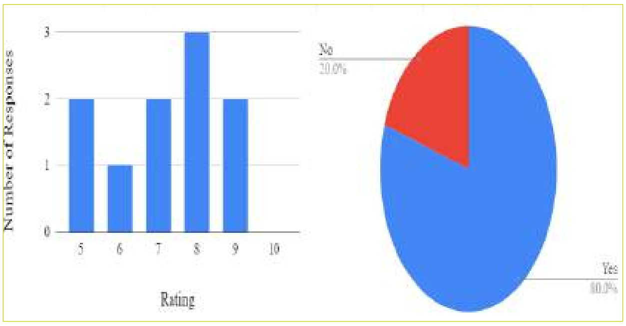

Figure 10. Survey test results (a) necessity of development and (b) likeliness to use.

Some of the additional comments that were given by text consisted of suggestions and positive feedback. One of the most requested suggestions was using the tactic motor inside the phones to use vibration to alert the users. If the user does not have audio because of a lack of headphones or a damaged phone, vibrations could be used to alert the user of the bus's arrival. Another popular suggestion was an alert system that would notify the user if there was a delay in the bus's arrival or congestion; this could help resolve the issues of the system during heavy traffic. The positive feedback also included a decrease in fear and adversity against riding public transportation, as the system allowed users to safely and easily ride buses in their daily lives.

Conclusion

This study proposed a system for assisting the visually impaired in their daily bus commute using an RFID sensor, a beacon, and a cloud-computing-based web server. Experiments in actual stations were performed to analyze the viability of the system and collect primary qualitative feedback regarding the system. The experiments demonstrated that the system effectively aided users through voice announcements. The following conclusions were drawn from the experiments: (1) The SBDS can successfully detect the arrival and departure of buses in real-time. (2) The SBDS can detect the boarding of users and display the data anytime and anywhere on the web server and application. (3) The voice alert system in the application could effectively notify users of bus arrivals and departures.

The experiment results also demonstrated the feasibility of the system for real-life applications to assist the visually impaired in their daily bus commute. Future studies should be conducted to improve the viability of the proposed system. This study demonstrated the practical applicability and effectiveness of the SBDS. However, more experiments and tests are necessary to test its accuracy and reliability. Additional features can be implemented on the platform, such as developing the application for Android users and converging artificial intelligence technology to the system.

However, the results also demonstrated that the system could be made more effective in correctly informing the user of essential information during heavy traffic. The response ratings declined when the users attempted to use the app in areas with congestion. Improving this flaw is crucial for the application's success as inconsistent results under pressure may negatively impact the app usage. Therefore, using a more accurate sensor or incorporating a more advanced algorithm can increase the accuracy of the system.

The system can also be improved by developing the application for Android users. Android phones are popular among the older generation with impairments, with 51% of such users (older than 33 years) choosing Android over iPhone owing to Android being relatively cheaper as well as supporting the visually impaired [38]. Developing the application for Android phones and making it available on Google Play Store is crucial to reach out to a wider population; this will also help widen the availability of the app to many more people who suffer from blindness.

The subsequent step to improve the platform is to introduce artificial intelligence into the application. This may be achieved by using visual recognition AI, such as the app Seeing AI, developed by Microsoft, for visually impaired individuals. Seeing AI uses object recognition to distinguish specific objects from their respective device's camera and then announces it to the user [39, 40]. The software can be used to spot specific bus features, such as the entrance or the payment area, to assist the user in their boarding experience. Thus, an application integrated into the platform would contribute to helping the bus boarding experiences.

Declarations

Acknowledgments: The authors are thankful to the Seoul Innovation Research Institute.
Author Contributions: The authors confirm responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.
Conflict of Interest: The authors declare no conflict of interest.
Consent to Publish: The authors agree to publish the paper in International Journal of Recent Innovations in Academic Research.
Data Availability Statement: The data presented in this study are available upon request from the corresponding author.
Funding: This research received no external funding.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.
Research Content: The research content of manuscript is original and has not been published elsewhere.

References

1. Eballé, A.O., Mvogo, C.E., Koki, G., Mounè, N., Teutu, C., Ellong, A. and Bella, A.L. 2011. Prevalence and causes of blindness at a tertiary hospital in Douala, Cameroon. Clinical Ophthalmology, 5: 1325-1331.
2. Nguyen, H., Di Tanna, G.L., Coxon, K., Brown, J., Ren, K., Ramke, J., et al. 2023. Associations between vision impairment and driving performance and the effectiveness of vision-related interventions: A systematic review. Transportation Research Interdisciplinary Perspectives, 17: 100753.
3. Keeffe, J.E., Jin, C.F., Weih, L.M., McCarty, C.A. and Taylor, H.R. 2002. Vision impairment and older drivers: Who's driving?. British Journal of Ophthalmology, 86(10): 1118-1121.
4. Jakob, A., Craig, J.L. and Fisher, G. 2006. Transport cost analysis: A case study of the total costs of private and public transport in Auckland. Environmental Science and Policy, 9(1): 55-66.
5. Mashiata, M., Ali, T., Das, P., Tasneem, Z., Badal, M.F.R., Sarker, S.K., et al. 2022. Towards assisting visually impaired individuals: A review on current status and future prospects. Biosensors and Bioelectronics: X, 12: 100265.
6. Seong-yong, P. 2022. Public transportation for the visually impaired is 'inconvenient'… "Improvement of convenience must come first". Available from: https://www.welfarenews.net/news/articleView.html?idxno=84393
7. Singh, R.R. and Maurya, P. 2022. Visual impairment and falls among older adults and elderly: Evidence from longitudinal study of ageing in India. BMC Public Health, 22(1): 2324.
8. Mizuno, T. and Tokuda, K. 2023. Reducing falls among visually impaired individuals on railway platforms: Field research on environmental challenges and solutions. Heliyon, 9(3): e14666.
9. Nižetić, S., Šolić, P., Gonzalez-de-Artaza, D.L.D.I. and Patrono, L. 2020. Internet of things (IoT): Opportunities, issues and challenges towards a smart and sustainable future. Journal of Cleaner Production, 274: 122877.

10. Zaidan, A.A. and Zaidan, B.B. 2020. A review on intelligent process for smart home applications based on IoT: Coherent taxonomy, motivation, open challenges, and recommendations. Artificial Intelligence Review, 53(1): 141-165.

11. Ushakov, D., Dudukalov, E., Kozlova, E. and Shatila, K. 2022. The internet of things impact on smart public transportation. Transportation Research Procedia, 63: 2392-2400.

12. Shendge, A.B. 2021. Internet of things (IoT): An overview on research challenges and future applications. International Journal of Engineering Applied Sciences and Technology, 6(8): 66-71.

13. Korade, S.A., Kotak, V. and Durafe, A. 2019. A review paper on internet of things and it's applications. International Research Journal of Engineering and Technology, 6(6): 1623-1630.

14. Jeong, R. and Rilett, R. 2004. Bus arrival time prediction using artificial neural network model. In: Proceedings of the IEEE Conference on Intelligent Transportation Systems (IEEE Cat. No. 04TH8749) (pp. 988-993). doi:10.1109/ITSC.2004.1399041

15. Lee, C. and Yoon, Y. 2022. A novel bus arrival time prediction method based on spatio-temporal flow centrality analysis and deep learning. Electronics, 11(12): 1875.

16. Mane, M.P.S. and Khairnar, V.D. 2014. Analysis of bus tracking system using GPS on smartphones. IOSR Journal of Computer Engineering, 16: 128–132.

17. Wang, H.L., Chen, Y.P., Rau, C.L. and Yu, C.H. 2014. An interactive wireless communication system for visually impaired people using city bus transport. International Journal of Environmental Research and Public Health, 11(5): 4560-4571.

18. de Andrade, H.G.V., Borges, D.D.M., Bernardes, L.H.C, de Albuquerque, J.L.A. and da Silva-Filho, A.G. 2019. BlindMobi: A system for bus identification, based on bluetooth low energy, for people with visual impairment. In: Proceedings of the XXXVII Brazilian Symposium on Computer Networks and Distributed Systems (pp. 391-402). Porto Alegre: SBC. doi:10.5753/sbrc.2019.7374

19. Kadam, A.J., Patil, V., Kaith, K. and Patil, D. 2018. Developing a smart bus for smart city using IoT technology. In: Proceedings of the 2018 Second International Conference on Electronics, Communication, and Aerospace Technology (ICECA), Coimbatore, India (pp. 1138-1143). doi:10.1109/ICECA.2018.8474819

20. Anu, V.M., Sarikha, D., Keerthy, G.S. and Jabez, J. 2015. An RFID based system for bus location tracking and display. In: Proceedings of the International Conference on Innovation Information in Computing Technologies (pp. 1-6). doi:10.1109/ICIICT.2015.7396080

21. Hasan, M.F.M., Tangim, G., Islam, M.K., Khandokar, M.R.H. and Alam, A.U. 2010. RFID-based ticketing for public transport system: Perspective megacity Dhaka. In: 2010 3rd International Conference on Computer Science and Information Technology (Vol. 6, pp. 459-462). doi: 10.1109/ICCSIT.2010.5564067

22. Hemalatha, S., Das, N.N., Ramasamy, J., Madan, S. and Mahesh, P.S. 2023. Automated service assistances to the visually impaired people using android application. World Journal of Engineering, 20(2): 337-345.

23. Oudah, A. 2016. RFID-based automatic bus ticketing: Features and trends. In: IOP Conference Series: Materials Science and Engineering (Vol. 114, No. 1, p. 012146). doi:10.1088/1757-899X/114/1/012146

24. Alwi, S.R.A.W. and Ahmad, M.N. 2013. Survey on outdoor navigation system needs for blind people. In: 2013 IEEE Student Conference on Research and Development, Putrajaya, Malaysia, 16–17 December 2013 (pp. 144-148). doi: 10.1109/SCOReD.2013.7002560

25. Divekar, S.N., Patil, S.R. and Shelke, S.A. 2018. Smart bus system. International Journal of Scientific Research in Science, Engineering and Technology, 4(4): 585–588.

26. Redij, S., Rao, A., Kumar, S.A. and Jadhav, A. 2022. Smart bus tracking for blind and visually impaired. In: ITM Web of Conferences (Vol. 44, p. 02001), EDP Sciences.

27. Raspberry Pi. 2015. Raspberry Pi 2 model B. Available from: https://www.raspberrypi.com/products/raspberry-pi-2-model-b/

28. Chafon. 2019. CF-RA5006 RFID sensor specification. Available at: https://ko.chafontech.com/rfid-antenna/uhf-rfid-antenna/3m-rfid-reader-antenna.html

29. GS1 Standards. 2015. EPC™ radio-frequency identity protocols generation-2 UHF RFID. Available at: https://www.gs1.org/sites/default/files/docs/epc/Gen2_Protocol_Standard.pdf
30. Highconen/Highconen. 2018. Access control attendance management fixed Beacon HRD-net compatible iBeacon-HyconN HyconN. Available at: https://smartstore.naver.com/hyconcard_iot/products/4257872328
31. Jo, B.W., Jo, J.H., Khan, R.M.A., Kim, J.H. and Lee, Y.S. 2018. Development of a cloud computing-based pier type port structure stability evaluation platform using fiber Bragg grating sensors. Sensors, 18(6): 1681.
32. Alam, T. 2022. Internet of things: Review, architecture and applications. Computer Science and Information Technologies, 3(1): 31-38.
33. Chaudhuri, A. 2018. Internet of things, for things, and by things. 1st Edition. Auerbach Publications. https://doi.org/10.1201/9781315200644
34. Wu, M., Lu, T.J., Ling, F.Y., Sun, J. and Du, H.Y. 2010. Research on the architecture of internet of things. In: 2010 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE) (Vol. 5, pp. V5-484). doi:10.1109/ICACTE.2010.5579493
35. Zhang, Y., Yu, H., Zhou, W. and Man, M. 2022. Application and research of IoT architecture for end-net-cloud edge computing. Electronics, 12(1): 1.
36. Tracy, K.W. 2012. Mobile application development experiences on Apple's iOS and Android OS. IEEE Potentials, 31(4): 30-34.
37. Eltaeib, T. 2015. TCP/IP protocol layering. International Journal of Computer Science and Technology Research, 3(1): 415-417.
38. Sherif, A. 2023. U.S. preferred smartphone operating system ownership 2021, by age. Available at: https://www.statista.com/statistics/1313944/main-smartphone-usage-share-by-age/
39. Dockery, D.M. and Krzystolik, M.G. 2020. The use of mobile applications as low-vision aids: A pilot study. Rhode Island Medical Journal, 103(8): 69–72.
40. Nam Kim, H. 2022. Digital privacy of assistive technology users with visual disabilities. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 66(1): 1105-1109.

Citation: Steve Rho and Albert Rho. 2024. Internet-of-Things-based Smart Bus Detection Platform for the Visually Impaired. International Journal of Recent Innovations in Academic Research, 8(10): 54-65.