Appendix 3.2

Report of Publishing Journal Papers

Name: (Presenter)	Olakunle Elijah, Sharul Kamal Abdul Rahim
Affiliation:	Universiti Teknologi Malaysia
Project Title:	An IoT-based Public Transport Data Collection and Analytics Framework using Bluetooth Proximity Beacons
Journal Name: (Website if any)	Frontiers in the Internet of Things https://www.frontiersin.org/journals/the-internet-of-things
Title of Research Paper:	Transforming urban mobility with internet of things: public bus fleet tracking using proximity-based bluetooth beacons
Name of all Co-authors (if any)	Sye Loong Keoh, Chee Kiat Seow, Qi Cao, Mohammad Adib bin Sarijari, Noor Farizah Ibrahim and Achmad Basuki

Reviewers' Questions and Comments:

(e.g. Questions or comments received by your submission)

Reviewer 1:

1. IEEE 802.11p is also being used in bus tracking as seen in the paper below. Please cite. Include this in line 45.

F. I. X. R. Gan, G. P. T. Mayuga, L. B. K. Lao and E. R. Magsino, "An Implementation of A Bus Following Model in an 802.11p Based Simulator in MATLAB," 2023 1st International Conference on Advanced Innovations in Smart Cities (ICAISC), Jeddah, Saudi Arabia, 2023, pp. 1-6, doi: 10.1109/ICAISC56366.2023.10085008.

Thank you for pointing out the IEEE 802.11p. We have included the citation

2. The "video" in line 45 has no proper citation. Please provide the correct reference.

We have removed the "video", as we couldn't find related work that used video-based fleet management. Sorry about that, and we have rectified the error.

3. The authors need to elaborate in Section 1 their major contributions. They have compressed it only in one paragraph. I suggest they provide more details to allow readers to see how their work is also different from published ones.

Thanks for your suggestion. We have provided more explanation on the contribution of this work, i.e., the proposed IoT-based proximity sensing using BLE as an alternative approach to bus fleet tracking and that

the system is currently on trial and deployed in Johor Malaysia demonstrates the feasibility of implementing such a solution in a real-world setting. Specifically, our contributions are as follows:

- **Design, implementation and deployment of the proposed IoT-based BLE proximity sensing for bus location tracking in a real-world public stage bus service in Malaysia.**
- **Derive insights relating the bus journey, duration between bus stops and traffic patterns based on the bus location data collected to provide ETA for the bus services.**
- **Devise a base algorithm to compute the ETA based on the historical journey time of the bus services, using the real-time location data obtained from the proposed IoT-based proximity sensing system to estimate the arrival times for subsequent bus stops.**
- **Share the challenges, experiences and lessons learnt from this real-world deployment, discussing the deployment architecture, power-supply, reliability of IoT devices, and efforts in engaging the relevant stakeholders.**

4. In line 97, what do the authors mean by "this"? What really is the problem being addressed with the use of BLE?
We have revised the sentence to the following:

A study by Gunady and Keoh (2019) proposed the use of BLE proximity beacons for bus tracking and estimation of arrival time as an alternative to using a GPS device.

5. The authors do not provide a clear motivation on the use of BLE. I think the discussion in section 1 is lacking in this part too and it leads in the lack of understanding until the related works section. Please provide more discussion on your motivation on why BLE is implemented.

We have improved the introduction section to include the motivation for the use of BLE.

There are still some smaller bus operators which are not part of the myBas ecosystem, especially in small towns. Managing the fleet can be challenging and without adequate funding from the government, the operators are reluctant to invest in the infrastructure, i.e., GPS system on the buses to improve their service offering. Given such a constraint, the idea is to investigate the use of alternative approaches to GPS, i.e., by using IoT technology, which is potentially lower in cost and yet sufficiently reliable to provide the basic fleet management needs to improve their bus services, so that they are at least on par with the other major operators.

This paper presents an alternative approach to track the location of buses without using a GPS device, offering an innovative IoT-enabled Bluetooth approach as a potential solution to collect bus location data based on proximity sensing. BLE has been widely used and deployed for presence sensing, e.g., Apple's AirTag, indoor positioning, e.g., Estimote's Bluetooth beacons, as well as proximity-based contact tracing during COVID-19 period. Our approach aims to build smart infrastructure at the bus stop by embedding IoT devices to perform sensing and information dissemination. The first task is to sense the arrival of buses at the bus stop using wireless proximity sensing and then transmits the location data to the cloud. Proximity sensing using BLE is fast and accurate as it is efficient to broadcast BLE advertisements periodically and no communication handshake is required.

6. In Section 2, place a last paragraph to explicitly discuss the difference of your work from the papers presented.

Thank you for the suggestion, we have summarised the main difference between our work and the existing papers presented.

Motivated by the increasing deployment of smart bus stops and the use of IoT technology, the state of the art surveyed has shown the feasibility and viability of using proximity sensing approaches for fleet tracking in a small scale. In this paper, we propose a data collection and analytic framework for public bus services based on BLE proximity sensing and scale up the solution for deployment in a real-world setting, i.e., trials on multiple bus services, spanning multiple cities in Johor, Malaysia. This further demonstrates the feasibility of using the IoT-based BLE proximity sensing as an alternative to the GPS-based system. The experience drawn from the real-world deployment of such a large-scale field trial in a developing country like Malaysia, involving the public bus operator and city councils is valuable. Despite the many challenges faced, this paper also highlights the solutions and strategies for mitigating both the technical and soft challenges encountered during the deployment.

7. In line 135, there are GPS-operated devices that also use batteries, right? You may want to change your reason for this.

Thanks for your observation. Yes, there are battery-powered GPS devices. From our survey of some of the commercial buses in Malaysia, they make use of connected GPS devices powered by the bus. One of the reasons is to avoid battery maintenance and less interruption with the system. We have accepted your suggestion to remove this statement as one of the advantages.

8. In line 138, BLE signals are very much affected by outdoor interference. So, I am not advising that you dwell on the shortcoming of the GPS system wherein your preferred solution will also have its own shortcomings.

Thanks for your observation. We outlined some of the limitations of the GPS-based approach and that of the BLE approach. The aim is to allow the readers to see the limitations of both approaches for an informed decision.

9. In line 143, there are more public WiFi hotspots. So, from the government's perspective, wouldn't it be cheaper if they use the IEEE 802.11 protocol instead of deploying new BLE systems?

In Malaysia, there are no public WiFi hotspots in most of the bus stops. Most of the Wifi hotspot APs are installed at crowded areas and not at the bus stops. Unfortunately there is no public hotspot along the entire route of the bus service that we can tap on, and hence we will not be able to devise a location tracking system using 802.11 in Malaysia. Additionally, from our literature study most of the presence sensing and proximity sensing approaches are based on BLE, and we had decided to deploy the proposed IoT-enabled BLE location tracking in the context of Malaysia to evaluate its feasibility as an alternative approach to GPS-based system.

10. In line 246, you mentioned machine learning. What specific algorithm or method do you intend to use?

Thanks for your suggestions. The bus location data collected from this research will then be fed into a machine learning model trained using nonlinear regression techniques, i.e., decision tree regressor, random forest regressor and k-nearest neighbors regressor, as well as other methods using Artificial Neural Network (ANN) and Multi-Layer Perceptron to refine the prediction engine, thus increasing the accuracy of the estimation of bus arrival time. Our initial exploration shows that ANN has the capability of

capturing the journey duration and temporal dynamics of the traffic environment from this dataset, producing a reasonable estimation of the journey duration.

We have added the paragraph above to the paper.

11. In line 163, you mentioned max range is 70m. This is one of the problems of BLE. If the bus is outside, then, the bus is no longer being tracked. How do you solve that and in terms of telling the users its whereabouts, how do users know that the buses are really tracked?

Also, given a simple straight line of 700m, you need 10 BLE devices as compared to 2-3 Wifi devices. Please check. Also, line of sight detection.

Thanks for your comment. This is correct, if the bus does not stop at the bus stop and travels on the furthest lane which could be > 70m from the RPi, it is likely that the BLE signal will not be detected. Actually, the bus is supposed to be driven on the left-most lane that is nearest to the bus stop, and the bus would usually stop at the bus stop. Hence, the distance between the RPi to the leftmost lane is at most 10m and detection of the bus will be feasible.

For a very wide road, we have installed an additional RPi device at the opposite bus stop to increase the range of detection. With this, although the bus could be 70m from the RPI, it could be 50m or less from the RPI at the opposite bus stop. From the deployment experience, we will be able to know whether the range of detection is sufficient, and if not, we will install an additional RPi on the opposite bus stop.

As our proposal is using proximity-based sensing for location tracking, our aim is to only detect that the bus is in close vicinity, near to the bus stop and we are not proposing a method to detect the bus which is 100 - 200m away. Our aim is also to build smart infrastructure at the bus stops, and therefore installing more BLE detection devices would fit well with this objective.

12. I never read a section on how ETA was calculated.
We have improved the discussion on how the ETA is calculated in Section 4.4.

13. It would be better if the routes in Figure 2 are superimposed to see if there are overlaps.

Thanks for the suggestion, we have added a grey area box on the map to indicate the overlaps of the bus stops for P-411 and P-211.

14. Does Table 1 record the BLE RSSI average? Wouldn't it be better if the time series RSSI values are presented?

Thanks for your comment, the table shows the average RSSI recorded comparing the difference in the RSSI when placing the RPi Zero in a metal enclosure or in the open field. This result is used to help us establish the feasibility of putting the RPi Zero in an enclosure (to protect RPi from theft and vandalism), and to determine the placement of the metal enclosure box to be installed.
Equation (1) is already confusing since you use D(k) twice in it. What does Figure 7 tell us, that the journey time is different and dynamic? Please clarify.

Thanks for the observation. The Equation has been corrected. Figure 7 shows a plot of the raw data

collected, we described that there were varying journey duration for these two bus services mainly due to the traffic and that there was an observation that the journey duration on public holiday (Apr 21st) was the shortest.

16. In Section 4.2, you never mentioned the reasons for the delays. You just stated that there are certain percentages of on-time departures. Where do these buses leave on time? What are the causes of the delays? E.g., if you have more passengers riding at a certain stop, is that already considered a delayed departure or arrival?

The on-time performance data presented is only relevant to the Bus Terminal Station (Departure point), and not the on-time arrival at the bus stops. The data collected was analyzed based on the time the scheduled Bus departed from the terminal. From the data, we are only able to analyse the late, early, and prompt departure of the buses based on the scheduled time at the bus terminal station. The analysis is expected to assist the bus management agency in monitoring the performance of the bus drivers. It is highly likely that the late departure of the bus is due to the driver's behaviour that they did not adhere strictly to the departure schedule and this should be left to the bus operator to deal with the drivers for on time departure by offering incentives or imposing penalty.

17. In equation (2), what does D(k) mean there?

Thank you for your observation. The symbol D(k) has been corrected in equation (1) and defined as TD(k) to denote the trip duration for bus k.

18. In Section 4.5, you mentioned that it is near the equator? Is this really a valid reason? When you are in Malaysia and in your targeted route of study, do the locations really change that much with respect to the equator? Please enlighten me or change the reason. Also, does your system include a fan to circulate heat in your enclosure?

We have rephrased the statement to avoid ambiguity as follows.

This could be due to the topography of the area.

19. I think one of the things the authors forgot to include here is its scalability issues. What happens when the RPi detects multiple buses? They should at least tested that scenario because an RPi detecting only one bus should always be successful.

The proposed system is able to detect multiple buses. We do not envisage that detection of multiple buses will be an issue in this case as different buses have different ID and BLE Beacon MAC address and the system will be able to handle the number of public buses that are registered to the system. In the current deployment there were instances where the RPI detected 2-3 buses at the same time.

20. The cost-benefit analysis only relied really on the installation and maintenance cost of the system. However, the authors are advised to widen their cost-benefit analysis. e.g., BLE data transfer is only limited to simple data as compared to WiFi. In Table 2, would a $3000 approximated difference be sufficient to really switch to BLE other than GPS? Please elaborate because the discussion is very weak.

Thanks for your comment. In the proposed proximity sensing based on BLE, the size of the data transfer is rather small, i.e., only the location data. Hence, in our opinion the use of BLE is sufficient. As for the

cost-benefit analysis, both GPS and IoT-based approaches have their own merits, and we are benchmarking the both approaches and offer a discussion in two parts in Section 4.6. First is the cost of deployment and second is the recurring cost.

The deployment cost shown in Table 2 shows that the initial cost for proposed systems is almost the same as the deployment cost of GPS-based. However, comparing the recurrent cost analysis in Figure 13, the BLE system is expected to provide cost-benefit in the long term.

21. In Figure 13, you linearly projected the difference between the two technologies. However, you forgot to mention the maintenance. Are you sure that your BLE devices would last longer than the GPS systems? Things like these must be considered in the discussion.

Thanks for the comments, in our opinion both GPS and BLE systems will require maintenance. the maintenance of the BLE system was mentioned in the discussion section in Section 4.6. where the battery of the beacons will need to be replaced periodically, and the batteries for RPi Zero too. However, we have left out the maintenance cost in the analysis due to a lack of data.

22. In Section 5.1.1, you mentioned the unavailability of power. Installing GPS in buses automatically removes this problem. The bus can simply send its whereabouts via cellular to notify its real-time data while the cloud computes it.

Do not get me wrong. The paper has its merits, however, the manner that you present it provides me an insight that there is too much to consider and discuss before really accpeting BLE IoT devices in such applications. I suggest that authors present their work in a clearer way.

Thanks for your comments and advice, as we all know GPS-approach is the current state of the art and our paper is to offer an alternative approach and as this journal's special issue is on the "real-world deployment challenges and experiences", we are highlighting some of the challenges when deploying the proposed system, and how these challenges can be resolved. We agree the deployment of GPS on buses will eliminate the issue of power supply. Though there was the issue of power supply, our system demonstrates that the use of batteries to power the RPi zero has successfully mitigated this issue. In outlining some of the challenges faced in the real-world deployment of the system In Johor Malaysia, Power interruption was an issue in most developing countries, on the contrary, we do not foresee the unavailability of power in developed countries.

23. I do not understand the "reliability of RPi". Do you mean the hardware design or its operation? Shouldn't it be always operational and reliable no matter what the conditions are?

It was necessary for us to check the reliability of using the RPI in the proposed system as they are critical to the operation of the proposed system. We have clarified with the following new text in the paper.

The RPi Zero must be operational during the day, and that the BLE detection and Internet connectivity must be up at all times. We observed that there were instances where the RPi Zero was down due to power cut, but it recovered automatically once the power supply resumed. While deploying the RPi Zeros in the field, we have created cron jobs to send heat-beats to Thingsboard to continuously monitor the RPi Zero's operational status, a daily restart is triggered to reset any transient software or BLE fault and Internet connectivity issue.

24. I think Sections 5.1.1-5.1.3 should be removed and not included in the paper.

Thanks for your suggestions. Section 5.1.1 - 5.1.3 highlights some of the challenges faced and how we mitigated the situations. In our opinion, this section serves as experience sharing on things that need to be considered when considering real-world deployment of the proposed system. The information can be useful for readership especially those who may wish to deploy the proposed IoT-based BLE system in the future.
In the abstract you mentioned improving ETAs and traffic management. However, the paper does not show how you were able to improve them.

Thanks for your comment. We have revised the abstract to mention the use of IoT-based approach as an alternative to fleet tracking, and the ability to estimate ETA based on the data collected. The devised base ETA calculation method based on the historical journey of the bus in combination with the real-time location data obtained from the proposed IoT-based proximity sensing system helps to provide a better estimate of arrival times as shown in Figure 10 (b).

In today's fast-paced world, efficient and reliable public transportation systems are crucial for optimising time and reducing carbon dioxide emissions. However, developing countries face numerous challenges in their public transportation networks, including infrequent services, delays, inaccurate and unreliable arrival times, long waiting time, and limited real-time information available to the users. GPS-based systems have been widely used for fleet management, but it can be a significant infrastructure investment for smaller operators in developing countries. The accuracy of the GPS location can be easily affected by the weather condition and GPS signals are susceptible to spoofing attacks. When the GPS device is faulty, the entire location traces will be unavailable. This paper proposes the use of Internet-of-Things (IoT)-enabled Bluetooth Low Energy (BLE) systems as an alternative approach to fleet tracking for public bus service. The proposed approach offers simplicity and easy implementation for bus operators by deploying BLE proximity beacons on buses to track their journeys, with detection devices using Raspberry Pi (RPi) Zero strategically placed at terminals and selected stops. When the bus approaches and stops at the bus stops, the BLE advertisements emitted by the proximity beacons can be reliably detected by the RPi Zero. Experiment results show that the BLE signals can be detected up to 20m in range when the RPi Zero is placed inside a metal enclosure. The location of the bus is then sent to the cloud to estimate the arrival times. A field trial of the proposed IoT-based BLE proximity sensing system involving two bus public bus services in southern Malaysian cities, namely Johor *Bahru*, *Iskandar Puteri* and *Kulai* is presented. Based on the data collected, a bus arrival time estimation algorithm is designed. Our analysis shows that there was a 5-10 minutes reduction in journey time on public holidays as compared to a normal day. Overall, the paper emphasises on the importance of addressing public transportation challenges. It also describes the challenges, experience, and mitigation drawn from the deployment of this real-world use case, demonstrating the feasibility and reliability of IoT-based proximity sensing as an alternative approach to tracking public bus services.

<u>Reviewer 2:</u>

1. The abstract could benefit from a clearer summary of the specific findings of the study. Presenting key numerical results or insights would enhance the reader's understanding without delving into the full paper.

Thank you for your comments. We have improved the abstract as follows:

In today's fast-paced world, efficient and reliable public transportation systems are crucial for optimising

time and reducing carbon dioxide emissions. However, developing countries face numerous challenges in their public transportation networks, including infrequent services, delays, inaccurate and unreliable arrival times, long waiting time, and limited real-time information available to the users. GPS-based systems have been widely used for fleet management, but it can be a significant infrastructure investment for smaller operators in developing countries. The accuracy of the GPS location can be easily affected by the weather condition and GPS signals are susceptible to spoofing attacks. When the GPS device is faulty, the entire location traces will be unavailable. This paper proposes the use of Internet-of-Things (IoT)-enabled Bluetooth Low Energy (BLE) systems as an alternative approach to fleet tracking for public bus service. The proposed approach offers simplicity and easy implementation for bus operators by deploying BLE proximity beacons on buses to track their journeys, with detection devices using Raspberry Pi (RPi) Zero strategically placed at terminals and selected stops. When the bus approaches and stops at the bus stops, the BLE advertisements emitted by the proximity beacons can be reliably detected by the RPi Zero. Experiment results show that the BLE signals can be detected up to 20m in range when the RPi Zero is placed inside a metal enclosure. The location of the bus is then sent to the cloud to estimate the arrival times. A field trial of the proposed IoT-based BLE proximity sensing system involving two bus public bus services in southern Malaysian cities, namely Johor Bahru, Iskandar Puteri and Kulai is presented. Based on the data collected, a bus arrival time estimation algorithm is designed. Our analysis shows that there was a 5-10 minutes reduction in journey time on public holidays as compared to a normal day. Overall, the paper emphasises on the importance of addressing public transportation challenges. It also describes the challenges, experience and mitigation drawn from the deployment of this real-world use case, demonstrating the feasibility and reliability of an IoT-based proximity sensing as an alternative approach to tracking public bus services.

1. Provide a more comprehensive overview of the existing literature on IoT applications in urban mobility. This would better situate the current study within the broader field.

Thank you for your suggestion. We have improved our motivation on the use of IoT in Section 1. In Section 2 Related work, many of the existing fleet management systems use GPS, which is the state of the art and hence in our opinion, we will not explain more on the use of GPS. Instead, we have expanded on the use of wireless technologies such as Wi Fi and Bluetooth for passenger sensing in the literature.

3. Elaborate on the specifics of the IoT system deployment, including the criteria for selecting bus stops, the process of obtaining permissions, and how stakeholder coordination was achieved.

Thank you for your suggestion. We have added the criteria for selecting the location of installation in Section 3.3.3. As for the coordination with the various stakeholders, approvals needed to be sought from the respective city councils for this project, and both site surveys and installation were done together with the electrician / contractor of the city councils to ensure the safety.

As there are 31 stops and 26 stops respectively for P-411 and P-211 in this study, numerous site surveys were conducted to identify suitable locations to install the BLE detection devices (RPi Zero in a metal enclosure). The locations are chosen based on the following considerations:

Power Supply - Most of the bus stops tap on the electricity from the adjacent street lighting to light up the bus stop at night. In cases where there are no lights at the bus stops, the nearby pedestrian overhead bridge was considered as the next alternative for energy sources as it is lighted up at night too. The locations were chosen based on the availability to tap on the electricity at night to charge the batteries in order to power the BLE detection device.

Bus Terminal - All bus terminals must have a BLE detection device installed as they serve as the departure point of the bus service.
Shelter - Most of the bus stops are sheltered and this ensures that the BLE detection devices are not exposed to direct sunlight and rain, though the metal enclosure is water-proof.
Crowd Level - Popular bus stops serving as the passenger hubs were chosen to ensure the safety of the BLE detection devices. This helps prevent potential vandalism as the bus stop is busy most of the time. In the future, the passenger information display can be integrated with the installed BLE detection device (RPi Zero) to show the bus arrival information.
Road Traffic - More BLE detection devices are installed at the congested road segment, so that the traffic congestion can be tracked, thus providing a finer granularity of the journey time data.

Once the bus stops had been identified, formal approval was sought from the respective city councils. Installation was done together with the electrician and contractor of the city councils to ensure the safety.

4. Clarify the statistical methods used in data analysis, especially regarding how the ETA computations were performed. Ensure transparency in the analysis steps.

Thanks for your suggestion, we have updated the equations used for deriving journey duration, average daily trip duration and the estimation of bus arrival time. The method is basically using historical data and averaging.

5. Address the missing data issue, particularly the absence of information for bus 32 after April 20th. Discuss potential biases introduced by this gap and how it was handled in the analysis.

Thanks for your comment, our aim is to mitigate the problem by equipping the replacement bus with the BLE beacon, so that we will not suffer from the missing data issue. The current data analysis is purely based on the data obtained, as the analysis is just deriving the journey duration for the entire route and to compute the journey duration between bus stops. As there are two instances of the bus, No. 32 and 31, we relied on the data collected from bus 31 for the ETA algorithm.

6. Further discuss the reliability assessment of the proposed system, especially in scenarios of intermittent power supply. Provide insights into how such situations impact data accuracy.

Thank you for your comment, we have added the following insights in Section 5.1.1

The intermittent power supply will typically lead to some services on the RPi Zero to be unavailable, e.g., when the battery's voltage drops below 6V, this will not be sufficient to power the 4G dongle even though the RPi Zero is still running. Without Internet connection, the bus location data though the BLE signal was detected by the RPi Zero, it cannot be sent to the cloud. Consequently, this may lead to intermittent inaccuracy of the bus ETA. However, once the bus is detected at the next bus stops, the location data updates will resume. In this case, although the Internet was down for the RPi Zero, once the power supply resumes and Internet connectivity will also recover, this means that all the bus detection data logged on the RPi Zero can be sent to the cloud in a batch. This ensures that the bus location data is not lost, and they are valuable as the dataset for training the journey duration prediction model.

7. Expand on the comparison between the proposed BLE-based system and traditional GPS-based systems. Discuss the trade-offs, advantages, and disadvantages of each approach in more detail.

Thank you. We have expanded our discussion on the proposed IoT-BLE systems by including the advantages, disadvantages and also identified the trade-offs in Section 3.1.

8. Elaborate on the feasibility and potential challenges in integrating a passenger counter into the system. Additionally, provide more details on the envisioned machine learning model for ETA prediction.

Thank you for your suggestion. The use of a passenger counter is outside the scope of this work. We have added a paragraph in Related Work on the use of WiFi and Bluetooth for passenger counting, and these approaches could be used in the future. The inclusion of passenger counters can be done by incorporating sensors at the bus stops or in the bus. The data collected from the sensors can be transmitted to the RPI and integrated into the database for further analysis.

The details on the envisioned machine learning has been included in Section 3.1.

The bus location data collected from this research will then be fed into a machine learning model trained using nonlinear regression techniques, i.e., decision tree regressor, random forest regressor and k-nearest neighbors regressor, as well as other methods using Artificial Neural Network (ANN) and Multi-Layer Perceptron to refine the prediction engine, thus increasing the accuracy of the estimation of bus arrival time. The initial exploration shows that ANN has the capability of capturing the journey duration and temporal dynamics of the traffic environment from this dataset, producing a reasonable estimation of the journey duration.

9. Summarize the main contributions and implications of the study more explicitly in the conclusion section.
Thanks for your suggestion, we have revised the conclusions and future works in Section 5.2

<u>Reviewer 3:</u>

1.In the introductory section, the contributions and the novelty are not clear or little specified.

Thank you for your comment. We have improved the introduction section to reflect the contributions and novelty.

We have provided more explanation on the contribution of this work, i.e., the proposed IoT-based proximity sensing using BLE as an alternative approach to bus fleet tracking and that the system is currently on trial and deployed in Johor Malaysia demonstrates the feasibility of implementing such a solution in a real-world setting. Specifically, our contributions are as follows:

- **Design, implementation and deployment of the proposed IoT-based BLE proximity sensing for bus location tracking in a real-world public stage bus service in Malaysia.**
- **Derive insights relating the bus journey, duration between bus stops and traffic patterns based on the bus location data collected to provide ETA for the bus services.**
- **Devise a base algorithm to compute the ETA based on the historical journey time of the bus services, using the real-time location data obtained from the proposed IoT-based proximity sensing system to estimate the arrival times for subsequent bus stops.**
- **Share the challenges, experiences and lessons learnt from this real-world deployment, discussing the deployment architecture, power-supply, reliability of IoT devices, and efforts in engaging the**

relevant stakeholders.

2. The literature lacks relevant technical approaches used in the domain of IOT field, that used BLE technology. Some relevant Bluetooth methods used in other fields should be cited and discussed into 'introduction' or 'related work'sections: i.e., 10.1186/s13673-020-0211-8, 10.1016/j.eswa.2023.121772. These recommended documents are essential for integrating modern IoT methodologies in different fields and domains, providing a comprehensive view for readers.

Thank you for your suggestion. We have added more related work in both Section 1 to motivate the use of Bluetooth for proximity sensing, as well as added other literature on using Wi-Fi and Bluetooth for passenger counting (object sensing in the proximity), though the focus of the paper is on the use of IoT-enabled BLE for bus tracking. Hence we have cited relevant papers in the manuscript in both the Introduction and Related Work Sections.

BLE has been widely used and deployed for presence sensing, e.g., Apple's AirTag, indoor positioning, e.g., Estimote's Bluetooth beacons, as well as proximity-based contact tracing Ng et al. (2021); Tang et al. (2021); Trivedi and Vasisht (2020) during COVID-19 period. We have also cited the use of BLE for bus tracking in Section 2: Related work

A study by Gunady and Keoh (2019) proposed the use of BLE proximity beacons for bus tracking and estimation of arrival time as an alternative to using a GPS device. This study focused on a single route with 37 bus stops and demonstrated an alternative to GPS for collecting, analysing, and disseminating bus transport information

Similarly, Dunlap et al. (2016) used Bluetooth and Wi-Fi to tackle the O-D counting and advocated that although Wi-Fi has a longer detection range, it adds a significant amount of spatial uncertainty to the data

3. Considering that the BLE system may encounter technical problems such as signal interference, limited range, or inaccuracies in position detection, which could affect the reliability of arrival time estimates and traffic monitoring, how did the authors handle this?

Thank you for your comment. The approach is based on proximity sensing, and it does not estimate the position or distance of the bus from the BLE detection device. As long as the BLE signal is detected, that is sufficient. As discussed in Section 3.3.4 and table I, we have tested the reliability of the BLE detection if the RPi Zero is housed in a metal enclosure, and we have shown that BLE advertisement can be detected up to 20m. In this use case, the bus is expected to be driven on the left-most lane of the road, closer to the bus stop, and in many cases stop at the bus stops. Hence the expected distance of the bus to the bus stop should be within 20m.

In Sections 5.1.1 and 5.1.2, we described that if the detection is missed at a bus stop, this is only 1 data point that is missed. The subsequent bus stop with an RPi Zero can still track the traveling bus as the system. In this deployment, we have built-in sufficient redundancy such that coarse location tracking can at least be guaranteed. While the missed detection may lead to intermittent

inaccuracy of the bus ETA, once the bus is detected at the next bus stop, the location data updates will resume and the ETA can be re-computed.

4. How do the authors address the fact that system performance could be affected by external factors such

as weather, urban density, or other environmental factors that could interfere with BLE signal transmission? **Thank you for your question. In response to your question.** **A pilot test was conducted to ascertain the system's performance at the University of Technology Malaysia's Main Campus by deploying a few RPI and BLE beacons on a few buses to determine the performance of the system. The effect of weather, power consumption, internet connectivity, and detention of buses was tested to ascertain the performance of the system before deploying in the three cities in Johor, Malaysia. Some of the tests carried out include BLE detection of the Buses, the effect of enclosure on the RPi, and the effect of power supply interruption as discussed in Section 3.3.2 and Section 3.3.4. Some of the challenges faced in the real-world deployment in Johor Bahru Malaysia have been discussed in Section 5.1.**
Contribution to the project: (e.g. Summary relating to your paper) This paper reports the main results of the deployment in Johor, Malaysia, detailing the software architecture, deployment effort and the challenges faced in the field study. It contributes 100% to the project.

[Required Documents]

C) Presentation Materials (reprint such PDF file) – **This is a journal publication, no presentation material**

D) Journal Cover Page and Contents Page of PDF file

Reporter: ___Sharul Kamal Abdul Rahim______

Date: ______16th Jan 2024__________________