Available online at
https://jcrinn.com/
https://crinn.conferencehunter.com/

Journal of Computing Research and Innovation 9(2) 2024

Journal of Computing Research and Innovation

FIXEL: Mobile Application for Roadside Assistance Provider Decision Making using TOPSIS

Mohd Suffian Sulaiman[1*], Mohd Fitri Afiq Azmi[2], Zuraidah Derasit[3], Azri Azmi[4]

[1,2,3]*College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[4]*Intelligence Informatics Department, Faculty of Artificial Intelligence, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia*

ARTICLE INFO

Article history:
Received 1 April 2024
Revised 15 April 2024
Accepted 18 May 2024
Online first
Published 1 September 2024

Keywords:
Mobile Application
TOPSIS
MCDM
PWA
AHP

DOI:
10.24191/jcrinn.v9i2.431

ABSTRACT

Many drivers have faced the struggle of getting help when their vehicle breaks down on the road. This difficult situation is extremely stressful because there are limitations to seeking help, such as the service provider being too far away or the service provider's contact number being unavailable. The complication of deciding to choose a service provider is also occurring because of the eagerness to fulfil different kinds of aspects, such as the lowest price of the services and the shortest distance from the service provider. From the service provider's perspective, it has become a challenge to get new customers when they are unfamiliar with their surroundings. Usually, the drivers will choose the most popular service provider, which may be far away from them. These issues sparked the motivation for this study, which aims to assist drivers and service providers through the mobile platform. One of the multi-criteria decision-making methods was employed to enhance the quality of choosing the right service provider based on the criteria involved, which are service availability, prices, distances and ratings. The result of this study would benefit drivers and service providers by improving decision-making, enhancing the customer experience, optimizing resource utilization and reducing cost.

1. INTRODUCTION

Roadside assistance is a type of protection when your vehicle stalls while out and about. A vehicle breakdown is one of the unexpected incidents that can occur. According to the Automobile Association Malaysia (AAM) analysis, there are approximately 40,000 to 60,000 cases of vehicle breakdown each year (Haridas et al., 2016). During a vehicle breakdown, getting out of the vehicle to inspect the problems on the vehicle can be extremely dangerous, especially on highways where there are frequently fast vehicles, and could result in a more tragic event (Sheng et al., 2016). During an on-road emergency, people typically use mobile devices to request assistance from professionals to repair or tow the vehicles. Having a lack of knowledge about any vehicle can be problematic. Finding a vehicle repair service provider (VRSP) nearby in an unfamiliar, stranded location can make the situation more challenging. frustrating for the driver in that case. The burden during vehicle breakdowns can be lessened with the aid of a proper application that can provide solutions for various problems that occur in the vehicles.

[1*] Corresponding author. *E-mail address*: m_suffian@uitm.edu.my
https://dx.doi.org/10.24191/jcrinn.v9i2.431

The issue of having multiple goals will always exist within organizations because complicates the decision-making process (Frazão et al., 2018). When comparing different criteria, it is possible to become confused and uncertain (Sürmeli et al., 2015). Thus, multicriteria decision-making (MCDM) methods will be employed in this study. MCDM is an operations research technique that evaluates several competing bases and improves the dependability and credibility of the chosen solution. Implementation of the MCDM methods can enable users to discover which alternative is most fitting for them.

Conflicting desires to fulfil tend to complicate the decision-making process because we will choose the option manually. From the drivers' perspectives, the prior matters that will be considered in this context are the price of the services, the time required for the VRSP to arrive on the scene and the VRSP's service performance. Each VRSP may differ in terms of location, price, and performance. The challenge for drivers is to make a firm decision about which VRSP to use based on the criteria without second-guessing themselves (Sürmeli et al., 2015). For example, the distance between the driver and the VRSP could be greater, but the price and performance are more convenient, or the services are very expensive but have high ratings, but the location is much closer to the driver. It is easier for well-known VRSPs in Malaysia to receive service requests from customers because well-known VRSPs with good ratings are usually recommended to customers, whether the recommendation comes from other customers, the internet, or any other related sources(Abdul Wahab et al., 2017). The challenge for an unknown VRSP that provides services that are comparable to those provided by a well-known VRSP is getting clients to recognise it. As a result, the MCDM approach will be utilized to balance the criteria and generate a VRSP that is appropriate for the drivers.

2. RELATED WORK

MCDM is well known as the branch of decision-making used to solve a problem. It manages the evaluation of the alternatives available according to the criteria specified using computational and mathematical tools. Several MCDM techniques have been introduced over the years to rank the alternatives. Analytic Hierarchy Process (AHP), Elimination Et Choix Traduisant la Realite (ELECTRE) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are a few examples (Parida, 2019).

2.1 Analytic Hierarchy Process (AHP)

AHP is a scoring method developed by Thomas L. Saaty in the year 1980, and it is the most used, particularly for academic matters in a variety of applications. AHP was chosen because it is a straightforward process and the quality assurance from the consistency check (Wu & Abdul-Nour, 2020). The disadvantage of AHP is that it can compensate for the best and worst scores on the criteria, resulting in information loss. The time required for computation is also considered a disadvantage for AHP.

2.2 Elimination Et Choix Traduisant la Realite (ELECTRE)

Bernard Roy proposed ELECTRE in 1968, which uses the concordance index as part of the calculation and is widely studied, and it includes ELECTRE I, II, III, IV, IS, and TRI. ELECTRE I triggered the evolution of ELECTRE methods due to insufficient techniques to deal with various types of decision-making problems. Because of its well-established ranking method, ELECTRE III is the most popular among the others and has been successful in many real-world applications. The advantage of ELECTRE methods is that they do not require compensation between normalization processes and criteria, which would deform the original data. However, the downside is the time consuming and complex application (Tscheikner-Gratl et al., 2017).

https://dx.doi.org/10.24191/jcrinn.v9i2.431

2.3 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS was introduced by Yoon and Hwang in 1981 and is still used in a variety of fields, such as marketing management and chemical engineering. This method's idea is to compare the performance of each alternative based on their shortest and farthest distances from the best and worst ideal solution, also known as the compromise solution. The advantage of this method is that it requires only a few inputs from the decision-maker and the output is very simple and easy to understand (Wu & Abdul-Nour, 2020). The disadvantage is the need for vector normalisation to solve multi-dimensional issues.

AHP, ELECTRE and TOPSIS acquire their uniqueness in terms of processing the output for decision making which also represents the strengths and weaknesses of the methods. Table 1 shows the comparison between AHP, ELECTRE and TOPSIS.

Table 1. Comparison between AHP, ELECTRE and TOPSIS

MCDM Methods	AHP	ELECTRE	TOPSIS
Consistency	Yes	Yes	No
Core process	Hierarchy principle	Pairwise comparison principle	Distance principle
Criteria and alternatives	Few	Many	Many
Concept model	Scoring	Concordance	Compromising

TOPSIS will be used in this study due to its simplicity and efficiency in terms of computational efficiency using simple mathematical models. Despite the lack of controlled consistency, TOPSIS employs a compromising model in which an optimal choice is the best of all possible choices.

3. METHODOLOGY

3.1 TOPSIS component

TOPSIS processes can be carried out manually because they are not based on a complex algorithm. The requirement to establish the TOPSIS method must be perfected before proceeding with any decision-making. The goal, criteria, and evaluation are the three main components of this method (Rahim et al., 2018).

3.1.1 Goal

The goal is the target to reach with this technique. It needs to be achievable throughout the process of TOPSIS. Goal changes can disrupt the evaluation process because the criteria differ from the previous goal. The goal of this study is to figure out which VRSP is optimal for clients, depending on the criteria.

3.1.2 Criteria

The criteria serve as the foundation for determining the ideal VRSP for clients. The distance between VRSP and the consumers, the projected arrival time of the VRSP, the pricing of the services, and the ratings of the VRSP offered by other prior customers are the foundations of this study. In the review process, the criteria will be compared to all of the other options.

3.1.3 Evaluation

The evaluation process is a key component of TOPSIS since it produces output for decision-makers in the form of a hierarchy level ranging from best to worst. TOPSIS operation comprises measurement, which includes decision matrix use, normalisation, the ideal solution, separation measures, and relative closeness. Fig. 1 shows the TOPSIS process.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

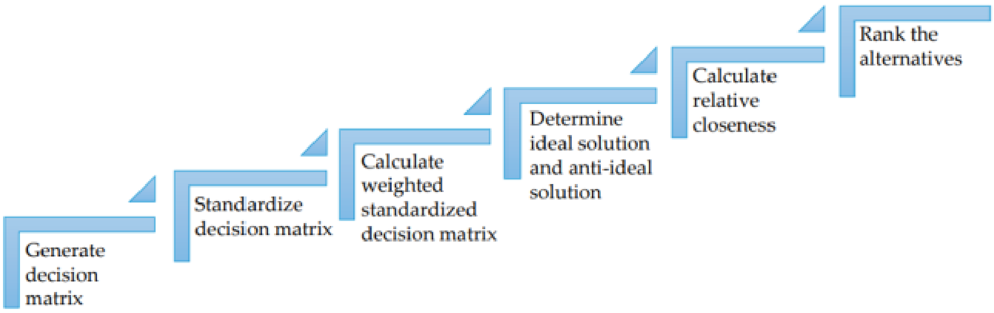


Fig. 1. TOPSIS process

3.2 TOPSIS operation

3.2.1 Decision matrix

The decision matrix evaluates and prioritises a set of options before making a decision. The VRSP, criteria and satisfaction values are included in this stage. The satisfaction value can be on a quantitative or qualitative scale for the original values. To proceed, the qualitative satisfaction levels must be in numerical form. For this study, the distances are measured in kilometres (km), the arrival time is measured in hours and minutes, the prices are in the form of Ringgit Malaysia (RM) and ratings are from zero to five.

3.2.2 Normalisation

This stage converts the satisfaction value to a single dimension that can be compared across criteria. The satisfaction values are in different units for different criteria initially. The transformation will make the weights into a normalised scale. Eq. (1) describes the formula for normalization. x_{ij} is the value in the decision matrix according to its rows and columns. For each column, x_{ij} is squared, accumulated and squared by the accumulated values. Then, each x_{ij} is divided by the square root of the accumulated values of each column, respectively.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (1)$$

3.2.3 Weighted

The criteria are made up of percentages, often known as weights. The normalized satisfaction values will be multiplied by each weight. After this procedure, the weight is in charge of composing a discrete result in decimal form. The mean weight is adopted, which also means each criterion is equally important. It is applied when the important information is insufficient to reach a decision. Eq. (2) describes the formula for the mean weight, where n is the number of criteria.

$$w_j = \frac{1}{n} \quad (2)$$

https://dx.doi.org/10.24191/jcrinn.v9i2.431

The weights were separated into four from the value of 1.00, which is equal to 0.25 for each criterion. The normalised values were multiplied by the weight of the criteria, which then produced a weighted normalised decision matrix. Eq. (3) describes the formula for the weighted normalised value, where w_j is the weight and n_{ij} is the normalised value.

$$w_j = w_j \times n_{ij} \tag{3}$$

3.2.4 Ideal Solution

The key to determining the best alternative is to look at the best ideal solution (BIS) and the worst ideal solution (WIS). The BIS is defined as a method that increases the criteria's benefit while lowering its cost. The WIS diminishes the benefit of the criteria while increasing the expense. As a summary, BIS holds the best values of the criteria and the WIS will hold the worst values.

3.2.5 Separation Measure

The separation measure determines the values that differ between two points. The two points to be measured will be the BIS and the WIS. This includes all possible alternatives for the two points. The difference values between positive ideal, d_i^+ and negative ideal, d_i^- were calculated using the formula as shown in Eq. (4). For each VRSP, the values in each criterion were subtracted from their BIS and squared. Next, the squared values from each criterion were added together, which ended with a square root operation that produced positive ideal values. The negative ideal values used a similar formula as shown in Eq. (5), but the BIS was replaced with WIS for the subtraction operation.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \tag{4}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{5}$$

3.2.6 Relative Closeness

The relative closeness to the positive ideal solution can be estimated using the separation measure. The relative closeness, R_i was measured to determine the order of the VRSP from the most to the least ideal based on the values. The relative closeness values were calculated by dividing the negative ideal values by the sum of positive and negative ideal values. Eq. (6) describes the formula for relative closeness.

$$R_i = \frac{d_i^-}{d_i^- - d_i^+} \tag{6}$$

3.3 Requirement Analysis and Design

3.3.1 Use Case Diagram

The use case diagram depicts how a user interacts with an application to complete a task in the system (Sulaiman & Azmi, 2021). This study used the use case diagram to provide an overview of who and what activities the user can do. An actor is a person or system that can integrate with the activities. In this study,

https://dx.doi.org/10.24191/jcrinn.v9i2.431

the actors are members, mechanics, and admins. The members have the option to login account, register account, manage vehicles, request service, view requests, and manage profiles. As for the mechanics, they can log in account, register account, view requests, manage profiles, manage workshops and view workshops' statistics. The admin can login account, view overall statistic, view user's profile and view the activity log. Fig. 2 shows the use case diagram for this study.

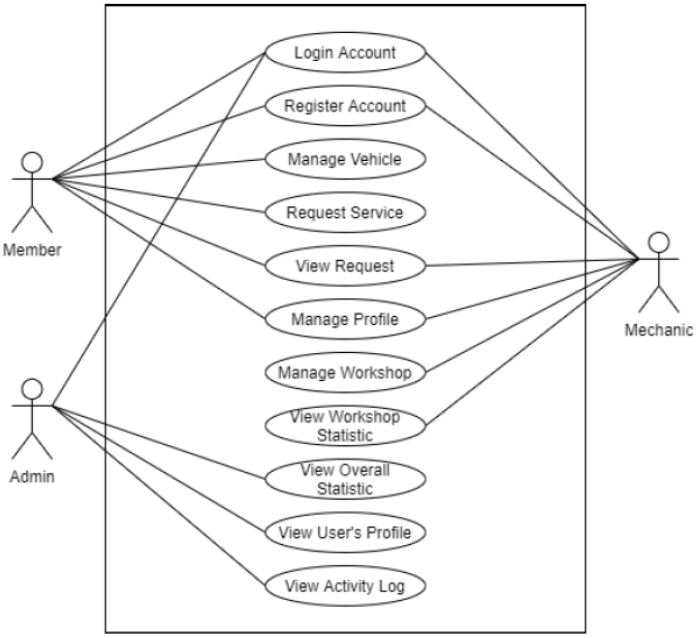


Fig. 2. Use Case Diagram

3.3.2 Class Diagram

The class diagram depicts the various classes and their relationships (Sulaiman et al., 2023). The classes represent the behaviour and states between the classes. Member, mechanic, admin, request, car, and service are the classes studied in this study. The class diagram for this study is illustrated in Fig. 3.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

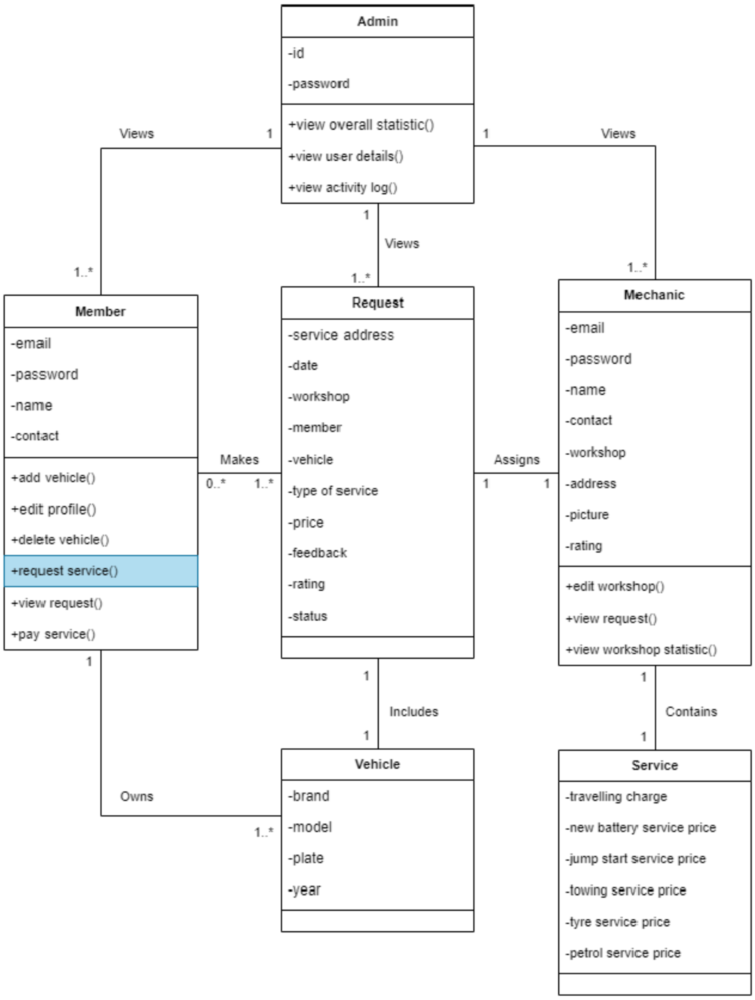


Fig. 3. Class Diagram

3.3.3 Architecture Diagram

An architecture diagram is an abstraction of the overall structure of the system (Azmy et al., 2021). Fig. 4 shows an illustration of the architecture diagram for this study. The member, mechanic and admin use their mobile phones to access the application. The application server retrieves the data requested by the users from the database.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

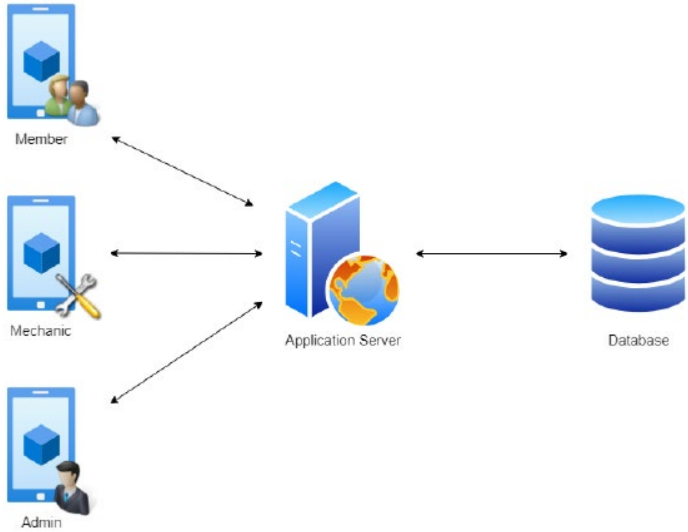


Fig. 4. Architecture Diagram

4. RESULT AND DISCUSSION

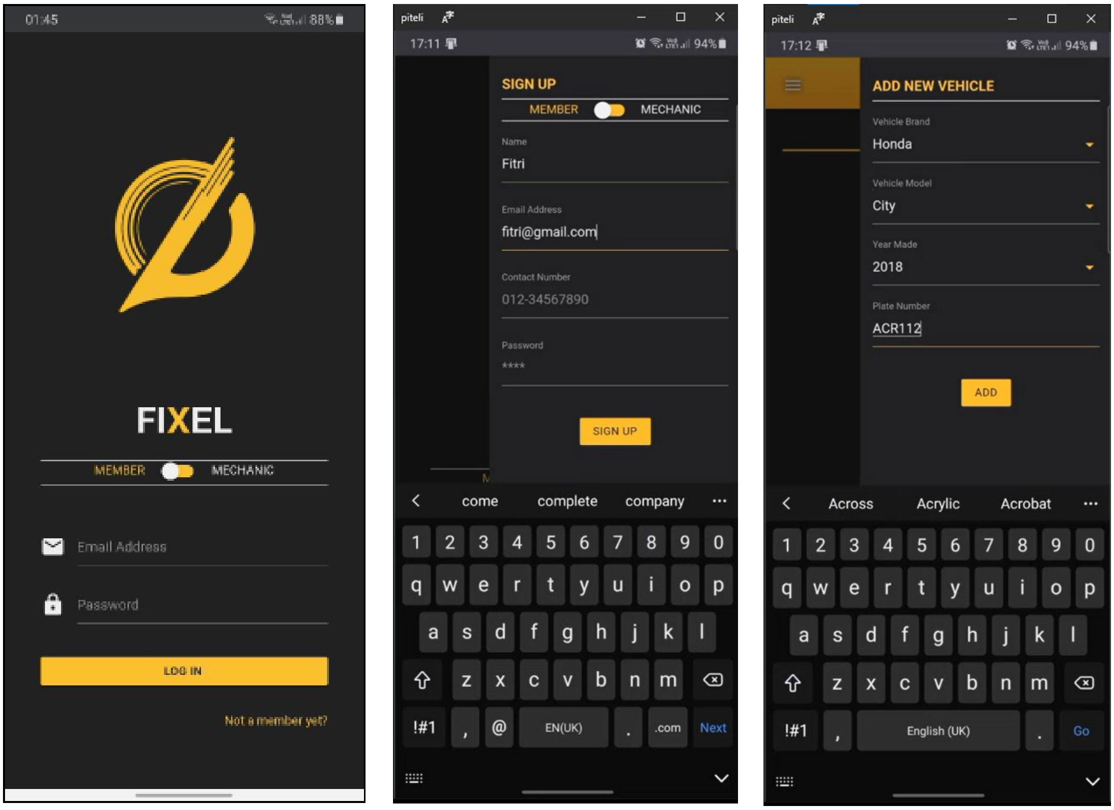
Progressive web applications (PWA) are used in this study since they can be accessible through the browser and can be used by a variety of operating systems. Furthermore, compared to native and web mobile applications, PWA has a major benefit. PWA combines the finest features of native and online mobile apps (Behl & Raj, 2018).

4.1 Graphical User Interface (GUI)

Fig. 5(a) shows a login GUI. There are three types of users: members, mechanics and admins. On the same page as the login option, there is a registration option. It is a side navigation page integrated into the login page that may be accessed by tapping the text “Not a member yet?” at the bottom of the page. A subpage will slide in from the right to reveal the input forms that users must fill out in order to register. Name, email address, phone number, and password are all required information. Only members and mechanics are permitted to register. The register subpage is depicted in Fig. 5(b).

The vehicle page is where members manage their vehicles in preparation for future servicing requests. Members who do not have a vehicle registered or who have just registered will be directed to this page first because vehicle information is one of the conditions for requesting a service. In the application, the member has the option of registering and deleting their vehicle. A sample scenario was presented to highlight the TOPSIS computation methods. The customer in this situation was having trouble with his total automobile and chose to get a towing service. Fig. 5(c) shows the form to register the vehicle information.

https://dx.doi.org/10.24191/jcrinn.v9i2.431



(a) (b) (c)

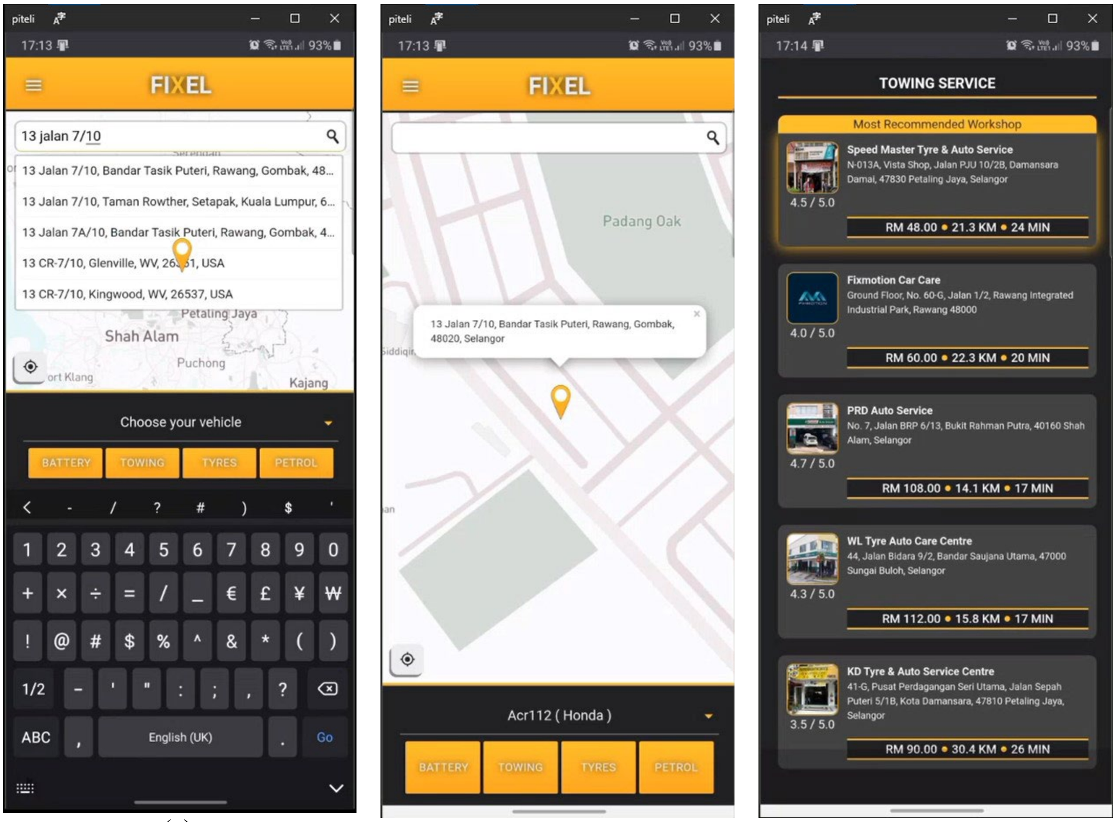
Fig. 5. Login, Sign-up and Add New Vehicle GUI

The service details fulfilment page will be the members' home page after logging into the application. It includes a map that indicates the mechanics that are available to supply their services on the map and pinpoints the member's present location. The member's current position can be found in one of three ways: by searching the address in the top input field, manually dragging and zooming on the map to the place or using GPS services on the mobile phone to pinpoint the current location as depicted in Fig. 6(a).

To request a service, three fields must be filled out first: the address, the vehicle, and the service requested. Once the address is presented at the pinpoint location, the address will be immediately populated. The breakdown vehicle must be specified here by choosing from a list of the member's registered vehicles. Finally, determine which service is required: batteries, towing, tyres, or gasoline. Fig. 6(b) shows the vehicle selection and service request.

The list of VRSP recommendations produced by TOPSIS computation includes information such as the workshop's name, address, photo, and all TOPSIS criteria. The most preferred VRSP is highlighted at the top of the list, and the type of service is listed at the top of the list. By tapping on any of the workshops, the member can select one. A screenshot of the list of VRSP recommendations based on the TOPSIS calculation is shown in Fig. 6(c).

https://dx.doi.org/10.24191/jcrinn.v9i2.431



(a) (b) (c)

Fig. 6. Search Location, Vehicle Selection and Service Request and Towing Service recommendation list GUI

4.2 FIXEL Implementation

Five VRSP, including KD Tyre, Fixmotion, WL Tyre, PRD Auto Service and Speed Master, have been identified with the objective of implementing and evaluating the calculation of TOPSIS using FIXEL apps.

Table 2. Decision matrix

VRSP	Criteria			
	Distance (km)	Time (minute)	Price (RM)	Rating
PRD Auto Service	14.1	17	108	4.7
KD Tyre	30.4	26	90	3.5
Fixmotion	22.3	30	60	4.0
WL Tyre	15.8	17	112	4.3
Speed Master	21.3	24	48	4.5

A decision matrix was constructed with the values for each criterion, such as distance, time, price, and rating as shown in Table 2. Table 3 shows the result of the normalised decision matrix.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

Table 3. Normalised Decision Matrix

VRSP	Criteria			
	Distance (km)	Time (minute)	Price (RM)	Rating
PRD Auto Service	0.293	0.325	0.552	0.498
KD Tyre	0.631	0.498	0.460	0.371
Fixmotion	0.463	0.574	0.307	0.424
WL Tyre	0.328	0.325	0.573	0.456
Speed Master	0.442	0.459	0.246	0.477

The weight of the criteria was set to 0.25 each. Table 4 shows the weighted normalized decision matrix.

Table 4. Weighted Normalised Decision Matrix

VRSP	Criteria			
	Distance (km)	Time (minute)	Price (RM)	Rating
PRD Auto Service	0.073	0.081	0.138	0.124
KD Tyre	0.158	0.124	0.115	0.093
Fixmotion	0.116	0.144	0.077	0.106
WL Tyre	0.082	0.081	0.143	0.114
Speed Master	0.110	0.115	0.061	0.119

The next stage was to find the BIS and WIS. The BIS are the shortest distance, shortest time, cheapest price and highest rating. WIS is the opposite of BIS. Table 5 shows the results of BIS and WIS for the scenario.

Table 5. Best and worst ideal solution

VRSP	Criteria			
	Distance (km)	Time (minute)	Price (RM)	Rating
PRD Auto Service	0.073	0.081	0.138	0.124
KD Tyre	0.158	0.124	0.115	0.093
Fixmotion	0.116	0.144	0.077	0.106
WL Tyre	0.082	0.081	0.143	0.114
Speed Master	0.110	0.115	0.061	0.119
Best Ideal (v_i^+)	0.073	0.081	0.061	0.124
Worst Ideal (v_i^-)	0.158	0.144	0.143	0.093

Table 6 illustrates the results of the separation measures for each VRSP, including positive and negative ideal values.

Table 6. Best and worst ideal solution

VRSP	Ideal Solution	
	Positive ideal (d_i^+)	Negative ideal (d_i^-)
PRD Auto Service	0.077	0.110
KD Tyre	0.114	0.034
Fixmotion	0.079	0.080
WL Tyre	0.083	0.100
Speed Master	0.050	0.102

https://dx.doi.org/10.24191/jcrinn.v9i2.431

The relative closeness was the final stage in the process. The rank will be greater if the relative closeness value is higher. The results of relative closeness and the rank of VRSP are shown in Table 7.

Table 7. Relative Closeness

VRSP	Positive ideal (R_i)	Rank
PRD Auto Service	0.589	2
KD Tyre	0.231	5
Fixmotion	0.502	4
WL Tyre	0.547	3
Speed Master	0.670	1

Based on the results in Table 7, Speed Master will be recommended first, followed by PRD Auto Service, WL Tyre, Fixmotion and KD Tyre.

4.3 FIXEL Evaluation

A Perceived Ease of Use (PEOU) test was administered to thirty respondents with varying backgrounds in order to validate the proposed TOPSIS-Driven Mobile Application (Saoula et al., 2023). The PEOU demonstrates the usability and comprehension of the FIXEL. Notably, Microsoft Forms was used to conduct this online testing. The FIXEL demonstration video is required to be viewed by all 30 respondents. They must next respond to the query on the attached Microsoft Form. The PEOU measures the degree to which this FIXEL is regarded as reasonably easy to use and understand. Table 8 lists the five questions that were available.

Table 8. The Questions of PEOU

Questions	Scale					Mean Score
	1	2	3	4	5	
I think using the FIXEL is easy				4	26	4.9
I think using the FIXEL is understandable			1	5	24	4.8
I think using the FIXEL will not require much mental effort			1	7	22	4.7
I assume I can use FIXEL independently			1	6	23	4.7
I believe FIXEL will be easy to use				5	25	4.8
Overall Score						4.8

https://dx.doi.org/10.24191/jcrinn.v9i2.431

The results obtained from the respondents and the graph for each question as shown in Fig. 7. The mean score for the PEOU assessment criterion is shown in the chart in Fig. 7.

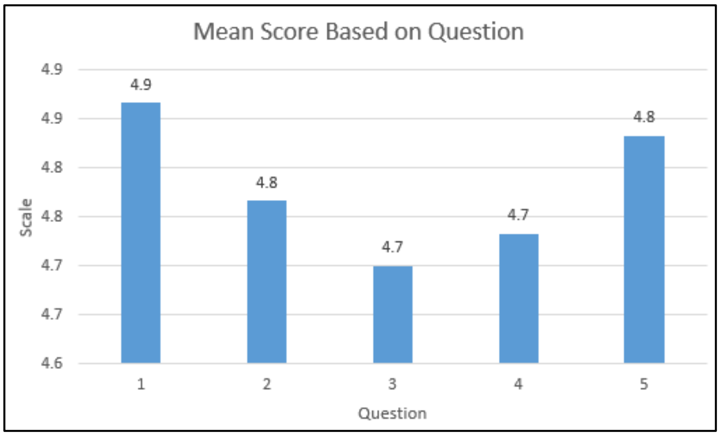


Fig. 7. Mean score of PEOU

It was found that most respondents considered the FIXEL to be easy to understand. For each question, the mean score may show it to be greater than 4.0 but lower than the predetermined scale. According to the respondents, utilising and examining the FIXEL is easy. A mean score of 4.8 was obtained.

5. CONCLUSION

The focus of this study is to use the mobile platform for the benefit of drivers and service providers. Map navigation, service provider suggestions based on certain criteria, online payment, and direct communication between drivers and service providers are only some of the capabilities of the application. In order to improve the quality of choosing the proper service provider based on the criteria involved, such as service availability, costs, distances, and ratings, one of the multi-criteria decision-making procedures was used. The impact of this study would improve the decision-making process, enhance the customer experience, optimise resource utilisation and reduce costs.

The recommendation for future enhancement of this study is to provide the users with options to sort the VRSP recommendation list based on specific criteria, such as price. The current VRSP recommendations are only based on the TOPSIS algorithm. The basic sorting options should enhance the user experience when scrolling through the VRSP recommendation list. In the future, the study could include a push notification capability to make the application behave more like a genuine mobile application. Designing the application architecture to accommodate a growing user base and increasing data volumes will address the scalability aspects. This may involve leveraging cloud-based infrastructure in the future. While sustainability considerations can be addressed by incorporating features that promote eco-friendly practices, such as optimising routes to minimise fuel consumption.

6. ACKNOWLEDGEMENTS/FUNDING

The authors would like to acknowledge the support of the College of Computing, Informatics & Mathematics, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for providing the facilities for this research.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

7. CONFLICT OF INTEREST STATEMENT

The authors declared that they have no conflict of interest to disclose.

8. AUTHORS' CONTRIBUTIONS

The article was written, edited, and conducted by **Mohd Suffian Sulaiman**. The smartphone application was designed by **Mohd Fitri Afiq Azmi**, who also conceptualized the main idea of the research. **Azri Azmi** anchored the review, made the necessary adjustments, and approved the submission of the manuscript, while **Zuraidah Derasit** verified the computation of the mathematical formula and methodology.

9. REFERENCES

Abdul Wahab, M. A. F., Mohd Jawi, Z., Abdul Hamid, I., Solah, M. S., Mohd Latif, M. H., Md Isa, M. H., Abdul Khalid, M. S., Ariffin, A. H., & Hamzah, A. (2017). Automotive consumerism in Malaysia with regard to car maintenance. *Journal of the Society of Automotive Engineers Malaysia*, *1*(2), 137–153. www.journal.saemalaysia.org.my

Azmy, I. H., Azmi, A., Sulaiman, M. S., & Mohd Yusop, O. (2021). Digital transformation in oil and gas industry: Developing an OSDU third-party application. *In 7th International Conference on Engineering and Emerging Technologies* (pp. 1-8). IEEE Xplore. https://doi.org/10.1109/ICEET53442.2021.9659636

Behl, K., & Raj, G. (2018). Architectural pattern of progressive web and background synchronization. *In 2018 International Conference on Advances in Computing and Communication Engineering, ICACCE* (pp. 366–371). https://doi.org/10.1109/ICACCE.2018.8441701

Frazão, T. D. C., Camilo, D. G. G., Cabral, E. L. S., & Souza, R. P. (2018). Multicriteria decision analysis (MCDA) in health care: A systematic review of the main characteristics and methodological steps. *BMC Medical Informatics and Decision Making*, *18*(1), 1–16. https://doi.org/10.1186/s12911-018-0663-1

Haridas, K., Baharudin, A. S., & Karkonasasi, K. (2016). Automotive servicing and breakdown assistance system (ASBAS): Impact of perceived ease of use (PEOU) and vehicle breakdown servicing necessity (VBSN) on vendor's intention to adopt ASBAS. *Indian Journal of Science and Technology*, *9*(48). https://doi.org/10.17485/ijst/2016/v9i48/87825

Parida, P. K. (2019). A general view of TOPSIS method involving multi-attribute decision making problems. *International Journal of Innovative Technology and Exploring Engineering*, *9*(2), 3205–3214. https://doi.org/10.35940/ijitee.b7745.129219

Rahim, R., Supiyandi, S., Siahaan, A. P. U., Listyorini, T., Utomo, A. P., Triyanto, W. A., Irawan, Y., Aisyah, S., Khairani, M., Sundari, S., & Khairunnisa, K. (2018). TOPSIS method application for decision support system in internal control for selecting best employees. *Journal of Physics: Conference Series*, *1028*(1). https://doi.org/10.1088/1742-6596/1028/1/012052

Saoula, O., Shamim, A., Mohd Suki, N., Ahmad, M. J., Abid, M. F., Patwary, A. K., & Abbasi, A. Z. (2023). Building e-trust and e-retention in online shopping: The role of website design, reliability and perceived ease of use. *Spanish Journal of Marketing - ESIC*, *27*(2), 178–201. https://doi.org/10.1108/SJME-07-2022-0159

Sheng, K. J., Baharudin, A. S., & Karkonasasi, K. (2016). A car breakdown service station locator system. *International Journal of Applied Engineering Research*, *11*(22), 11037–11040.

https://dx.doi.org/10.24191/jcrinn.v9i2.431

Sulaiman, M. S., & Azmi, A. (2021). Evaluation of interactive WebSIR using Software Usability Measurement Inventory (SUMI). *Lecture Notes in Electrical Engineering*, *741 LNEE*, 109–116. https://doi.org/10.1007/978-981-33-6490-5_10

Sulaiman, M. S., Derasit, Z., Aziz, A. A., Ismail, A., Azmi, A., & Rahim, S. K. N. A. (2023). Rielkies nearby sales agents finder using Haversine method. *International Conference on Computing (ICOCO)* (pp. 444-449). IEEE Xplore. https://doi.org/10.1109/ICOCO59262.2023.10397729

Sürmeli, G., Kaya, I., & Erdoɫan, M. (2015). A fuzzy multi-criteria decision making approach for choosing a logistics center location in Turkey. *In 6th International Conference on Modeling, Simulation, and Applied Optimization, ICMSAO* (pp. 1-6). IEEE Xplore. https://doi.org/10.1109/ICMSAO.2015.7152195

Tscheikner-Gratl, F., Egger, P., Rauch, W., & Kleidorfer, M. (2017). Comparison of multi-criteria decision support methods for integrated rehabilitation prioritization. *Water (Switzerland)*, *9*(2). https://doi.org/10.3390/w9020068

Wu, Z., & Abdul-Nour, G. (2020). Comparison of multi-criteria group decision-making methods for urban sewer network plan selection. *CivilEng*, *1*(1), 26–48. https://doi.org/10.3390/civileng1010003