Development of expert system for bus services in Klang valley

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Abstract: Growing population could be one of the main factors which affect the daily increase in road movement. A developing country like Malaysia still requires transport system planning and development. In 2012, nearly 1.5 million daily and public transport trips in Klang Valley represented almost 30% of the daily main public transportation. Development of an expert system could identify problems on bus services and assist to encounter problems raised based on the expert system. Therefore, this study was aimed to develop an expert system for bus service in Klang Valley. In this study five major cities in west Klang Valley were selected, including Puchong, Petaling Jaya, Subang Jaya, Shah Alam and Klang. The Transit Capacity and Quality of Service Manual (TRCPM) was referred as study guidelines. Three mainphases were involved in the expert system development by using MATLAB, which include analyzing job scope, management of information knowledge and development of prototype. System was named as BUS-QOS and could be used to identify the bus service quality level in specific locations and obtain suggestions from experts to improve the bus service quality of in that area. At the end of the study, validation, verification and evaluation processes should be done to check the output of system in terms of its operation and result. The result of BUS-QOS was verified based on system analysis and manual calculation. It showed that all designated attributes were almost 100% accurate. The output of the system was based on transportation engineering knowledge which could be easily used by users.

1. Introduction

Today natural disaster is all over the world and pandemic disaster is also classified as natural disaster. Natural disaster always gives a significant impact on the public transport system. These days most countries in the world are faced with traffic congestion issues, such as bus service emergencies,
evacuation and disaster transportation. Growing population could be one of the main factors which affect the daily increase in road movement [1]. It contributes to the increase in the daily vehicles and traffic congestions, especially in downtown areas. Generally, traffic congestion is considered as a problem raised by development and urbanisation. A developing country like Malaysia still requires transport system planning and development [2]. The number of personal vehicle amongst Malaysians is considered as one of the highest in these regions. Malaysians prefer to use private vehicles instead of the public transport to move [3]. This would totally cause traffic congestions on the road, especially during peak hours. Therefore, improving the public transport will be the best alternative to solve these issues. In 2012, nearly 1.5 million daily and public transport trips in Klang Valley represented almost 30% of the daily main public transportation [4,5]. Public transportation should offer efficient services to passengers and it would increase the significant impact on their trustworthiness. Therefore, it is required to evaluate the service quality of public transportation, specifically on bus service [6,7].

RapidKL is the main operator for urban areas of Klang Valley, including Kuala Lumpur and several major cities in Selangor. In Malaysia, public transportation is supervised by the Land Public Transportation Commission (SPAD), which is currently known as Agensi Pengangkutan Awam Darat (APAD). It has authority on behalf of the Malaysian Government. In December 2015, SPAD launched a blueprint known as the Klang Valley Network Revamp to improvise public transportation in Klang Valley [8]. Therefore, SPAD received feedbacks from passengers regarding the bus service quality in Klang Valley. The issues raised by passengers were punctuality, drivers’ behaviours, and service area [4]. Recently, due to fast growing technology, users have e-hailing alternatives such as Grab and MyCar. Instead of using public transportation they could use these alternatives to simply determine their exact pick up and drop point [9]. Moreover, bus service needs to evolve based on technology and modernisation periods, and it should give a good service to passengers [4]. Essentially, people know that by using public transportation they could save travelling cost, reduce traffic congestion, and preserve the environment by using the same vehicle. In the first place, the government must take responsibility to provide good public transportation.

Increasing passengers’ demand to travel and quality of service by operators would act simultaneously [10]. Both issues must be countered with correct perceptive because these issues have mutual connection. For example, demand would affect operation cost and quality service of operators would affect the number of demand from passengers. Therefore, it is important to ensure that the bus operator deliver a good service quality because it would determine the trustworthiness on the bus service from passengers’ perceptive [11]. Passenger trustworthiness is an important transit issue for passengers [4]. Essentially, people know that by using public transportation they could save travelling cost, reduce traffic congestion, and preserve the environment by using the same vehicle. In the first place, the government must take responsibility to provide good public transportation.

Performance for buses would be the main key indicator to measure service quality provided by operators [14,15]. Consistency of bus service should be constantly measured based on several factors, such as speed, handling management and others [16,17]. Several issues were raised by passengers, such as inappropriate bus schedules, lack of service information and expensive tickets. It could cause unpleasant and unsafe situation for passengers [18,17]. There were also issues raised by bus operators, such as low coordination of public transport by authority, limited passenger for specific time and traffic congestion on selected routes during peak hours [19,20]. Service facility should also be rectified for passengers’ convenience, increasing bus service frequency and reducing total number of transit before reaching the final destination [19,21]. Bus service quality was referred based on the Manual of Transit Capacity and Quality Service [22], which states that quality of service would be considered as passenger perception regarding the whole quality of transit service [23,24]. Quality of service is the understanding of customer’s
demands that will affect customer’s perceptions on the service given. Level of service quality is an important aspect that should be addressed to produce a good service level [4].

Development of the expert system could identify the problem on bus services as well as encounter problems raised based on the expert system [25]. The system could gather and solve complex problems as well as it has low cost to develop and operat [26]. The expert system also has similar professional and systematic combination for customer [27]. It could be used as a supporting method to determine the best decision or solution. Normally, the development of an expert system is collaboration between field expertise to collect all necessary data and software expertise and develop the system based on problems addressed by field experts. There were few approaches on expert system development, such as gathering human information or problems on specific issues, developing specific system based on gathered information and lastly, selecting experts who could evaluate the developed system and give several feedbacks for improvement [28]. Several expert systems were previously developed, such as expert system which could assist and provide advice to reduce problems related to traffic safety [29], Concept of Expert System for Modal Split in Transportation Planning [30] and Route Design Model of Feeder Bus Services for urban rail transit station [31]. Therefore, this study was aimed to develop an expert system for bus service in Klang Valley.

2. Methodology

The study covered the development of expert system for bus service in Klang Valley. Five major cities in west Klang Valley were selected, including Puchong, Petaling Jaya, Subang Jaya, Shah Alam and Klang. The study was conducted in January 2018 and Figure 1 shows the areas covered in the study. Service quality data were taken at selected routes in these areas. Most of the routes operated by RapidKL were owned by Prasarana Berhad. For a RapidKL bus, the total capacity is 65 passengers, consisting of 25 seated and 40 standing passengers. Three routes were selected for each area in west Klang Valley. Necessary data taken for each route were Shah Alam (Route T757, T758 and SA01), Petaling Jaya (Route PJ02, PJ03 and PJ04), Subang Jaya (Route T776, T777 and T778), Klang (Route KLG1, KLG2 and 704), and Puchong (Route T600, T604 and T605).

![Figure 1. Areas covered in the study](image)

The data were collected for weekdays and weekends. Total journey for one area was 24 journeys, while total journey for five different areas was 120 journeys. The internal conditions of buses are shown in Figure 1. Transit Capacity and Quality of Service Manual (TRCPM) was referred as guidelines and key indicator identified to determine the bus quality service in selected areas. Five specific areas were focused, such as on time performance, service frequency, passenger load, service hours and transit auto travel time.
For the load factor, the analysis revealed a quality of service for every three routes in five different areas in west Klang Valley. However, consideration of service quality for every journey on weekends, weekdays, peak hours or non-peak hours should be differentiated.

The development of expert system started as soon as all necessary data were collected on site. There were three main phases in the expert system development, including analysing job scope, management of information knowledge and development of prototype. Verification of system was needed by selecting experts in this area. Table 1 shows a summary of the expert system development. Analysed task comprised identified service quality elements to evaluate bus services. The selection of attributes must be suitable with the study areas and was advised by experts such as authorities, bus operators and bus passengers. Transit Capacity and Quality of Service Manual (TRCPM) was selected as guidelines in the expert system development. MATLAB was chosen as medium in the expert system development as this software has high performance language for technical computing and solving mathematical and specific technical problem. Validation, verification and evaluation were required to ensure that the expert system is ready for use as bus services system checker in Klang Valley.

Table 1. Summary of expert system development

| Method                      | Scopes                                      |
|-----------------------------|---------------------------------------------|
| Analysed Task               | Determine level of service                  |
|                             | Evaluation LOS                              |
|                             | Strategy                                    |
| Knowledge Transfer          | Analysing from book, journal and guidelines |
| Prototype Development       | Data transfer                               |
|                             | Design system                               |
| Expansion and Detailing     | Gathering additional information            |
|                             | Interface development                       |
| Validation, Verification and Evaluation | Final comparison with manual calculation |

3. Result
The development of prototype was by using MATLAB. Result showed the development of expert system, as illustrated in Figure 3. The system was called BUS-QOS system and was introduced to understand the fundamental of quality bus service. BUS-QOS can be used to identify level of bus service quality in specific locations, as well as provide suggestions by experts to improve the bus service quality in that area. BUS-QOS consisted of five different attributes for service quality, such as service frequency, on time performance, service hours, passenger load and comparison of auto transit time travel. BUS-QOS comprised four different sections, such as quality of service (QOS), ABOUT, E-LIBRARY AND EXIT. Inputs from experts regarding solutions for the bus service quality level were also added into the system.
E-Library would explain in detail the procedure and method for each attribute showed. Table classification was also provided for each attribute. To use BUS-QOS, users need to key in all necessary information, such as service frequency (departure time on peak hours), service hours (starting and end of service daily), passenger load factor (number of seat and passenger), on time performance (late arrival and on time arrival) and transit auto travel time (respectively travel time by bus and car). Figure 3 and Figure 5 show the BUS-QOS interface of service frequency and interface of BUS-QOS transit auto travel time, respectively, as example of interface for all five attributes in BUS-QOS. Meanwhile, Figure 4 and Figure 6 show the BUS-QOS interface result on service frequency and interface result for transit auto travel time, respectively, as well as their classification for level of service (LOS) as example of interface of result for all five attributes in BUS-QOS.

For service frequency attribute, average for each day was counted and classification of service frequency for weekdays and weekends. If the average level is below than 5 min the service quality will be classified as Class A. However, if the average level is more than 5 min BUS-QOS would change its classification to Class B based on classification table. For transit auto time travel, if the ratio of time travel is less than 1, the quality of service could be classified as Class A. If the ratio of time travel is between 1 and 1.25, BUS-QOS would change its classification to Class B.
At the end of the study, validation, verification and evaluation processes were done to check the output of the system in terms of operation as well as its result. The result of BUS-QOS was verified based on system analysis and manual calculation. The comparison between both results should be made to identify the accuracy of system result before it can be used in future. Table 2 shows the comparison between BUS-QOS and manual calculation of data for each attribute. The result showed that there were few differences in decimal points between auto transit travel point and passenger load. It can justify that BUS-QOS can determine the service quality of bus service correctly within a short time period as compared to manual calculations.

Four evaluators were selected to evaluate the overall BUS-QOS system. All selected evaluators have experiences on transportation. The result would measure the overall quality of system. The marks 1, 2, 3, 4
and 5 represent “very bad”, “bad”, “medium”, “good”, and “very good”, respectively. Table 3 shows the overall BUS-QOS evaluation. The average grade given was 4 out 5, which was “good”.

![Result Transit Auto Travel Time](image)

**Figure 6.** The BUS-QOS result for transit auto travel time

**Table 2.** Comparison between BUS-QOS and manual calculation

| Attribute              | Manual                  | BUS-QOS                  | Accuracy |
|------------------------|-------------------------|--------------------------|----------|
| Service hours          |                         |                          |          |
| Case 1 Weekdays        | 17 hour 30 minute (B)    | 17 hour 30 minute (B)    | 100%     |
| Case 1 Weekend         | 17 hour 30 minute (B)    | 17 hour 30 minute (B)    | 100%     |
| Case 2 Weekdays        | 17 hour 30 minute (B)    | 17 hour 30 minute (B)    | 100%     |
| Case 2 Weekend         | 17 hour 30 minute (B)    | 17 hour 30 minute (B)    | 100%     |
| Service frequency      |                         |                          |          |
| Case 1 Weekdays        | 26 minute (D)            | 26 minute (D)            | 100%     |
| Case 1 Weekend         | 26 minute (D)            | 26 minute (D)            | 100%     |
| Case 2 Weekdays        | 18 minute (D)            | 18 minute (D)            | 100%     |
| Case 2 Weekend         | 18 minute (D)            | 18 minute (D)            | 100%     |
| On time performance    |                         |                          |          |
| Case 1 Weekdays        | 94.74%                  | 94.74%                   | 99%      |
| Case 1 Weekend         | 100%                    | 100%                     | 100%     |
| Case 2 Weekdays        | 94.44%                  | 94.44%                   | 99%      |
| Case 2 Weekend         | 100%                    | 100%                     | 100%     |
| Auto transit time travel |                      |                          |          |
| Case 1 Weekdays        | 1.37                    | 1.3721                   | 99.84%   |
| Case 1 Weekend         | 1.23                    | 1.2303                   | 99.97%   |
| Case 2 Weekdays        | 1.29                    | 1.2841                   | 99.99%   |
| Case 2 Weekend         | 1.39                    | 1.3875                   | 99.99%   |
| Passenger load         |                         |                          |          |
| Case 1 Weekdays        | 13.7% (A)               | 13.70%                   | 99.98%   |
| Case 1 Weekend         | 26.3% (A)               | 26.33%                   | 99.87%   |
| Case 2 Weekdays        | 12.3% (A)               | 12.33%                   | 99.72%   |
| Case 2 Weekend         | 7.7% (A)                | 7.67%                    | 99.99%   |
Table 3. Overall evaluation of BUS-QOS

| No. | Interface:       | Evaluator 1 | Evaluator 2 | Evaluator 3 | Evaluator 4 | Average |
|-----|-----------------|-------------|-------------|-------------|-------------|---------|
| 1   | Easy to used    | 3           | 4           | 5           | 4           | 4       |
|     | Friendly        | 3           | 5           | 4           | 5           | 4.25    |
| 2   | Result Presentation: |           |             |             |             |         |
|     | Adequate result | 4           | 5           | 4           | 4           | 4.25    |
|     | Final result    | 3           | 4           | 5           | 4           | 4       |
| 3   | Usable system:  |             |             |             |             |         |
|     | Useful system   | 3           | 5           | 4           | 4           | 4       |
|     | Particle system | 3           | 5           | 4           | 4           | 4       |
| 4   | System efficiency: |           |             |             |             |         |
|     | Effective system| 4           | 4           | 5           | 5           | 4.5     |
| 5   | Overall rating: | 3           | 4           | 4           | 4           | 3.75    |

4. Conclusion

The study was aimed to develop an expert system for bus service in Klang Valley. The data were collected from five different main cities in west Klang Valley, such as Petaling Jaya, Puchong, Subang Jaya, Shah Alam and Klang at selected locations for collected data. Development of an expert system, called BUS-QOS, was by using MATLAB as the system is easy to use and could interpret the analysis in detail. On-site data have been used to generate analysis based on five main cities in Klang Valley. Besides, the output of BUS-QOS was also validated with manual calculations to determine the accuracy of system output. The comparison between BUS-QOS and manual calculation showed almost 100% accuracy on auto transit travel point and passenger load attributes and 100% accuracy for other attributes. Based on validation and evaluation, it showed that the suggestion regarding service quality was suitable to be used locally and its explanations coincided with the public transport guidelines as well as expert opinions. According to evaluation of BUS-QOS, the system is acceptable to be used by users in evaluation stages. Unfortunately, there were several issues raised by the evaluators to improve the system before it can be used publicly. The expert system can be used by the authorities, bus operator as well as bus passengers to determine the bus service quality in the country. The system output is based on transportation engineering knowledge which can be easily used by users. In this study the expert system consisted of only five service quality attributes. In future, the system could be improvised to evaluate the quality of buses during natural disaster, such as tsunami, hurricane and disease pandemic. Therefore, further studies as well as improvements in expert system development are highly recommended in the future.

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