

# Developing Expert System Prototype for Urban Bus Service in Transportation Engineering

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## Abstract

The quality of service for bus performance is calculated using a long manual calculation by engineers based on expert experience using some formulas. As calculating the level of service takes a long time, a more flexible approach is needed. This review presents the development of a prototype of an expert system for quality service performance of buses (BUS-QOS) as a tool for calculating the level of service for certain attributes. BUS-QOS, also focusing on the rating system for bus service, depends on certain attributes. Evaluation of quality of service is based on service frequency, hours of service, on time performance, headway adherence, passenger load, and transit auto travel time. Condition assessment for quality of service for each attribute is based on analysis of data obtained using different formula for every existing attribute. The system uses the knowledge acquired from the study of past literature review and also from the Transit Capacity and Quality of Service Manual (3rd edition). This knowledge is then performed using a decision tree in the form of production rules using the formula for each attribute. BUS-QOS is developed using Matlab software which is more suitable for solving certain mathematical or technical problems especially those with matrix and vector formulation. The operating system has been successfully verified, validated and evaluated through a comparison between the manual calculation and the results of the system. This study shows that the BUS-QOS can be used to help certain parties, such as engineers in the calculation of level of service for buses. This system has also been evaluated by experts involved in the management of the bus about the features and interface system.

**Keywords:** Expert system, bus performance rating, quality of services

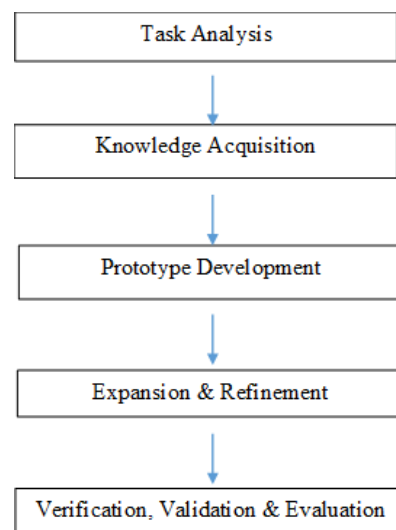
## INTRODUCTION

This paper discusses the development and the application of BUS-QOS (bus – quality of Services System), a bus rating system. In this phase, the knowledge acquired by performing a literature review is transferred into an empty knowledge base through the decision models produced in the knowledge structure phase. The knowledge base of BUS-QOS is

constructed using an expert system shell, Matlab. The expert system shell could provide various development tools for entering and editing code besides creating graphic user interfaces. All methods are written in an object-oriented programming language. The system is then being tested and validated to ensure it is performed correctly.

## METHODOLOGY

Artificial intelligence of expert systems is used to obtain specific information domain and solutions such as in a medical diagnosis, financial advice, agriculture, production design and so on. The most important part of the system is the shell. Shell of expert systems is a software development environment that contains basic components required to build expert systems. It does not contain the knowledge base. For each domain specific system, a knowledgeable engineer is assisted by domain experts who have expertise in the features of specific areas. Therefore, the shell-based approach for building systems that focus primarily on system components but less on the user interface and creating a shell-based system, is ideal for consumers with programming skills. According to Norlela Ismail (2014), the process involved in developing expert system is as illustrated as follows:



**Figure 1.** Methodology of Expert System Development

### Task Analysis

The first order in designing a prototype of expert systems involves the analysing task. A knowledgeable engineer's certainty refers to resolving problems, which is focused on the selection of attributes for buses.

This study was limited to six steps namely, the service frequency, hours of service, on time performance, compliance progress, transit auto travel time, and passenger load.

METHOD	SCOPE
Task Analysis	<ul style="list-style-type: none"> <li>Determine level of service</li> <li>LOS evaluation</li> <li>Strategy</li> </ul>
Knowledge Acquisition	<ul style="list-style-type: none"> <li>Text analysis from books, journals, manuals &amp; guidelines</li> </ul>
Prototype Development	<ul style="list-style-type: none"> <li>Choose building tools</li> <li>Transfer data</li> <li>Design system</li> </ul>
Expansion and Refinement	<ul style="list-style-type: none"> <li>Collect additional data</li> <li>Develop user interface</li> </ul>
Verification, Validation & Evaluation	<ul style="list-style-type: none"> <li>Compare final result with manual calculation</li> </ul>

Figure 2. Summary of Methodology

### Knowledge Acquisition

The knowledge to develop the prototype for the expert system was obtained from Transit Capacity and Quality of Service Manual (3rd edition). The information involves the evaluation of the frequency of services, assessment of the hours of service, assessment of the compliance progress, evaluation for auto transit travel time, passenger load assessment, and evaluation for the performance period.

### Prototype Development

Engineers exchange experience and knowledge with experts to work in the commuting programme. Shell has been an expert system builder for the development of prototypes as it increases the productivity of others. Matlab was chosen as a tool for building the prototype system as it is considered a development expert in the study. Matlab has an expert system nowadays that can integrate with another application such as MS Excel and Visual Basic. In addition, Matlab is better suited to solve a math problem or a certain technical issue with the help of matrix and vector formulation.

### Verification, Validation and Evaluation

The test and evaluation expert system builder is essential to ensure it is done correctly and to enhance its credibility at an acceptable level. Testing and evaluation of prototype expert system builder in this study affect three phases namely, verification, validation, and evaluation.

#### Verification

Knowledgeable engineers study production methods in the prototype system to ensure no regulations are missing, so that the internal is correct. Next to that, all the windows advances are inspected regularly.

#### Validation

Knowledgeable engineer verifies the system's performance by way of decision and organisation system. Performance results have been verified to determine the correct conclusion for the system. All properties in this study were confirmed with real data and compared with manual calculations. The expert involved in validating this prototype is En. Ahmad Faizal bin Baharudin from Land Public Transport Commission (SPAD).

#### Evaluation

Knowledgeable engineer issues a form provided (Appendix A) to help the public to evaluate the prototype. These people are those who are knowledgeable on the quality of service. This system has been evaluated in terms of effectiveness, accuracy, performance, ease of use, adaptability, adequacy, reliability and credibility. Evaluators who participated in this assessment are Manager of SPAD, HR Coordinator of RAPIDKL, and Site Engineer of D.R.2.A.

## RESULTS

### A. Application of the BUS-QOS

The knowledge base in BUS-QOS is about the decision in selecting the appropriate level of bus service in the transportation system. It consists of six Quality of Services which are Service Frequency, Hours of Service, On Time Performance, Headway Adherence, Passenger Load, and Transit Auto Travel Time.

The BUS-QOS starts by opening the Matlab software which shall bring the user to the main interface as shown in Figure 3. The two-way communication between user and BUS-QOS is shown in this interface window, which consists of four buttons which is QUALITY OF SERVICE, ABOUT, e-LIBRARY and EXIT. The e-LIBRARY button provides the understanding of user in each definition and term used for BUS-QOS. Figures 4 until 19 show an example of the interface of e-LIBRARY. Figure 20 displays the ABOUT button which gives general information about the system, whereas the EXIT button allows users to leave the system



Figure 3. Main Interface

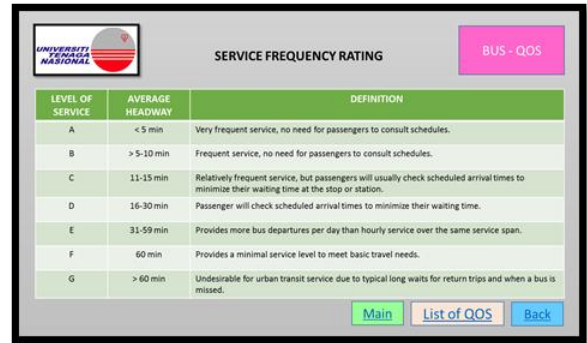


Figure 7. e-Library Interface



Figure 4. e-Library Interface

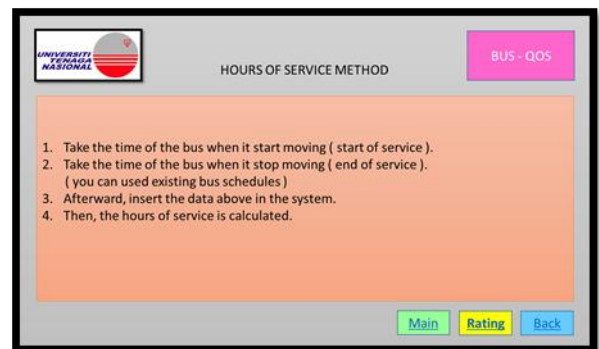


Figure 8. e-Library Interface

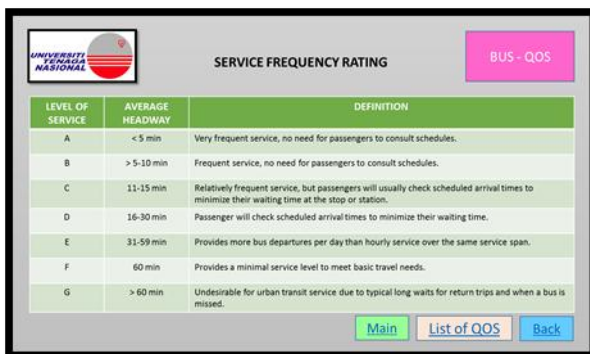


Figure 5. e-Library Interface



Figure 9. e-Library Interface

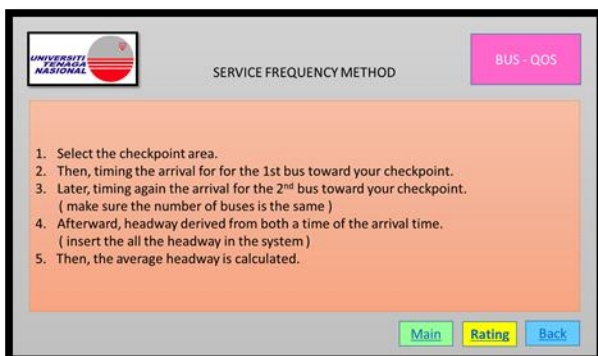


Figure 6. e-Library Interface

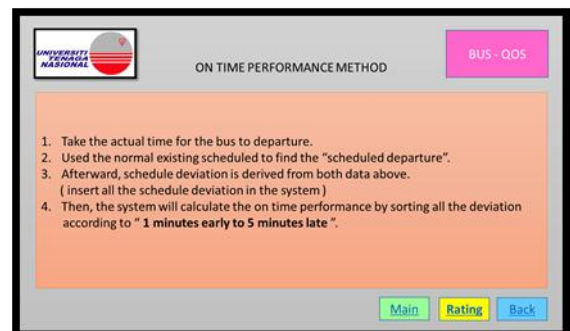


Figure 10. e-Library Interface



Figure 1.1 e-Library Interface



Figure 15. e-Library Interface

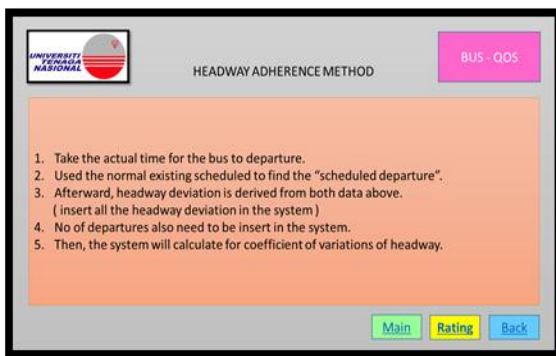


Figure 12. e-Library Interface

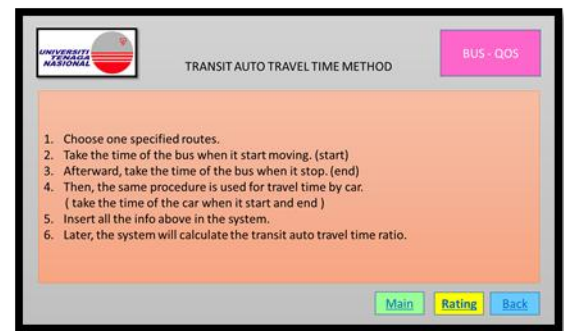


Figure 16. e-Library Interface

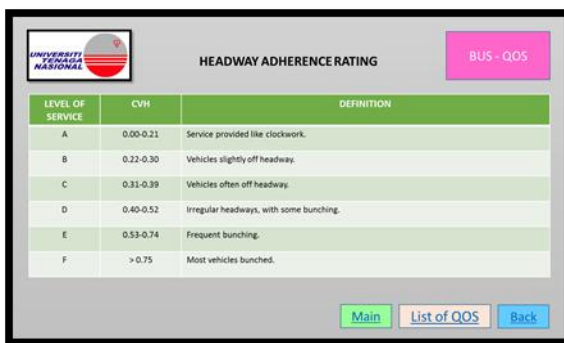


Figure 13. e-Library Interface

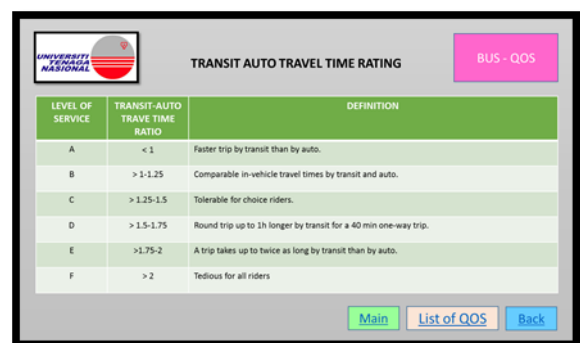


Figure 17. e-Library Interface

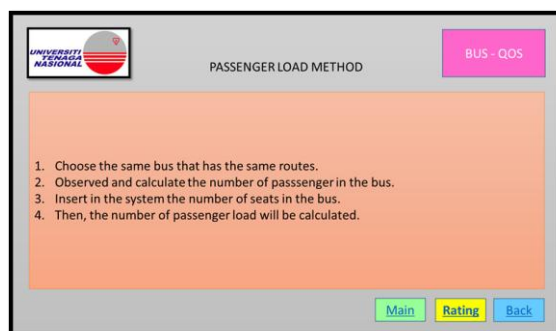


Figure 14. e-Library Interface

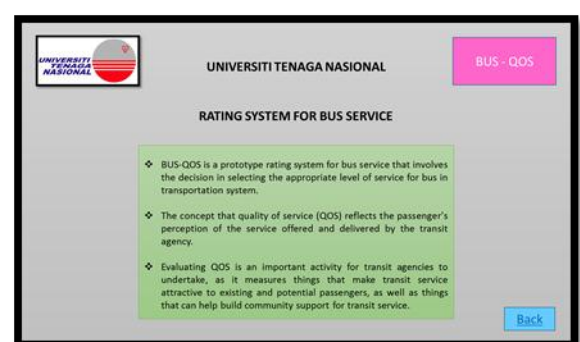
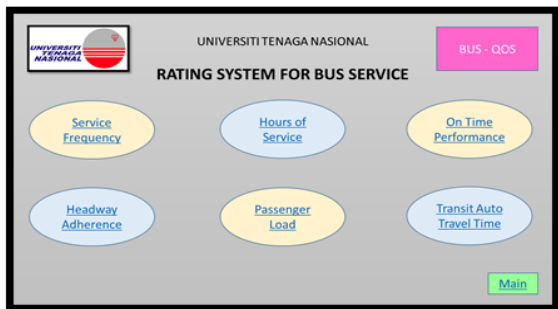


Figure 18. About Interface

**B. Evaluation for Bus Service**

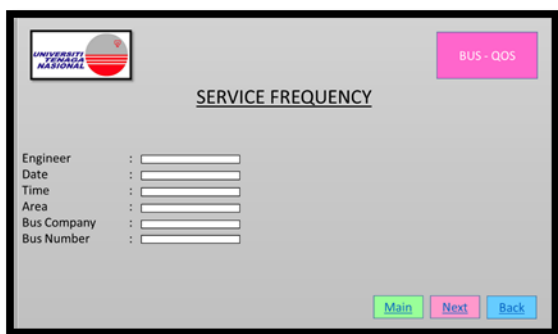
Clicking the QUALITY OF SERVICE button leads the user to the interface of project evaluation. This interface requires the user to choose among the six attributes to proceed with the evaluation for the bus service as shown in Figure 4.17. Then clicking the selected button will lead the user to the first phase of evaluation of the bus service which is Service Frequency.



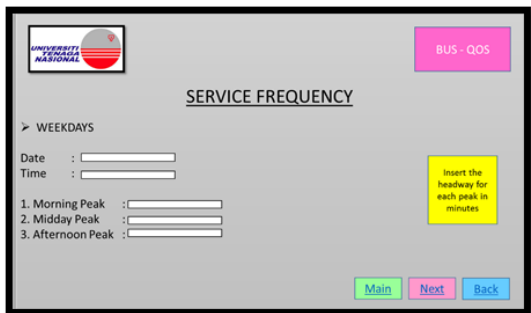
**Figure 19.** Project Segment Interface

*Service Frequency Evaluation*

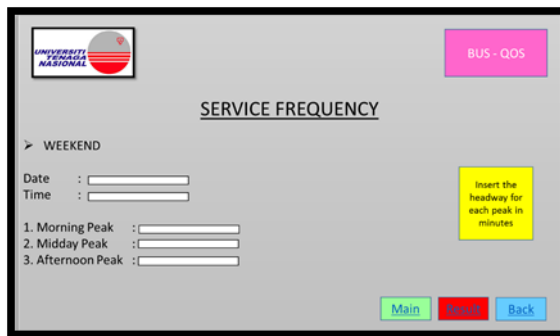
In evaluating Service Frequency, Figure 4.18 shows the interface that requires the user to fill in the information of the project segment such as name of the engineer, date, time, area, bus company, and bus number. By clicking the NEXT button, BUS-QOS asks the user to insert the all the headway for the morning peak, midday peak and afternoon peak in minutes. It is usually separated for weekdays and weekend as shown in Figure 4.19 and Figure 4.20 below.



**Figure 20.** Information Segment of Service Frequency Interface

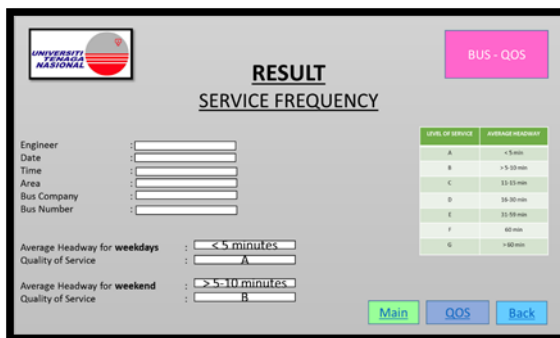


**Figure 21.** Data Input for Service Frequency Segment Interface



**Figure 22.** Data Input for Service Frequency Segment Interface

The interface window for the result of the Service Frequency evaluation is shown in Figure 4.21. The results are shown by the average headway calculated and the classification of service level for both weekdays and weekend. If the average headway is less than <5min, then the level of service is classified as class A. Otherwise, if it is more than >5min, then BUS-QOS will change the level of service to class B according to the rating table. The user may proceed to other evaluations by clicking the QOS button in the interface window. Pressing the MAIN button in Figure 4.21 will take the user back to the main interface or terminate the system.



**Figure 23.** Result for Service Frequency evaluation

*Hours of Service Evaluation*

The objective of Hours of Service is to play an important role as frequency and service coverage in determining the availability of transit service to potential users. If transit service is not provided at the time of the day a potential passenger needs to take a trip, where or how often transit service is provided the rest of the day is eliminated. The longer the hours of service that are provided, the greater the variety of trip purposes that can be served.

In evaluating Hours of Service, Figure 4.22 shows the interface that requires the user to fill in the information of the project segment such as name of the engineer, date, time, area, bus company and bus number. By clicking the NEXT button, BUS-QOS asks the user to insert all the hours for weekdays and weekend using the 24-hour system. It is usually separated

for weekdays and weekend as shown in Figure 4.23 and Figure 4.24 below.

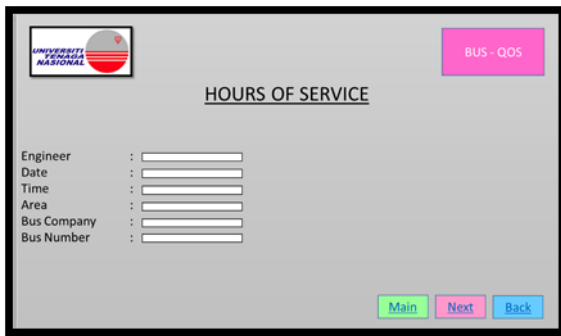


Figure 24. Information Segment of Hours of Service Interface

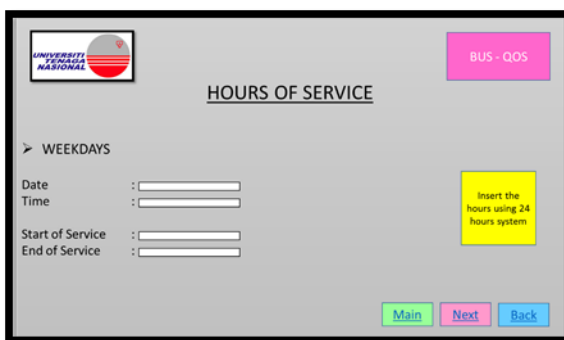


Figure 25. Data Input for Hours of Service Segment Interface

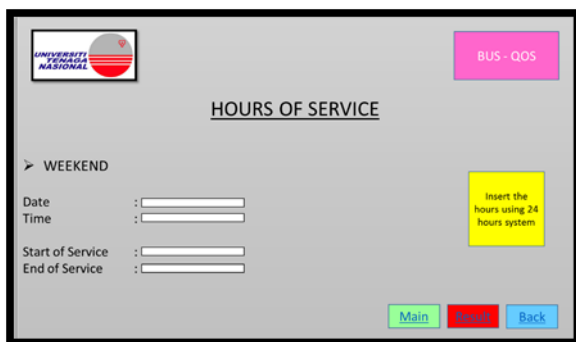


Figure 26. Data Input for Hours of Service Segment Interface

The interface window for the result of the Hours of Service evaluation is shown in Figure 26. The results are shown by the calculated Hours of Service and the classification of service level for both weekdays and weekend. If the hours of service are more than >18h, then the level of service is classified as class A. Otherwise if it is 15-18h, then BUS-QOS will calculate and change the level of service to class B according to the rating table. The user may proceed to other evaluations by clicking the QOS button in the interface window. By pressing the MAIN button in Figure 27 will allow the user go to the main interface or terminate the system.

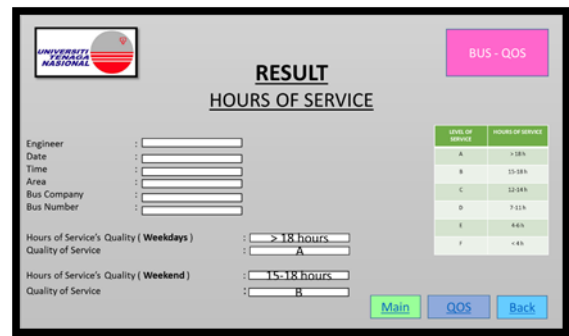


Figure 27. Result for Hours of Service evaluation

## CONCLUSION

The selection of an expert system to calculate the quality of service has been an ongoing case study as shown in previous literature.

The goal of an expert system is usually more ambitious compared with a conventional computer program. It has the ability to collect human knowledge in accordance to a problem-solving without having to change. The prototype of an expert system development, BUS-QOS, has also been achieved as a third goal in this study. This system has successfully passed a number of case studies and expert advice as well.

The results indicated that the evaluation of the quality of service was 100% matched. This is because the calculation of the manual is the same as the BUS-QOS.

Therefore, this shows that BUS-QOS is suitable for use as it is faster than the existing manual calculation. In addition, it can also be applied to save time and regulate service quality.

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