Transport Modelling for Improved Environment: Engineering Education Studies of Environmental Impact and Customers Attitude

James O. Uhomoibhi[1] and Dailin Huang[2]

[1] Faculty of Engineering, University of Ulster, Newtownabbey, BT37 0QB, Northern Ireland, United Kingdom; Email: j.uhomoibhi@ulster.ac.uk *(author for correspondence)*

[2] School of Computing and Mathematics, Faculty of Engineering, University of Ulster, Newtownabbey, BT37 0QB, Northern Ireland, United Kingdom; Email: Huang-D1@ulster.ac.uk

Abstract - - **Global warming and recent technological advancements have had impacts on our environment. Air pollution worldwide is perceived largely to be one of the major causes of global warming. The greatest source of emissions has been established to be principally the automobiles. A gas such as carbon dioxide, which contributes to global warming, is recognized by scientists as one of the chief pollutants. A diverse school of thoughts exists. Some sees gas as being essential to life and have presented differing interpretation to gas being classed as a pollutant. However, road vehicles remain a major source of air pollution in urban areas. Results from recent research studies undertaken by AEA Energy and Environment group show that road vehicles are responsible for over half of the nitrogen dioxide emissions and over 75% of carbon monoxide emissions in the United Kingdom. In most areas in Europe, these pollutants are principally the products of combustion from heating, power generation or from motor vehicle traffic. Pollutants from theses sources are not only a problem in the immediate vicinity of these sources but also can travel long distances, chemically reacting in the atmosphere to produce secondary pollutants such as acid rain or ozone. The study of this complicated problem, based on the mathematical modeling and research techniques applied to transport in relation to the environment remains a challenge. We designed and administered questionnaire to understand the customers' attitude. In-depth study was also undertaken involving obtaining and analyzing data from statutory bodies and the business sector, especially the transport service providers. The case study reported in this paper focused on commuters at the University of Ulster and the environs. The university has approximately 28,000 students and over 3500 employees. Through the use of mathematical modeling techniques, we defined a model to address the problem of bunching and propose strategy to improve public transport on the municipal level. The operations model developed is used to define the objectives and design measures to reduce the greenhouse gas emissions and other types of air pollutions attributable to transport. We also examine whether the services in place and the policy of the local transport systems in the region is satisfactory to the customers. This was considered important taking cognizance of the need for service improvement and customer satisfaction. This papers reports on attitudes towards the various forms of transport (public and private transport, cycling, walking etc.). Also examined and presented are the policies in place to encourage the use of public transport and other measures for improved environment and the protection of individuals and society. A brief comparison of available transport systems is reported. It is established that learning and knowing about the environment is important. Engineering education is a useful vehicle for achieving this goal. It provides the means and tools for developing the information and acquiring such knowledge, understanding and skills. The use of public transport and promoting awareness of its use is vital to achieving improved environment and a healthier society.**

Index Terms - Transport Modelling, global warming, engineering education, greenhouse gas emission, air quality

INTRODUCTION

In Europe, the continuing rise in private car users, has resulted in increasing demands on energy and fuel, raw material resources and space and the situation could be described as overburden. Transport emission is seen as the major source of air pollution. Of this, over 90% deleterious emission comes from cars.

There exist a relationship between transport and environment: emission from vehicles such as carbon dioxide generates the air pollution. Air pollution contributes to climate change and results in global warming. In recent timesit is claimed that human activities directly contribute to climate change.

Public transport is acknowledged to be the most efficient mode of transport to reduce traffic congestion, improve emission performance and mitigate situation of global warming. However, it must be noted that not all forms of public transport play positive role in society. It can substantially be dependent on measures to improve the service frequency, span and coverage, better on-road priority for bus operation, improved marketing and service integration and fuel types [1]. The present research examines the frequency of the local public bus departure times to design a mathematical model, with a focus on addressing the bunching problem and passengers' satisfaction.

REVIEW OF TRANSPORT MODELING AND SIMULATIONS

Bunching problem is not new to society. Bunching has been defined by Taylor, Yong and Bonsall, as a situation involving vehicles traveling in clusters on the roads [2]. Due to limited amount of work done in modelling related to bus bunching, we adopted a variety of ways and approaches for the present study.

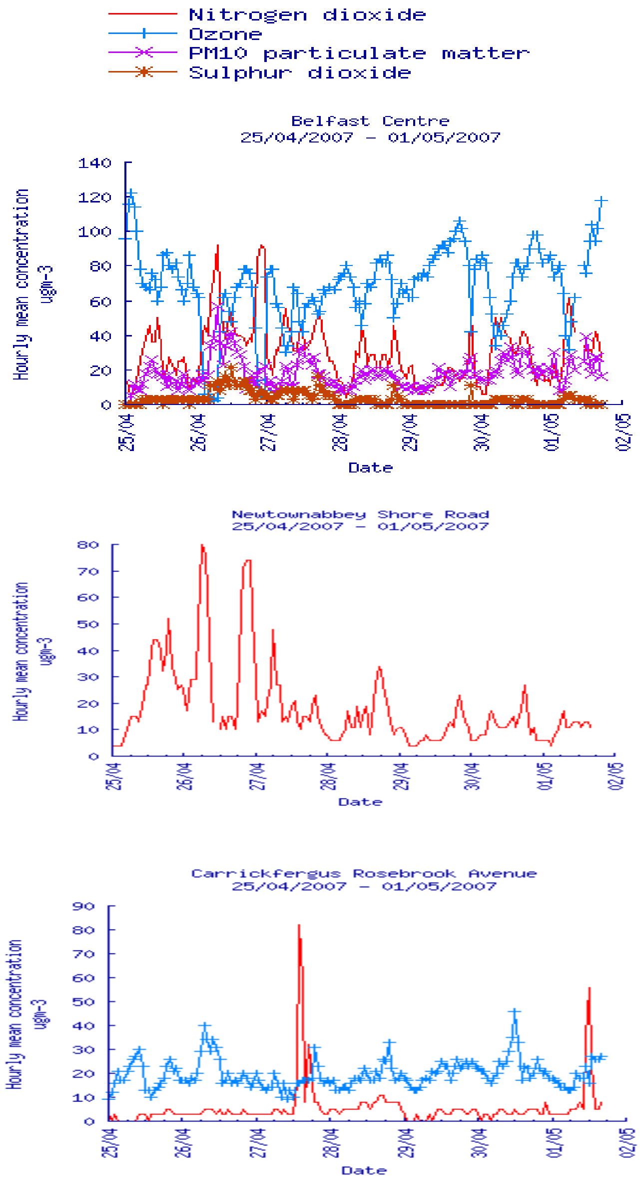
In the year 2003, Milan Krbalek and Petr Seba developed a cellular automaton (CA) simulation model to investigate headway statistics of public transport in Mexican cities [3]. The situation of the Mexican public transportation system is similar to the system operational in Northern Ireland. For comparisons, in Mexican cities, the driver is the bus owner whose aim is to maximize the income. There is no company responsible for the public transport. In Northern Ireland, there is one leading company responsible for public transport. For the company in question, there is no risk of competition and their aim is to maximize profits for shareholders. The CA model provides a cellular automaton, simulating the behavior of public bus transport in several Mexican cities. This reports irregularity in the transport system which causes a lot of problem. Examples include when two buses arrived at the same bus stop within a very short time interval; the first bus collects all of passengers while the second bus, arriving slightly later finds the pick-up-point (bus stop) practically empty. This is defined as the problem of "bunching" which happens at bus stops, and forms the main focus of this paper. Having examined extant methods used in modeling, we believe the CA algorithm is useful in tackling such a problem. It is easily adaptable to parallel computing and can deal with large scale computer simulations. However, a limitation of the modified version of CA model is the fact that it can only apply in area lacking transport management or where there are irregular transport systems.

CASE STUDY AND METHODOLOGY

Our study involved interviewing some representatives of transport providers, some statutory bodies, and customers with the intention to raise awareness and stimulate interest in understanding key issues the society cared about.

There is one single operator with sole control and monopoly on public transport service provision in Northern Ireland. Its provision covers the railways, bus services and is responsible for over 70 million bus and rail passenger journeys each year. Interview with the technical unit of this company reveals that the dedicated uni-link bus service is very popular with public users and students. A relational database system is used to arrange timetable and modify the timetable each year according to the demands. To offer better public bus service the following were designed: a 76 seats double decker and single decker with 44 seats on low floor, a 53 seats type bus and a 65 seats high capacity type buses. It is claimed that the services offered are independently monitored and is geared towards benefiting the customers. Although as yet there is no in-house environment related studies conducted into the improvements and increased use of public transport services to date, this is something they are looking into providing in the future. A review and improvement of bus services is underway. In its report, *Environmental Plan 2004/05-2006/07* published in 2004, the current environmental situations that the public transport service providers face are described. Ways were proposed to develop an environmental management system to ensure regulatory compliance with new and existing environmental legislation and to promote continual environmental improvement. However, because this plan just outlines the organization's primary environmental objectives and responsibilities, with no further details supporting action in this proposal, it has not been possible to give an in-depth treatment to this problem here.

The Department of Environment (DOE) caters for the 26 local councils in Northern Ireland. The department aims to improve the quality of life for everyone in the region. It is acknowledged that road transport is a major source of local air pollution. Data from the department indicated that between 1986 and 2000, the number of cars on the road increased from 16.9m to 23.1m; therefore, cutting road transport emissions places an emphasis of local air quality management. They arranged 39 air quality monitoring stations across the region to observe whether there has been a worsening or improvement and if the declared areas of poor air quality should remain. Air quality levels at these local areas such as those in the region of the present study (Belfast city council, Newtownabbey borough council and Carrickfergus borough council) are shown in the figure 1 [4]. The results shows the high levels of emissions and its implications when referring to Ozone and Nitrogen dioxide in some of these areas for the different times. These are high for Belfast., while for the other two borough councils the values can be considered to be low. Although levels of pollution have been reduced significantly over the past decade, in some areas , the level of pollution in some others still continue to exceed standard level as indicated by the bar/marker in figure 2 [5]. In areas such as Newtownards Rd and Dale's Corner, the annual mean NO_2 exceeds the AQS.



FIGURES 1: EMISSION VALUES MONITORING FOR BELFAST (TOP), NEWTOWNABBEY (MIDDLE) AND CARRICFERGUS (BOTTOM). SOURCE: STATISTICS FOR NORTHERN IRELAND AIR QUALITY IN 25/042007-1/05/2007

In describing the current organizational problem faced by the public service provider in Northern Ireland and how they are attempting to solve the problem, we examine the department of the environment's ways of addressing their targets in an attempt to improve environment; The local organization recognizes, that as a provider of public transport within NI, they are responsible for directly controlling a wide range of environmental risks [6].

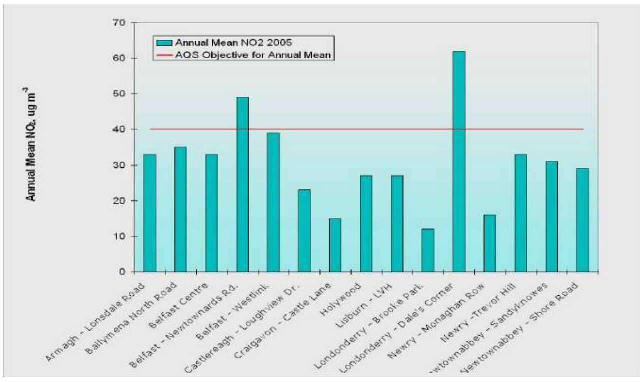


FIG 2. COMPARISON OF 2005 ANNUAL MEAN NO2 CONCENTRATION WITH AQS OBJECTIVE. SOURCE: AIR QUALITY MONITORING IN NI 2005, DEPARTMENT OF THE ENVIRONMENT.

However, they have not to date, conducted specific study to examine issues related to the environment. They remain convinced that they provide a high quantity of service to passengers, since at the present moment there is absence of effective and authentic data to show otherwise. Our research focuses on this and related issues

MATHEMATICAL MODELLING

The present paper sets out to define a Mathematical Model to address the bunching problem.

Based on a variety of evidence related to how transport impact environment, an engineering mathematical approach to bus bunching is presented using the following steps: in our data analyses and in consideration of feasibility, a typical workday is categorized into three periods: peak, normal and off-peak and an average loading factor Z is introduced. Taking into account passengers benefits, we highlight the level of bus service's quality, which is related to the level of passengers' dissatisfaction. We use "Lingo" mathematical software to work out the bus time interval. [7].

- **Modelling Assumptions***:* For the purposes of mathematical formulations, we made the following assumptions that , the ticket fare is fixed and the time interval between any two buses leaving the bus stop in a specifically defined term time is fixed. We assume that the acceptable limit of waiting limit is 10 min at peak, 15 min at normal and 20 min at the off-peak. That the time spent by the passenger alighting and boarding the bus is ignored, that the speed of travel between bus stops is taken as fixed and that no passenger is left behind whenever a bus leaves a bus stop. It is essential to determine the time interval between two buses leaving the bus stop so that buses en-route do not catch up with each other and passengers do not have very long waits between buses. Based on initial analysis, it was concluded that (i) maximizing the loading factor, Z, is one of the way to avoid the bus bunching problem and (ii) minimizing the probability value of passengers, W, whose waiting time is over the acceptable limit.

- **Variables, Notations and symbols:** - The following notations, symbols and their meaning have been used for computation:
  i : index of service bus (i=1, 2, 3…n)
  k : index for identifying the bus stops/stations on the transit route. (k =1, 2, 3…h)
  j: index of time period (j=1, 2, 3…m;)
  f: departure frequency/ times of vehicle during period j.
  Dj: the first bus departure time at j_{th} period
  dij: the ith bus's departure time at j_{th} period
  Δ dj: The departure headway (or departure interval) between bus i-1 and bus i at period j
  Δt : Departure interval between j and j+1 period
  T_{ijk} :The ith bus's arrival time at bus stop k during j_{th} period
  q_k : running time from original bus stop to bus stop k.
  Z: the average loading factor
  p_{ijk} : Total numbers of passengers on bus i when i leaves bus-stop k during j_{th} period.
  P_{tot} : Total number of passengers traveling by bus.
  bjk : average number of passengers waiting for boarding bus per minute at bus stop k during j_{th} period
  ajk : total number of passengers alighting bus at bus stop k during j_{th} period
  cjk: : the number of passengers increase on bus per minute at bus stop k during j_{th} period.
  u: the standard passenger capacity;
  $Wijk$: number of passengers whose waiting time is over the acceptable limit when the bus i didn't arrive the stop k on time during j_{th} period
  W: the probability of number of passengers whose waiting time is over the acceptable limit

Denoting the first bus's departure time during j period with , D_j and that for j+1 period by D_{j+1}, we have that for the departure interval (D_{j+1} - D_j), between the period j and j+1 is given by :

$$\Delta t = D_{j+1} - D_j \qquad (1a)$$

Where Δt is a time period, f_j is frequency. So calculating the "time interval ($\vartriangle d$) between two buses" within "a time period (Δt)", that is,
Departure interval between buses i-1 and i during the jth period is given by :

$$\vartriangle d_j = \frac{\Delta t}{f_j} = \frac{D_{j+1} - D_j}{f_j} \qquad (1b)$$

where the symbols have their usual meanings. It is known that during j period, the first bus's departure time (D_j) and departure interval is $\vartriangle d_j$, then the i_{th} service bus's departure time, during j_{th} period is given

$$d_{ij} = D_j + \Delta d_j \bullet i \qquad (2)$$

The i_{th} bus's arrival time at specified bus-stop, k, during j_{th} period (q_k : the running time from original bus-stop to bus-stop k):

$$T_{ijk} = d_{ij} + q_k \qquad (3)$$

The numbers of passengers increase on bus per minute at bus stop k during j_{th} period is:

$$c_{jk} = b_{jk} - a_{jk} \qquad (4)$$

The numbers of passengers waiting to board the bus at bus stop, k, is: $b_{jk} * \Delta d_j$ (5)

Total number of passengers traveling during j period by bus can be estimated using the following::

$$P_{tot} = \sum_{j=1}^{m}\sum_{i=1}^{f_j}\sum_{k=1}^{l} p_{ijk} \qquad (6)$$

The average loading factor is:

$$Z = \frac{P_{tot}}{u * \sum_{j=1}^{m} f_j} \qquad (7)$$

Utilizing the data obtained from our survey, we assume that passengers' acceptable time limitation is 10 minutes during the peak and 20 min during the off peak periods.

The probability estimate for number of passengers whose waiting time is over the acceptable limit is:

$$W = \frac{\sum_{j=1}^{m}\sum_{i=1}^{f}\sum_{k=1}^{l} W_{ijk}}{P_{tot}} \qquad (8)$$

Therefore, we build the optimization model, in a bid to prevent the bunching problem, and maximize the loading factor:

$$Z_{max} = \frac{P_{tot}}{u * i * \sum_{j=1}^{m} f_j} \qquad (9)$$

In order to optimize the bus service level, we minimize the degree of passengers' dissatisfaction and use the expression

$$W_{min} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{f}\sum_{k=1}^{l} W_{ijk}}{P_{tot}} \qquad (10)$$

Subject to $\begin{cases} f_j > 0 & \text{for } j = 1, 2\ldots m; \\ & i = 1, 2\ldots n; \\ P_{ijk} \le u & k = 1, 2\ldots. \end{cases}$

MODEL RESULTS AND TIMETABLE

A closer study of the particular bus service which connects the two main universities campuses show the distribution of bus stops to be (i) h = 3 ($1\le k\le 3$) and (ii) h = 3 ($1\le k\le 3$) for outbound and inbound stops respectively.

Assuming $\Delta t = 60\,\text{min}$ and that the hours of operation for the vehicles range from 08:00 hrs to 23:00 hrs, it turns out that this gives 15 periods of operation per-day. We let j=1 define period for time between 08:00 hrs and 09:00 hrs; j=2 for time between 09:00 hrs and 10:00 hrs. right through to j=15 for period from 23:00 hrs -24:00 hrs. We note that the average bus capacity is 53 and that the number of passenger boarding and alighting bus was estimated from the 5 days survey conducted. Calculating the values of parameters for the periods gives:

At Peak Period: The average number of passengers b_1 waiting to board the bus is given by:

$$b_1 = 40;\ b_2 = 3$$

Average number of passengers alighting each bus at original stop and at second bus stop:

$$a_1 = 0;\ a_2 = 20$$

This gives the number of passenger boarding the bus when it leaves the original stop is:

$$p_1 = b_1 + a_1 = 40; \qquad (11)$$

From the equation (5), the number of passenger boarding the bus when bus leaves the second bus stop is:

$$p_2 = p_1 + b_2 * \Delta d_j - a_2 = p_1 + b_2 * (\Delta t / f_{peak}) - a_2$$
$$= 45 + 3 * (60 / f_{peak}) - 20 \qquad (12)$$

Using equation (1b), we get:

$$\Delta t / f_{peak} = \frac{D_{j+1} - D_j}{f_j} = \Delta d_{peak} \qquad (13)$$

Therefore, total number of passengers traveling by bus (P_{tot}) during 60 min (Δt) at peak period is:

$$P_{tot}^{peak} = (\Delta t / f_{peak})\{ p_1 + p_2 \}$$
$$= 2p_1 + b_2 * (\Delta t / f_{peak}) - a_2$$
$$= (60 / f_{peak})\{ 2*40 + 3*(60 / f_{peak}) - 20 \}$$

Similarly,

at normal period:

$b_1' = 35$; b_2' =2 per minute, $a_1' = 0$; a_2' =15

at off- peak period:

$b_1'' = 36$; b_2'' = 0.8 per minute, $a_1'' = 0$; a_2'' = 17

Calculating, then, this gives

at normal period: $p_1' = b_1' + a_1' = 35$;

$$p_2' = p_1' + b_2' * (\Delta t / f_{nor}) - a_2'$$
$$= 35 * 2 * (60 / f_{nor}) - 15$$
$$\therefore P_{tot}^{\prime\, nor} = (\Delta t / f_{nor})\{ p_1' + p_2' \}$$
$$= 2p_1' + b_2' * (\Delta t / f_{nor}) - a_2'$$
$$= (60 / f_{nor})\{ 2*35 + 2*(60 / f_{nor}) - 15 \}$$

At off peak periods: $p_1'' = b_1'' + a_1'' = 36$;

$$p_2'' = p_1'' + b_2'' * (\Delta t / f_{off}) - a_2''$$
$$= 36 * 0.8 * (60 / f_{off}) - 17$$
$$\therefore P_{tot}^{\prime\prime\, off} = (\Delta t / f_{off})\{ p_1'' + p_2'' \}$$
$$= 2p_1'' + b_2'' * (\Delta t / f_{off}) - a_2''$$
$$= (60 / f_{off})\{ 2*36 + 0.8*(60 / f_{off}) - 17 \}$$

For instances involving students at both campuses, the peak and off peak period is shown to be more concentrated around school time-table (see Table 4).

TABLE 1: 3 TYPES OF PERIODS AT INBOUND AND OUTBOUND STOPS

		inbound stops	**outbound Stops**
Bus Frequency	Conditions	Time Period ($1\le j\le 15$)	Time Period ($1\le j\le 15$)
6	Peak Period	5,6,7,8	1,2,3,5,6,8,9
4	Normal	2,3,4,9,10	4,7,10
2	Off Peak Period	1,11,12,13,14, 15	11,12,13,14

This yields the following model:

$$z_{\max} = \frac{P_{tot}}{u * i * \sum_{j=1}^{m} f_j} \qquad (14)$$

$$W_{\min} = \frac{\sum_{j=1}^{m} \sum_{i=1}^{f} \sum_{k=1}^{l} W_{ijk}}{P_{tot}} \qquad (15)$$

subject to
$$\begin{cases} f_j > 0 & \text{for } j = 1, 2\ldots 15; \\ & i = 1, 2\ldots n; \\ P_{ijk} \le 53 & k = 1, 2 \end{cases}$$

This problem formulated is a nonlinear programming problem; lingo [7], a mathematical programme was used to solve it. Firstly, we calculate the loading factor *Z*. For 3 types of time periods, each period is then discussed separately.

For Peak Period,

$$Z_1\ (max) = \frac{P_{tot}^{\ peak}}{u * i * f_{peak}}$$

$$\Rightarrow Z_1(\max) = \frac{\frac{60}{f_{peak}} * (2\times 40 + 3\times \frac{60}{f_{peak}} - 20)}{53\times 2\times f_{peak}}$$

subject to:
$$\begin{cases} 40 + 3\times \frac{60}{f_{peak}} - 20 \le 53; \text{ and} \\ \frac{60}{f_{peak}} \ge 0 \end{cases}$$

Using Lingo we obtained the loading factor, Z_{peak} = 87.74% and the departure frequency, $f_{peak} = [6,5]$ times for the peak period.

Applying equation (1b), the departure headway between bus i-1 and bus i at peak period gives

$$\Delta t / f_{peak} = \frac{D_{j+1} - D_j}{f_j} = \Delta d_{peak}.$$

$$\Rightarrow \quad \Delta d_{peak} = \Delta t / f_{peak} = 60 \text{ min}/ 6 \text{ times} = 10 \text{ min}$$

It means that in every 10 min to 12 min, bus must be arriving at each bus stop.
Similarly, we do the same, to calculate for the normal and off peak period, and obtain:
At Normal period: Z_{nor} = 83.02 %; $f_{nor} = 3.64 \approx [3,4]$
Δd_{nor} = 15 min
At off peak period: Z_{off} = 84 %; $f_{off} = 1.4 \approx [1,2]$
Δd_{off} =30 min
We estimate that the average loading factor: Z_{peak} = 87.74 %, Z_{nor} = 83 % and Z_{off} = 84 % values of efficiency, close to standard capacity, and are the optimal solutions.
Hence, Δd_{peak} =10 min; Δd_{nor} =15 min & Δd_{off} = 30 min can be used as a real-time optimal model.

Secondly, we calculate the value of probability of passengers' dissatisfaction *W*. From the maximum number of passengers whose waiting time is over the acceptable limit *(Wijk)*. Using the results from the questionnaires, during peak period passenger's acceptable time limit is 10 min and 20 min for off-peak period.

So, during peak period,

W_{ijk} = max { $b_{jk} * (\Delta d_j$ - 10 min}, 0}

At normal period, we assumed that:

W_{ijk} = max { $b_{jk} * (\Delta d_j$ - 15 min}, 0}

At off-peak period, then:

W_{ijk} = max { $b_{jk} * (\Delta d_j$ - 20 min}, 0}

Based on the factual information obtained from the data we have collected, using Lingo, we get:

at peak period, then:
Max W_{ijk} = 3*(60/-10)
Subject to: 45+3*60/ f_{peak} -20<=53; and f>0;
Giving: W_{ijk} = 3. Which implies the maximum number of dissatisfaction are 3.
Similar, following results where obtained: W_{ijk} =7 for normal period and W_{ijk} =7 for off peak.
When W_{ijk} = 3, W_{ijk} = 7 and W_{ijk} = 21, we get:
For peak period, W_{peak} = 0.032, $f_{peak} = 6$,

$$\Delta d_{peak} = 10 \min$$

For normal period, W_{nor} = 0.080, $f_{nor} = 4$,

$$\Delta d_{nor} = 15 \min$$

For off-peak period, W_{nor} = 0.23, $f_{nor} = 2$

$$\Delta d_{nor} = 30 \min$$

Combine the *Z* model and *W* model, we obtained model timetable for both the inbound and outbound bus service per day.

TABLE2. MODEL INBOUND AND OUTBOUND TIMETABLE FOR THE PUBLIC BUS SERVICE BASED ON OPTIMIZED CONDITIONS.

Inbound timetable		Outbound timetable	
Time of Day (hrs)	Time (min)	Time of Day (hrs)	Time (min)
08:00-09:00	30	08:00-09:00	30
09:00-11:00	10	09:00-11:00	10
11:00-12:00	30	11:00-12:00	30
12:00-17:00	10	12:00-17:00	10
17:00-18:00	15	17:00-18:00	15
18:00-23:00	30	18:00-23:00	30

And we also obtain the following values for the total numbers of buses demand per day to be 46, the average loading factor to be 1/3*(87%+83%+84%) = 85%
The probability of passengers' dissatisfaction to be 1/3*(3.2%+8%+23%) =11.4%

TEST AND ANALYSIS OF MODEL

Sensitivity analysis approach was applied to test the model similar to that used by Taha [8]. Assuming no one was left behind when a bus departs a bus stop, and based on the a condition with the maximum loading factor, we obtained results as shown in the table below (see Table 4).

These indicate that the model which focuses on loading factor to improve bunching problem is a steady model.

TABLE 4 COMPARED RESULTS FOR MODEL PARAMETERS

Period	Var	Original	Test 1	Test 2
Peak	f	6	5; 6	6
	Z	87.74%	81%	91%
	Δd	10 min	10 min	10 min
Normal	f	4	4	4
	Z	15 min	20 min	15 min
	Δd	83%	81%	86%
Off peak	f	2	2	2
	Z	84%	81%	87%
	Δd	30min	30 min	30 min

Therefore, the model could be regarded to be an effective useful steady model.
However, when we test the Passenger's Dissatisfaction Probability Model, we found that: Since at off peak period, if there are only 2 buses arranged in a term time (60 min) at each bus stop, the degree of passengers' dissatisfaction tends to be a bit high 23%. To improve this model, we assume that bunching problem doesn't exist if the bus frequency at off peak period is only 2, this makes the result of loading factor unimportant as the passenger's complaint level was highlighted. This suggestion is that at off peak period, minimizing the passengers complaint level is more important than preventing the bunching problem. The public transport service provider should considered dispatching more buses frequently during the off peak time.

ATTITUDES TO PUBLIC TRANSPORT

Questionnaire was used to assess attitude of over 500 commuters. There were 155 public bus transport users. This formed the focus and the data collected were analyzed using SPSS [8]. The highest proportion of bus service users comprise those who use it between 3-4 times per week, and account for ~41.9% of respondents. The smallest comprise those utilizing it everyday (3.9%) followed by those using it approximately once per week (8.4%). Regular weekly users account for ~30% of those sampled. (see Figure 3).

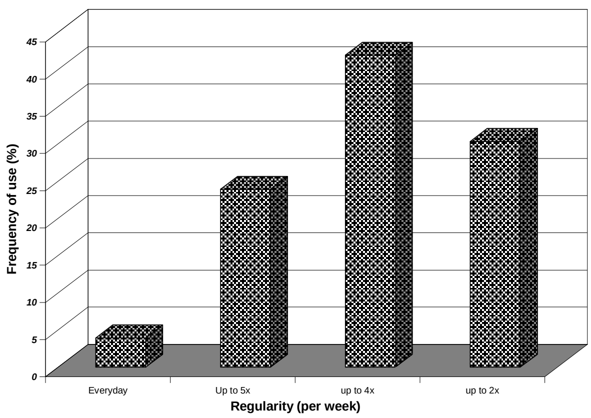


FIGURE 3. REGULARITY AND FREQUENCY OF USE OF THE PUBLIC TRANSPORT BUS SERVICE.

Investigation into the preferred mode of transport reveals that a higher proportion prefer to use their private cars (see Figure 4) They account for ~52% of total respondents. ~23% opted for bus and the remainder were in favour of train. More would need to be done to encourage less use of private cars and increase the use of public transport services.

In investigating reasons for such an attitude towards the use of public transport, an analysis was carried out of attitudes of respondents to current service provision of public transport and their view as to whether or not it was reasonable to encourage the use of public transport for improved environment. Results are as shown in Figure 5.

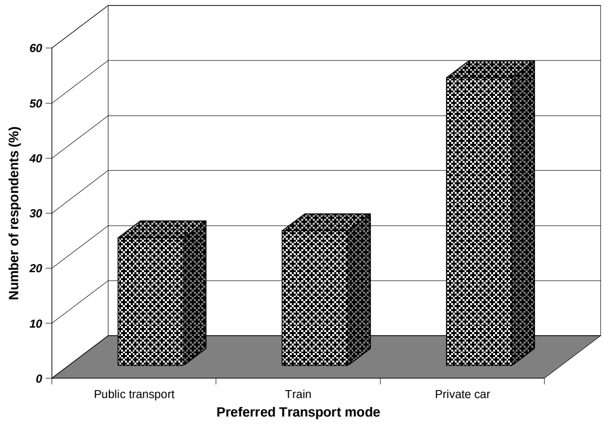


Figure 4. Respondents preferred transport mode

A large proportion of respondents are of the opinion that the current provision as it stands requires improvement (67.7%) and a higher proportion believe that it is reasonable to use public transport for improving environment through reduced air pollution and gas emission.

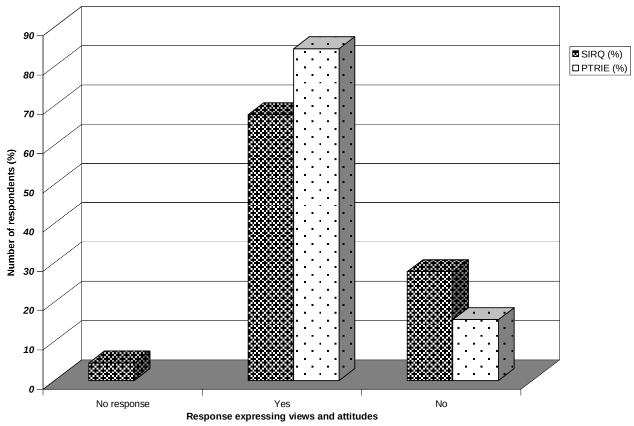


Figure 5. Users attitudes towards current public transport service provision (SIRQ: level of satisfaction) and the need for its use for improved environment (PTRIE: reasonableness of use).

There may be few reasons why different models could apply to different people. This may be due to differences in policies in operation, cultural differences [10, 11].

However, the surveys clearly point to the fact that there are a large range of people who prefer to use car as their daily transport mode, even if it is acknowledged that emission from car could impact air pollution. If bus services could operate more quickly and frequently, and the price could be reduced, this can be one way to encourage the car user become users of public transport.

CONCLUSION

This research focused on study of public transport and the impacts to the environment. We have reviewed the previous research work on approaches to public transport modelling and issues of bunching problem. The attitude of the local public transport service providers have been assessed as well as the policies and ways devised by government and relevant authorities aimed at preventing environmental crisis and developing a transport for a sustainable future. We have developed a model to address to address the bus bunching problem and to the coordination public bus service directed at tackling the bus bunching problem.

The key findings of this research are that transport is an important source of greenhouse gases and air pollution, and impact of the environment. Public transport systems such as rail and bus have controlled emissions. Its use could contribute less emission with resulting positive impact on eh environment. A well managed public transport service provider in a region with no competition may result in a less optimized bus service especially where punctuality and ticket cost are perceived by users as important. Local institutions such as the Department of Environment (DOE) and public bodies have a duty to improve environmental conditions aimed at improving the quality of life for everyone in any given part of the world. There is a clear need to substantially improve the quality of public transport services in delivering a modern and integrated transport system. It is suggested that local and regional authorities avail of professional expertise in public transport undertakings. Adequate funding should be provided for the public transport network to deal with traffic congestion and support the implementation of the regional transportation strategy. Competition is the key to increasing patronage and better services. More service providers should be encouraged to operate which should lead to optimized services and achieve higher level of customer satisfaction.

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