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Identifying the Potential for Bus Route Mergers using Electronic Ticketing Data

K P Nallaperuma and Amal S Kumarage
University of Moratuwa, Sri Lanka

1. Introduction

Technology based surveys on public transport are rare due to lack of technology uptake in the field. However, the 'SAHASARA' pilot project has provided a full year's Electronic Ticket Machine (ETM) data from 350 buses operating on 48 routes along two corridors - Dumbara and Denuvera- serving the city of Kandy. The Dumbara corridor operates27 routes with the longest route being 46.1 km, while the Denuvera corridor operates 21 routes with the longest route being 29.7 km [1].

The primary objective of this research is to investigate if the Sahasara ETM data can be used for bus route re-planning also called route rationalising [2]. Route re-planning would investigate a number of potential changes to service routes in a bus network. These could range from new routes to route extensions and route mergers. The ETM data has an inherent limitation in that it can only be used for route mergers since ticket data is only for individual bus trips. Route mergers are when two routes that terminate at a common terminal are spliced together to operate as a through route.

This usually results in two arterial routes becoming a cross town route, thus serving two corridors without terminating in the city Centre. The use of Smart Cards which can provide entire trip details are much more versatile for a wider range of route re-planning efforts that can achieve several outcomes such as reducing passenger travel time and cost, reducing passenger transfers and transfer time as well as reducing bus operational time and distance, thereby increasing bus productivity [3].

However, proposing suitable routes for mergers requires identifying routes that have compatible demand and revenue profiles as well as supply characteristics so that issues arising in route merging can be minimized. The latter is important since in Sri Lanka the private buses are provided by individual small-scale operators on permissions that entitle then to collect the daily revenue while meeting operating expenses thereof [4].

2. Methodology

The main objective of the research was to propose suitable routes which have the ability to integrate with others of similar characteristics. As shown in Figure 1, particular routes should have similar demand profiles, similar supply profiles and similar revenue profiles to be successfully integrated.

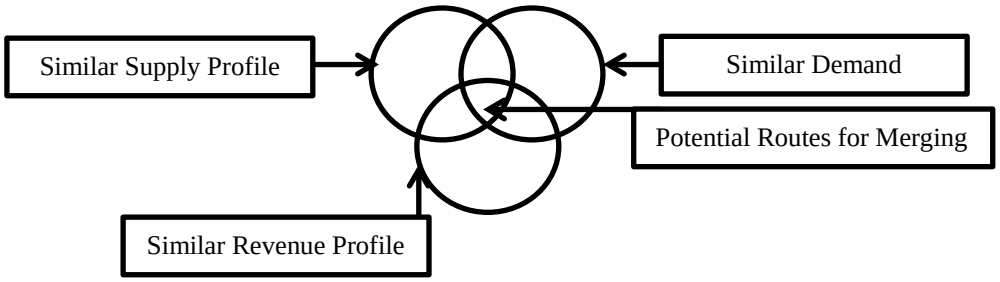

Figure 1: Considerable factors for integrating

Initially similar revenue profile has been identified, and the following equation was used to find out the particular revenue of buses:

$$Revenue\ per\ bus = Revenue\ per\ trip\ x\ Number\ of\ trips\ per\ day$$

[Equation 2.1: Revenue calculation 1]

When considering revenue per km, the following equation was used:

$$Revenue\ per\ Kilometre = \frac{Average\ revenue\ per\ trip}{Distance\ of\ the\ trip}$$

[Equation 2.2: Revenue calculation 2]

This gives the revenue per bus/kilometre for each day, and weekly average revenue of each route was calculated. Among these values, values which have similar averages were selected and a T-test was used to identify similar demand and supply profiles. Mean values of each of the above for each of the routes in the Dumbara corridor were compared with that of the Denuvera corridor to study what routes could be spliced and run through town.

A hypothesis testing was carried out to determine if they could be considered having compatible distributions. In this case the null hypothesis (H_0) and the alternate hypothesis (H_1) for testing compatibility were determined as follows:

H_0= there is no considerable difference between the two routes

H_1= there is a considerable difference between the two routes

The null hypothesis was accepted as a p value higher than 0.05 using the t-test. Routes that satisfied all three requirements were identified for route merger.

2.1. Compatible Demand Profile

Routes having compatible demand profiles from the two corridors as shown in Table 1 were selected to carry out the t-test. The four route pairs that returned p values higher than 0.05 were selected as having compatible demand profiles.

Table 1: Testing for similarity in demand profile

Compatible Routes (Digana/Denuvera)	Daily Mean Passenger Demand	Correlation	p-value
Kandy-Digana Kandy-Kadugannawa	10,720 10,943	90%	0.225
Kandy- Mahawaththa Kandy- Nethulemada	1,631 1,881	76%	0.093
Kandy-Theldeniya Kandy-Pilimathalawa	7,744 7,475	97%	0.774
Kandy-Ayuruweda Hospital Kandy-Aladeniya	1,734 2,038	78%	0.187
Kandy-Aluthwaththa Kandy-Dehianga	2,379 2,233	89%	0.800
Kandy-Aluthwaththa Kandy-Madamahanuwara	2,379 2,584	86%	0.121

2.2. Compatible Supply Profile

Table 2: Testing for compatibility in supply profile

Compatible routes (Digana/Denuvera)	Daily Mean Supply Trips	Correlation	p-value
Kandy-Digana Kandy-Kadugannawa	150.00 148.00	80%	0.125
Kandy- Aluthwaththa Kandy- Madamahanuwara	38.00 35.00	76%	0.103
Kandy-Mahawaththa Kandy-Aladeniya	26.86 26.57	96%	0.253
Kandy-Madamahanuwara Kandy-Dehianga	35.00 36.00	83%	0.541
Kandy-Aluthwaththa Kandy-Ayurveda Hospital	38.00 40.30	93%	0.876
Kandy-Aluthwaththa Kandy-Dehianga	38.00 36.00	72%	0.192

The average daily frequency of bus supply profiles as shown in Table 2 were selected to carry out the t-test. The four route pairs that returned p values higher than 0.05 were selected as having compatible supply profiles.

2.3. Compatible Revenue Profile

The average revenue per km of buses operated as shown in Table 3 were selected to carry out the t-test. The four route pairs that returned p values higher than 0.05 were selected as having compatible revenue profiles.

Table 3: Testing for compatibility of revenue profile

Compatible routes (Digana/Denuvera)	Mean Revenue per km(Rs)	Correlation	p-value
Kandy-Digana Kandy-Kadugannawa	83.00 85.00	82%	0.114
Kandy-Ayuruweda Hospital Kandy-Nethulemada	70.40 71.60	88%	0.236
Kandy-Aluthwaththa Kandy-Dehianga	61.53 64.26	72%	0.106
Kandy-Aladeniya Kandy-Mahawaththa	89.20 88.40	92%	0.353
Kandy-Nethulemada Kandy-Theldeniya	71.60 72.30	86%	0.413

2.4. Selection of Routes for Merging

Routes with compatible demand, supply and revenue profiles were identified and summarized as shown in Table 4.

Accordingly, only two routes have high potential for merging, while others could be considered at a lower level of suitability.

Table 4: Selection of Routes for merging

Considerable Routes	Demand Profile	Supply Profile	Revenue Profile	Integration
Kandy-Digana Kandy-Kadugannawa	✓	✓	✓	**Yes**
Kandy-Theldeniya Kandy-Pilimathalawa	✓	✗	✗	**No**
Kandy-Aladeniya Kandy-Ayuruweda Hospital	✓	✗	✗	**No**
Kandy-Aluthwaththa Kandy-Dehianga	✓	✓	✓	**Yes**
Kandy-Aladeniya Kandy-Mahawaththa	✗	✓	✓	**No**
Kandy-Madamahanuwara Kandy-Dehianga	✗	✓	✗	**No**
Kandy-Ayurveda Hospital Kandy-Nethulemada	✗	✗	✓	**No**
Kandy-Nethulemada Kandy-Theldeniya	✗	✗	✓	**No**
Kandy-Aluthwaththa Kandy-Madamahnuwara	✓	✓	✗	**No**

3. Conclusion and Recommendation

The main outcome of this research is identifying routes on two corridors terminating at a common point that are suitable for merging. Two sets of routes from a total of 48 routes have shown suitability for merging to operate as two cross town routes without terminating in Kandy as is the current practice. With overcrowding of the terminal in Kandy and bus parking and loading issues, this would be a useful identification of suitability. According the routes shown in Table 5, (i) Kandy-Digana with Kandy-Kadugannawa, and (ii) Kandy-Aluthwaththa with Kandy-Dehianga can be merged.

Table 5: Characteristics of routes chosen for merging

New Route	Tripe Distance	Travel Time	Number of One-way Trips per Bus
Digana-Kadugannawa	33.2 km	110 minutes	8 trips per day
Aluthwaththa-Dehianga	35.1 km	100 minutes	6 trips per day

However, there are other parameters such as operator's agreements as well as regulatory aspects that may also have to be considered in making a final decision.

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