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AN IMPROVED STRATEGY TO REDUCE THE PASSENGER TRAFFIC AT COASTAL AND SUBURBAN AREA DIVISION OF SRI LANKA FORT RAILWAY STATION TICKETING COUNTERS

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Abstract

Sri Lanka Railway Department (SLRD); which is the major transport organization in Sri Lanka, provides transportation for about 0.29 million passengers daily. Fort railway station is the main railway station in Sri Lanka which caters 0.2 million commuters daily. It comprises with 10 platforms and two ticketing divisions. Since the Coastal and Suburban area ticketing division is more crowded compared to the other division, the objective of the study was to introduce an improved strategy to reduce the passenger traffic at Coastal and Suburban area division ticketing counters. First, the reasons for the conjunctions were identified. Then the passenger flow was analyzed by (railway) line-wise and ticketing counter-wise. To arrive at a solution the counters were rearranged with the aid of graph theory. Then a new system was introduced and the efficiency of the system was proved using queuing theory.

Keywords: Graph Theory, Queuing Theory, Cut Sets, Ticketing Counters.

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INTRODUCTION

Sri Lanka Railway Department is a major transport service provider and is the only rail transport service in the country. The railway network was introduced in 1864, to transport tea and coffee from the hill country to Colombo. The Figure 1, depicts the contemporary deployment of railway lines and the related destinations in Sri Lanka. Today, it is passenger oriented carrying about 0.29 million passengers daily. SLRD owns and maintains 1420 km of rail tracks, 175 locomotives, 900 carriages and a signaling network. At the moment, it has a workforce of 14400. Colombo Fort railway station is the heartiest railway Station in Sri Lanka. It consists of 10 platforms, 17 ticketing counters, and caters 0.2 million passengers daily. It has two divisions; Long Distance area division and Coastal and Suburban area division. Compared to the Long Distance area division, Coastal and Suburban area division is more crowded. Hence the study was centered on the Coastal and Suburban area division. The Coastal and Suburban area division issues tickets for four railway lines namely Main line (Maradana to Rambukkana), Coastal line (Slave Island to Matara), Puttalam line (Peralanda to Puttalam) and Kelaniweli line (Baseline road to Avissawella). The initial phase of this study; 'A Strategy to Reduce the Passenger Traffic at Sri Lanka Fort Railway Station Ticketing Counters' which was centered on the Coastal and Suburban area division of the Colombo Fort railway station carried out a station wise analysis, considering the time period from 3.00 p.m. to 6.00 p.m. Further, that study comprised the data of three week days, which challenged the reliability of the findings [1]. As a result, the study was extended to its second phase under the title; "An Improved Strategy to Reduce the Passenger Traffic at Coastal and Suburban Area Division of Sri Lanka Fort Railway Station Ticketing Counters".

Since the passenger traffic at the ticketing counters was very high up to 7.00 p.m. during weekdays, in the new study the time period 3.00 – 7.00 p.m. was considered. Furthermore data were collected at ten weekdays. The objective of the study was to introduce an improved strategy to reduce the passenger traffic at Coastal and Suburban area division. It was identified that, so as to accomplish the above objective, the time consumed by a passenger to reach the relevant platform, after he/she joins the queue at the counters should be minimized. The passenger flow was analyzed by (railway) line-wise and ticketing counter-wise. To arrive at a solution the counters were rearranged with the aid of *graph theory*. The concepts of graph theory were applied in finding the cut sets of the required weight.

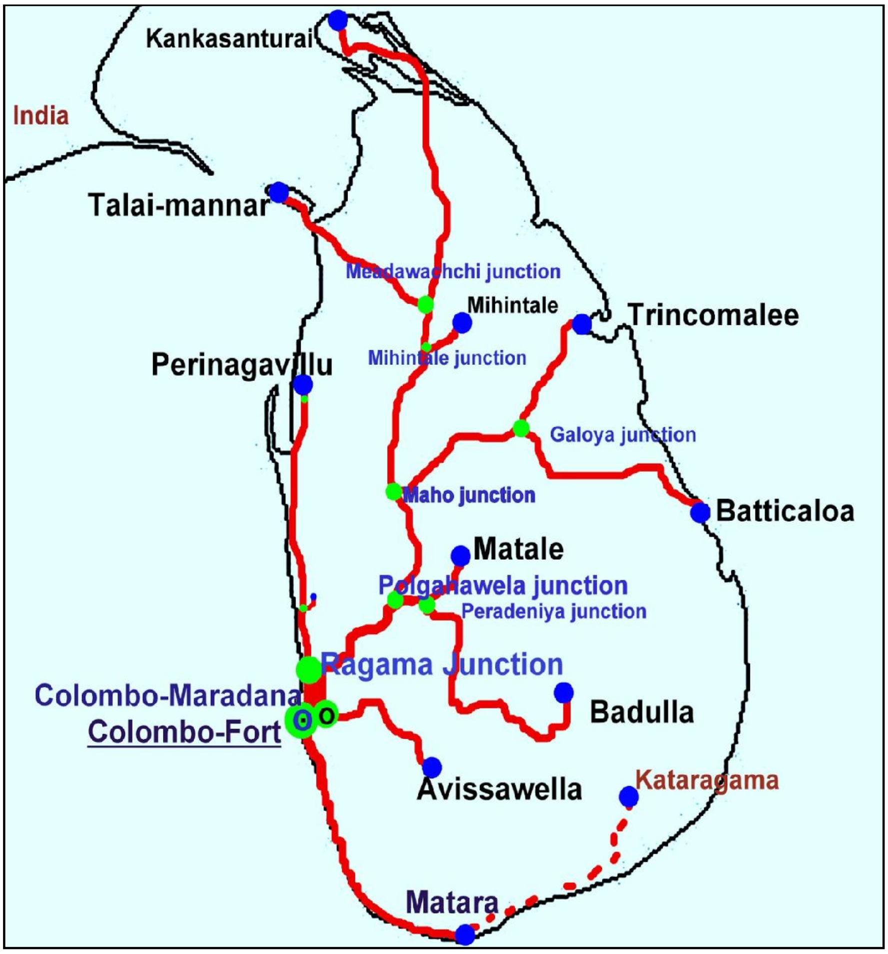


Figure 1. The Existing Railway Network, Sri Lanka

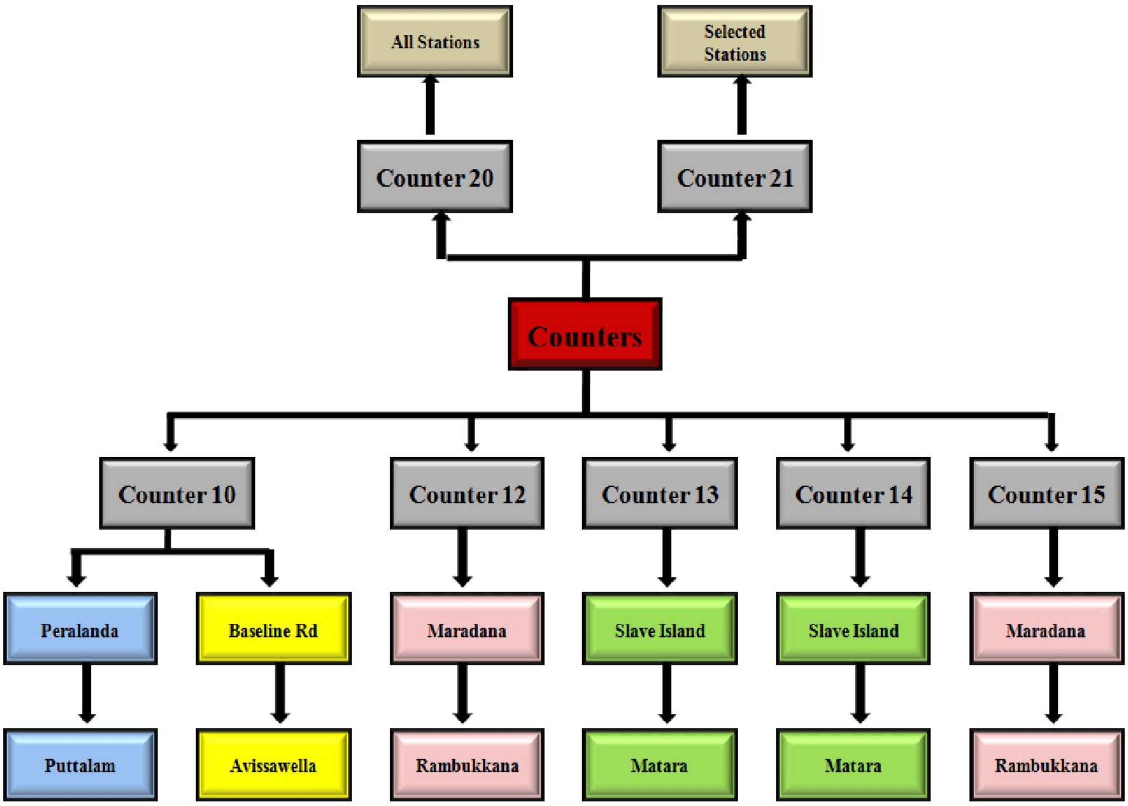


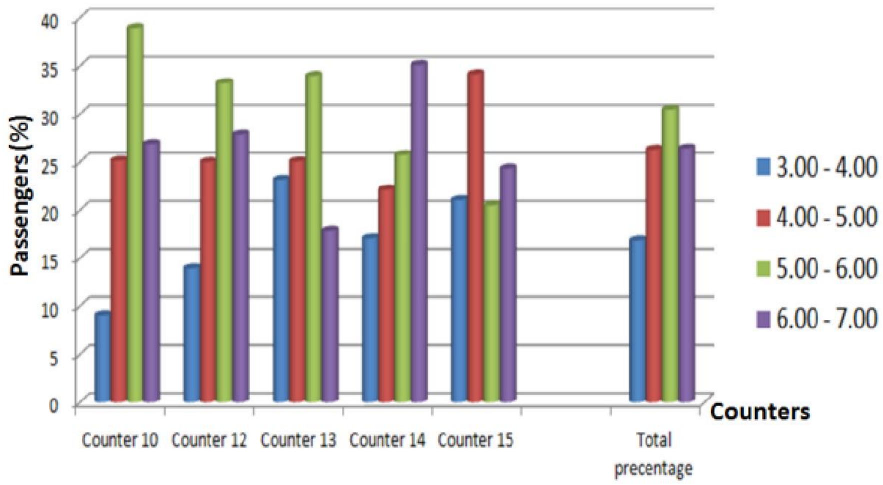
Figure 2. The arrangement of the ticketing counters

Finally, the proposed system was evaluated using *queuing theory*; which allowed assessing the efficiency via arrival rates and service rates.

MATERIALS AND METHODS

As mentioned, the Coastal and Suburban area division issues tickets for four railway lines, and it has seven ticketing counters (10, 12, 13, 14, 15, 20 and 21). Nevertheless, in the analysis, only the ticket counters (10, 12, 13, 14 and 15) were considered, which are located nearby facing Olcott Avenue, since those were found to be the most crowded and compacted set of counters. Further, counter 10 issues tickets for Puttalam line and Kelaniweli line, Counters 12 and 15 issue tickets for Main line, while Counters 13 and 14 issue tickets for Coastal line.

As the initial step, the passenger flow of the selected division was studied counter-wise, considering ten weekdays records during the time period 3.00 p.m. – 7.00 p.m. The counters which have arrival rate higher than service rate were recognized to be inefficient. However, all the counters were not inefficient throughout the entire time period. To begin with, the deployment of stations in all the four railway lines leading to Puttalam, Avissawella, Matara and Rambukkana was studied, and it was found to be a tree where the vertices were stations and edges were the number of tickets issued to a particular station from Fort railway station. In fact, it was a rooted tree where the vertex Fort was designated as the root.
According to the present-day practice there must be a unique ticket printed for each station. But customarily SLRD issues tickets to the border station in the same zone (set of stations in a particular railway line for which the ticket price is same).



Graph 1. Passenger arrival rate

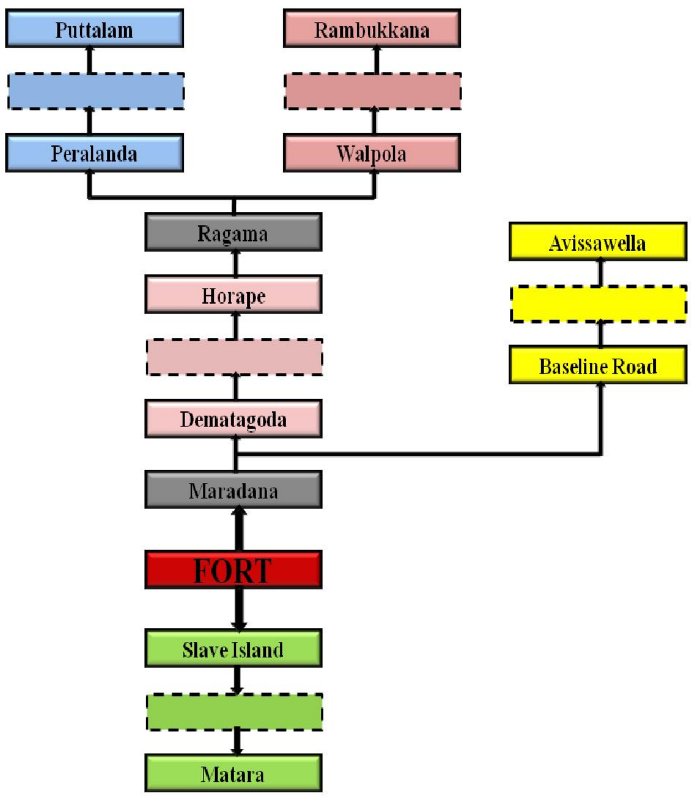


Figure 3. The rooted tree

Therefore, when taking the total ticket counts only the zones were considered. According to the study of passenger flow it was identified that certain counters were inefficient, emphasizing the need to establish a new counter. Then the aim was to make all the 6 counters issue approximately the same number of tickets during 3.00 p.m. – 7.00 p.m.

Table 1. Average no. of tickets issued by counters (3.00 – 7.00 p.m.)

Counters	Average no. of tickets
Counter 10	1594
Counter 12	2044
Counter 13	1363
Counter 14	1601
Counter 15	1549
Average	≈ 1360

As a consequence the desire was to extract segments from each railway lines and combine suitably, so that each counter issues approximately the average of 1360 tickets. The preceding objective was addressed through the concept of *cut sets* in graph theory.

Two different methods were followed when identifying the suitable cut sets. Hence two categories of outputs were obtained

A. Finding cut sets starting from the root of the tree (Fort).
B. Finding cut sets starting from two leaves of the tree (Puttalam and Rambukkana).

RESULTS AND DISCUSSION

As the first step, the Coastal line was selected, and the total *count* of tickets issued from zone "Coastal 25" (the last zone) up to zone "Coastal 01" (the first zone), was found as below. Initially the *Count* was set to zero and the process; *Count= Count+ no. of tickets issued to the next zone,* was carried out using Depth First Search (DFS) until all the zones in the railway line were accessed. Nevertheless, the total count was still lesser than the cut weight 1360. Thus, to achieve the cut weight 1360, the Kelaniweli line was combined. Therefore, zone "Main 01" (the first zone of the Main line) was combined with the Kelaniweli line.

Again, each *category* comprises of two types of analysis

Theoretical Analysis	Stations are partitioned such that the weight of each cut set is exactly 1360.
Zonal-wise Analysis	Borderline stations of the relevant zones are included considering the ticket price in one of the adjacent cut sets such that the weight of each cut set is approximately 1360.

Table 2. Six cut sets

		Theoretical Analysis			Zonal-wise Analysis		
Cut	Lines		Tickets	Error		Tickets	Error
1	Coastal25 – Coastal 6	1338	1360	0	1338	1338	-22
	Coastal 5	22			0		
2	Coastal 5 – Coastal 2	1222	1360	0	1200	1200	-160
	Coastal 1	138			0		
3	Coastal 1 + Kelaniweli line	1092	1360	0	1230	1230	-130
	Main 1	268			0		
4	Main 1 – Main 4	1360	1360	0	1709	1709	349
5	Main 4	81	1360	0	0	1435	75
	Main 5 – Main 10	1279			1435		
6	Main 10	156	1360	0	0	1204	-156
	Main 11 – Main 16	467			467		
	Puttalam line	737			737		
	Average Error			0			180.16

Same analysis was done for category (B) (starting from two leaves)

Table 3. Evaluation Table

Cut	Capacity (240 min)		Arrival rate		Service rate		ρ		Length		Waiting time	
	Theoretical	Zonal	Theoretical	Zonal	Theoretical	Zonal	Theoretical	Zonal	Theoretical	Zonal	Theoretical	Zonal
1	1360	1338	5.67	5.58	7.7	7.7	0.74	0.72	2.06	1.90	0.36	0.34
2	1360	1200	5.67	5.00	7.7	7.7	0.74	0.65	2.06	1.20	0.36	0.24
3	1360	1230	5.67	5.13	7.7	7.7	0.74	0.67	2.06	1.32	0.36	0.26
4	1360	1709	5.67	7.12	7.7	7.7	0.74	0.92	2.06	11.37	0.36	1.60
5	1360	1435	5.67	5.98	7.7	7.7	0.74	0.78	2.06	2.70	0.36	0.45
6	1360	1204	5.67	5.02	7.7	7.7	0.74	0.65	2.06	1.22	0.36	0.24

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Table 4. Recommended output

		Zonal-wise Analysis	
Cut	Lines		Error
1	Coastal 25 – Coastal 6	1338	-22
2	Coastal 5 – Coastal2	1200	-160
3	Coastal 1 + Kelaniweli line	1230	-130
4	Main 1 – Main4	1709	349
5	Main 5 – Main 10	1435	75
6	Main 11 – Main 16 + Puttalam line	1204	-156
	Average Error		180.16

A similar procedure was followed till the required cut weight was obtained, in the other segment using Breath First Search (BFS) and DFS.

Evaluating the Efficiency of New System through Queuing Theory

When a particular counter is considered, it can be identified as a single server queuing model with infinite queue length and infinite population. In queuing theory arrivals are assumed to follow a Poisson distribution (λ) whereas service is assumed to be exponentially distributed (μ). For infinite queue length the ratio $\frac{\lambda}{\mu} < 1$, otherwise the system is said to be inefficient and queue length will increase. For a single server system, length of the queue (L_q) and waiting time (W_q) in the queue can be calculated as follows,

$$\rho = \frac{\lambda}{\mu}, L_q = \frac{\rho^2}{1-\rho}, W_q = \frac{\rho^2}{\lambda(1-\rho)}.$$

According to the existing arrangement, the following arrival and service rates were calculated. Then $\rho = \frac{\lambda}{\mu}$ ratio was calculated for each counter, and found to be greater than one, which implied that the each queue was growing without ending. In relation to the introduced modifications, arrival rates were again calculated theoretically for each of the four outputs obtained. In theoretical analysis, ρ= 0.8<1, which indicates that all the counters are performing efficiently. Yet again, all the cut sets performed efficiently in both categories. The given table illustrates the evaluation of category (A).

Conclusion

When considering the entire time period a new counter arrangement was introduced. Basically the research findings were not to disturb the zonal system while proposing a new arrangement of ticket counters.

In order to address the practical issue stated above, it was required to select one of the zonal wise outputs, even though the average error is high compared to theoretical analysis. Subsequently the following segmentation under the category (A) (Zonalwise – starting from the Root) which has the minimum error of 180.16, among two zonal wise outputs, is recommended to be adopted.

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