Dynamic B.E.S.T. Optimization

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Abstract

In a densely populated city like Mumbai where urban transportation systems are always hanging by a thread, the mass transportation system can only be relied on, if the service is reliable, timely and caters to all class of people. The core objective is to design a dynamic system model of BEST network which will provide the users with a robust & highly inter-connectable, independent & reliable mass transportation system which ensures minimum waiting time for passengers, profitability for the service provider & reduced network congestion in the city which helps us work towards a smart & planned city even with all the current constraints.

Problems with current system

The current system implemented encompasses the complete coverage of the city, it has still witnessed a shortfall of passengers on a Year-on-Year basis. The reasons for the problem can be attributed to:

(a) Erratic Bus Timings:

Passengers have no Estimated Time of Arrival of busses, thereby giving the passengers impression of unreliability.

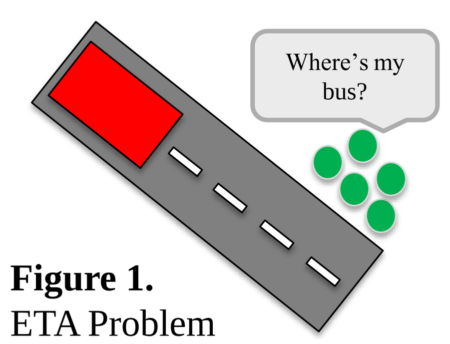

Figure 1. ETA Problem

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(b) Mismanagement of Bus Routes & Frequency:

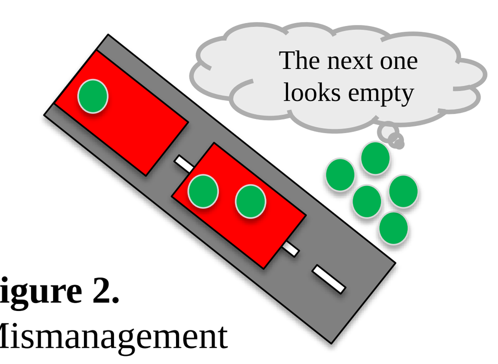

Figure 2. Mismanagement

Multiple buses are deployed on the same route, some of them get full and the rest are empty, this makes busses not available on required routes.

(c) Interconnectivity:

Two stops that are not connected by any route must have an intermediate stop to transfer. However, due to the unreliability, passengers avoid buss hopping.

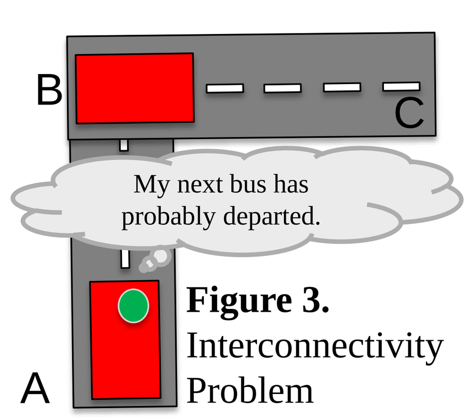

Figure 3. Interconnectivity Problem

A Dynamic Schedule can be implemented to improve how the buses are deployed. This solution does not require major infrastructural changes or heavy investments. A simple and calculated deployment method can yield significant improvements in quality of Public Transportation as well as significant increase in Revenue.

Approach

Model Network:

Time Slots	2	T0, T1
Routes	4	R1,R2,R3,R4
Nodes	4	N1,N2,N3,N4

Table 1. Model Network

Here, for the analysis of the scheduling algorithm, we created a model network, which is divided to two time instants of 5 minute durations. The model has 4 Bus stops (Nodes), out of which two are Depots (N1 & N2). The model Network has 4 Routes that connect the nodes in a particular order.

Route Matrix:

A matrix that gives us information about the routes connecting the nodes in a particular order. The Rows Represent the Routes and the column represents nodes. The number in the corresponding cell represents that the route has the corresponding node in that order.

Route Matrix				
	D	D		
Nodes / Route	N1	N2	N3	N4
R1	3	1	2	0
R2	3	1	0	2
R3	1	3	2	0
R4	1	3	0	2

Table 2. Route Matrix.

Demand Matrix: For each time instant we represent the node to node demand in a matrix form, here the columns of the matrix represent sources and the rows represent destinations.

Demand for T0	Source					Total Demand in the entire network between this time slot
Destination	*Node*	N1	N2	N3	N4	
	N1	0	1	4	3	
	N2	2	0	1	1	
	N3	4	3	0	0	
	N4	2	2	0	0	23

Demand for T1	Source					Total Demand in the entire network between this time slot
Destination	*Node*	N1	N2	N3	N4	
	N1	0	2	2	1	
	N2	3	0	5	0	
	N3	2	1	0	0	
	N4	0	1	0	0	17

Table 3 & 4. Node to Node Demand in the Network for corresponding time intervals.

Travel Time Matrix: Similar to Demand Matrix, it shows the time it takes to travel Node to Node.

Travel Time for T0	Source				
Destination	*Node*	N1	N2	N3	N4
	N1	0	2	3	5
	N2	4	0	6	1
	N3	2	3	0	0
	N4	1	2	0	0

Travel Time for T0	Source				
Destination	*Node*	N1	N2	N3	N4
	N1	0	1	2	4
	N2	3	0	5	1
	N3	1	2	0	0
	N4	1	1	0	0

Table 5 & 6. Node to Node Travel Time for corresponding time intervals.

Genetic Algorithm: A class of algorithms that are used for optimization problems. The design of which is based on theory of evolution.

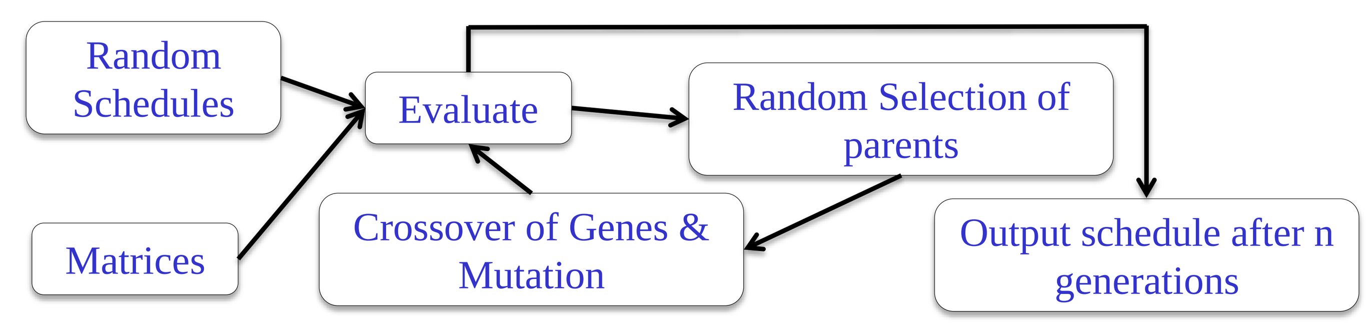

Figure 4. Block diagram of implemented genetic algorithm

Schedule Representation as a Binary Genome:

Every schedule is represented as a binary value. The MSB to LSB Arrangement is done depot wise. And each route under a depot is considered. Binary value 1 represents that the bus is set to schedule at that instant. Binary value 0 represents that the bus is not to schedule at that instant. Here, R1 is set to schedule, R2 is not set to schedule, R3 & R4 are set to schedule. For the model network there are 16 possible schedules.

	D1		D2		
MSB	1	0	1	1	LSB
	R1	R2	R3	R4	

Figure 5. Representation of a schedule.

Objective Function: It is an indicator of how well the schedule is considering different parameters. Higher function values indicate that the schedule performs better than the other schedules.

$$f = 1 * \frac{Revenue}{Cost\ to\ BEST} + 1 * \frac{Served\ Demand}{Expected\ Demand + Approximation}$$

Evaluation of a schedule:

In the graphical representation of the evaluation, we have time on x axis with 1 minute divisions, on the y axis we have the schedule. As we move across the time axis we clear corresponding demand and calculate revenue and cost.

Sr. No	Combination	Routes	Tag	T1 - T2 (minutes) 0	1	2	3	4	T2 - T3 (minutes) 5	6	7	8	9	Revenue	Cost to BEST	
10	1	R1	Bus	1										Total Revenvue generated by running this bus	No of Minutes Run	6
			Stop Code	N2			N3			N1						
			PAX Count	4			5			0					Cost of running this bus to BEST	53
			PAX Up	4			4			0						
			PAX Down	0			3			5						
			Revenue	40	40	40	80	80	80	80	80	80	80	80		
	0	R2	Bus	2										Total Revenvue generated by running this bus	No of Minutes Run	
			Stop Code	N2	0	N4	0	0	0	0	N1	0	0			
			PAX Count												Cost of running this bus to BEST	5
			PAX Up													
			PAX Down													
			Revenue	0	0	0	0	0	0	0	0	0	0	0		
	1	R3	Bus	3										Total Revenvue generated by running this bus	No of Minutes Run	8
			Stop Code	N1	0	N3	0	0	0	0	0	N2	0			
			PAX Count	6		3							0		Cost of running this bus to BEST	69
			PAX Up	6		1							0			
			PAX Down	0		4							3			
			Revenue	60	60	70	70	70	70	70	70	70	70	70		
	0	R4	Bus	4										Total Revenvue generated by running this bus	No of Minutes Run	
			Stop Code	N1	N4	N2	0	0	0	0	0	0	0			
			PAX Count												Cost of running this bus to BEST	5
			PAX Up													
			PAX Down													
			Revenue	0	0	0	0	0	0	0	0	0	0	0		
							Total Revenue of Combination							150	Total Cost to BEST	132

Figure 6. Evaluation of the fitness of a schedule.

Evaluation Table:

Sr. No.	Combinatio				Revenu	Cos	Unsatisfie	Total Demand	Fitness
1	0	0	0	1	50	36	35	40	1.5139
2	0	0	1	0	70	84	33	40	1.0083
3	0	0	1	1	100	100	30	40	1.25
4	0	1	0	0	60	76	34	40	0.9395
5	0	1	0	1	110	92	29	40	1.4707
6	0	1	1	0	130	140	27	40	1.2536
7	0	1	1	1	160	156	24	40	1.4256
8	1	0	0	0	80	68	32	40	1.3765
9	1	0	0	1	130	84	27	40	1.8726
10	1	0	1	0	150	132	25	40	1.5114
11	1	0	1	1	180	148	23	40	1.6412
12	1	1	0	0	130	124	27	40	1.3734
13	1	1	0	1	180	140	23	40	1.7107
14	1	1	1	0	200	188	20	40	1.5638
15	1	1	1	1	230	##	17	40	1.7025

Table 7. Objective /Fitness function values of every possible schedule

Accuracy Test:

```
*****************
Combination: 1817
[11, 12, 13, 15]
Solution: [9, 9, 9, 9]
*****************

*****************
Combination: 1818
[11, 12, 14, 15]
Solution: [9, 9, 9, 9]
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Combination: 1819
[11, 13, 14, 15]
Solution: [9, 9, 9, 9]
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*****************
Combination: 1820
[12, 13, 14, 15]
Solution: [9, 9, 9, 9]
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Number of times best combination: [0, 0, 0, 0, 0, 0, 0, 0, 0, 1729, 0, 8, 0, 29, 0, 53]
Percentage accuracy of best genome: 95.0
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Figure 7. Results of test cases indicating accuracy 95%

Results

For the model network schedule 9 is the best schedule. If we select 4 from the 16 at random as the initial population, there can be 1820 possibilities. Testing the algorithm with all possible combinations, the algorithm produces the optimum solution with accuracy of 95%.

Conclusions

The implemented algorithm can find the best schedule which is economically and socially responsible. The algorithm is able to find the best schedule with the accuracy of 95%

References

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For further information

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