MODELING OF TRANSIT VEHICLE SERVICES AND STOP SPACING OF DHAKA METROPOLITAN AREA (DMA), BANGLADESH.

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Introduction

Bus/minibuses are only the mass transit available modes in Dhaka Metropolitan Area (DMA). However, its services are extremely inadequate, irregular, inefficient, unreliable in terms of schedule and punctuality, long queues and waiting time, access/egress, and overloading. Stops and spacing are not arranged as per transport service and travel demand. Most of the stops are undesignated, uninformative, and unpleasant waiting and difficult to identify by unknown passengers. The purpose of this study is to develop theoretical models for varieties of transit services by correlating different variables like user travel time, in vehicle riding time, access/egress time, waiting time and stop sapcings, that significantly related to its performance. The services are incorporated in this study are local service (stop all stops), call-on service (stop where passengers demand for boarding/alighting), demand service (stop anywhere along the route where passengers request for boarding/alighting) and express service. However, we will explain here about local service.

Stop and Spacing

The number of stops (or spacing) makes a tradeoff between user access and egress time to and from the bus stops and operating speed of the vehicles. The number of stops in a fixed route transit system is inversely related with the vehicle operating speed and users access and egress time. Whenever, vehicles faces traffic congestion, signals, pedestrian crossing, the stopping distance between stops changes, consequently speed as well as users travel time changes. In this study we would like to estimate the effects of such obstacles on user travel times and hereby, considered the following three cases as:

Case 1: When the stop spacing between two adjacent stops is very short so that the vehicle must begin to decelerate before reach to its maximum speed V.

Case 2: When the spacing distance between two adjacent stops is so that the vehicle can attain its maximum speed V for a moment and immediately begin to decelerate to stop.

Case 3: When the spacing distance between two adjacent stops is long enough to attain its maximum speed V and begin decelerate after moving some distance at constant speed V.

Travel Time between Two Consecutive stops

It is clear that in case 1 and case 2 vehicle only have two states of motion, acceleration and deceleration. Therefore, travel time between two adjacent stops is the sum of the acceleration time, deceleration time and stopping time, t_s for boarding and alighting passengers

$T_i = \sqrt{2S_d(a+b)/ab} + t_s$ ----(1), where, a and b are linear rate of acceleration and deceleration, and S_d is the spacing distance between two stops for case 1. Whenever, the vehicle faces traffic congestion or any obstacle, it has to slow-down and causes to decelerate. The frequencies of such slow-down will depend on the level and frequencies of congestion or obstacles that the vehicle will face within S_d. Assuming that the vehicle will slow-down to zero m times at equidistant apart within two adjacent stops. Then, the travel time between two consecutive stops for case 1, case 2 and case 3 are respectively as

$$T_i^m = \sqrt{2(m+1)S_d(a+b)/ab} + t_s \text{ ------(2)}$$

$$T_c^m = \sqrt{2(m+1)S_c(a+b)/ab} + t_s \text{ -------(3)}$$

$$T^m = \sqrt{2(m+1)S_c(a+b)/ab} + t_s + (S - S_c)/V \text{ -----(4)}$$

Where, S_d, S_c & S are spacing distances between two stops and T_i^m, T_c^m & T^m are interstation travel time for case 1, case 2 and case 3 respectively. And V is the average cruising speed of the vehicle.

Stopping Time at Bus Stops

Totals stopping time nt_s for boarding and alighting of passengers is a function of number of passenger board and alight along the route. Assuming average boarding or alighting time per person μ is to be equal. Therefore, total stopping time at stops $nt_s = 2p\mu\theta/N$. Where, p is the mean number of trips generated per unit time along the route, θ is the cycle time, and N is the fleet size.

Vehicle Travel Time, T_v

Assuming s is the total number of equidistant stops including terminals in route length L, and n is the number of stopping. Again, since start terminal are using only for boarding and end terminal only for alighting. Therefore, the maximum number of stopping for local service, $n = (s-1)$ at $L/(s-1)$ interval. The vehicle travel time over the route for local service T_v^l, including patrons boarding and alighting for case 1, and case 2 and case 3 are respectively as:

$$T_{v1}^l = n_1\sqrt{2(m+1)S_d(a+b)/ab} + n_1 t_s \text{ -------(5)}$$

$$T_{v2}^l = n_2\sqrt{2(m+1)S_c(a+b)/ab} + n_2 t_s \text{ -------(6)}$$

$$T_{v3}^l = n_3\left\{\sqrt{2(m+1)S_c(a+b)/ab} + t_s + (S - S_c)/V\right\} \text{-(7)}$$

Where, n_1, n_2 and n_3 are the no. of stopping for case 1, case 2 and case 3 respectively.

Users Riding Time, T_r

User's riding time, T_r is the time to travel users average distance, l, at operating speed $V_0 = L/T_v$, i.e., $T_r = l/V_0 = lT_v/L$. Therefore, from equation (5), (6) & (7) we can write user's riding time for three cases as:

$$T_{r1} = l/L\left\{n_1\sqrt{2(m+1)S_d(a+b)/ab} + n_1 t_s\right\}\text{--(8)}$$
$$T_{r2} = l/L\left\{n_2\sqrt{2(m+1)S_c(a+b)/ab} + n_2 t_s\right\}\text{--(9)}$$
$$T_{r3} = n_3\, l/L\left\{\sqrt{2(m+1)S_c(a+b)/ab} + t_s + (S - S_c)/V\right\}\text{--(10)}$$

Users Travel Time T_u:

User travel time T_u consists of users riding time, access/ egress time and waiting time. In DMA, walking and rickshaw is the main access/egress modes and rickshaw moves 3 times faster. In considering the parallel access travel component to the transit line and the average access and egress times to and from the closest bus stops, $T_e = L/2(s-1)(3-2x)/3V_a$ ------(11) where, x is the portion of passengers 'access/egress by walking, and V_a is the users average walking speed.

The average waiting time, T_w is one-half the headway when the passengers arrivals at random and the buses arrives at perfectly regular. However, in DMA bus and passengers both arrives at random at bus stops and passengers have no information regarding buses arrivals. Under such condition and when the probability of occurrence of two consecutive full vehicles in the stream is small at most points of the routes, Ezra Hauer[1] express the expected waiting time at some point of bus route is: $T_w \cong h/2(1+2q)$------(12). Where, h is the mean headway between vehicles, $(h = \theta/N)$, and q is the probability of the vehicles to be full to capacity.

Therefore, the users travel time for case 1, case 2 and case 3 are respectively as under:

$$T_{u1}^{l} = \frac{l}{L}\left[n_1\sqrt{2(m+1)S_d(a+b)/ab} + n_1 t_s\right] + L/2n_1(3-2x)/3V_a + h/2(1+2q)\text{--------(13)}$$

$$T_{u2}^{l} = \frac{l}{L}\left[n_2\sqrt{2(m+1)S_c(a+b)/ab} + n_2 t_s\right] + L/2n_2(3-2x)/3V_a + h/2(1+2q)\text{--------(14)}$$

$$T_{u3}^{l} = \frac{l}{L}\left[n_3\sqrt{2(m+1)S_c(a+b)/ab} + n_3 t_s + n_3(S - S_c)/V\right] + L/2n_3(3-2x)/3V_a + h/2(1+2q)\text{-----(15)}$$

Graphical Representation of parameters (Case 3)

To illustrate the relationship between users travel time, number of stops, passengers volume and traffic congestion fig.1, fig.2 and fig.3 has been developed by assuming a set of values (L=20Km, l=14km, V= 40 km/hr, a=1.0 m/sec^2, b=1.2 m/sec^2, x=0.7, V_a=4.5 km/sec, h=10 min, 3sec/per, q=0.1). It is seen that the number of stops, which minimizes the average users travel time, varies with passengers volume and traffic congestion between bus stops. Fig 1 and fig 2 shows that influence of traffic congestion on users travel times significantly increase with the increasing of number of stops. It is also observed that the minimum number of stops for minimizing users travel time from a given set values are lies within the range of 20 to 22 stops per 20 km.

Fig.1: Relationship between no. of stops and users travel time (case 3)

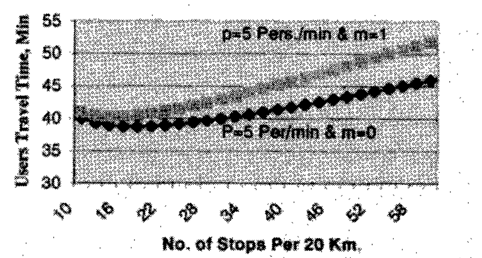


Fig.2 Relationship between no. of stops and users travel time (Case 3)

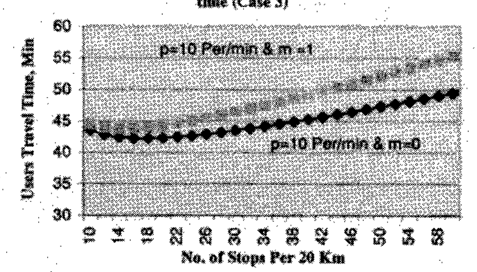
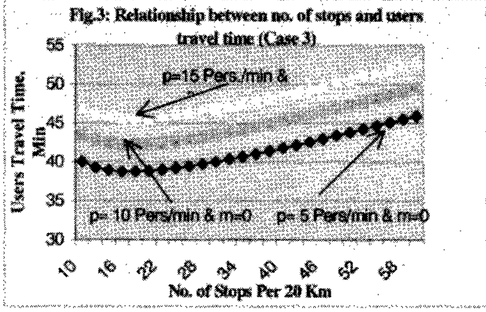


Fig.3: Relationship between no. of stops and users travel time (Case 3)



Conclusions: The passengers' volume and traffic congestion have significant effect on number of stops of the transit service. With the increasing of passenger volume the user travel time increasing very sharply. Since the traffic congestion and passengers volume sharply increase during peak periods. We could find out the best-suited possible combinations of services for Dhaka's mass transit system in considering peak and off peak demand and traffic congestion.

References

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