Investigate the effects of bus and passenger arrival patterns and service frequency on passenger waiting time and transit performance of Dhaka metropolitan area.

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Abstract

A detailed analysis in bus transit system of Dhaka Metropolitan Area (DMA) is conducted based upon field surveys. We evaluated travel and stopping patterns of bus and passengers in order to reach a better understanding of the situation. We observed bus and passengers arrival process and stopping and departure patterns at stops and terminals, passengers waiting time, drivers irregular stopping behaviors at stops and en route in peak and off-peak periods significantly changes according to the time of day and direction of operation. In peak and off-peak period, driver’s irregular stopping behaviors on en route and at stops are remarkably influenced on vehicle travel times and passenger waiting times and stopping times. Vehicle travel times and waiting times in off-peak is found higher in comparison with peak periods are resulted from absence of time scheduling and drivers stopping behaviors. At the end, we discussed the introduction of varieties of scheduled transit services in peak and off-peak periods with fixed stopping criteria that could be reduced passengers’ waiting and vehicle travel times and increase transit productivity and fleet utilization.

1 Introduction

The unfortunate reality bus transit service of DMA is that there is no readily recognizable bus operating companies of any size and having their own corporate identities, amongst which are amalgamate. Individual owner of having average 2 bus fleet per owner provides the transit services are interested to their own benefits and engaged in wasteful and aggressive competition rather thinking for
passengers' interest and service quality. There is no fixed timetable and schedule of bus services in all transit routes. Services are extremely irregular, unreliable, uncomfortable, and overcrowded due to lack of professional management, schedule reliability, bus time table, long waiting time, inconvenient access and egress facilities, drivers' irregular stopping behaviors in peak and off-peak periods. Therefore, only poor passengers who can not afford any other modes and do not have any alternatives are using bus services. And usually passengers swing from bus to any other convenient modes with raising income.

A significant deterrent to the use of public transportation is the excessive travel time, including both out-of-vehicle and in-vehicle times. The out-of-vehicle travel times includes access to bus stop, waiting for the bus, transferring and egress to destinations. The in-vehicle travel time is the riding time in bus that includes vehicle running time, stopping time and dwell time at stops and congestion delay. The waiting time depends on the bus headway and time schedule and bus and passenger arrival patterns, vehicle loading condition and traffic congestion. And the waiting time experienced by transit users is one of the most important elements of the level of service provided by a transit system. Therefore, it is important to understand the effects of waiting time to the changes in basic service characteristics, such as headway and schedule reliability. The commonly used model which asserts that average waiting time is one-half the headway when the passengers arrivals at random and the buses arrives at perfectly regular. However, this situation does not meet in DMA’s bus transit system. Here, bus and passengers both are coming at random at the bus stops and the passengers have no information regarding buses arrivals. Buses playing on queue basis instead of a specific regulated scheduled or controlled headway. The route owner associations are regulate the terminal departure intervals randomly without considering the peak and off peak demands based on “first return first start”, i.e., the buses return early to the terminal gets early start serial for the next trip. This “first return first start” policy is one of the main source of irregularities as the drivers and conductors have freedom of deciding where and how long to stop and when and which stops to skip. They are deciding it based on maximum possible revenue i.e., stop where the possibilities of boarding of number of passenger are more otherwise skipped. So, in practice, buses sometimes depart from the terminal earlier and sometimes delayed from the scheduled departure time based on passenger demand in peak and off-peak periods and boarding condition.

In peak-period passenger demand is very large and driver stopped vehicle mostly at major stops and skipped small stops even passenger were waiting for boarding. But in off-peak buses stop almost at all stops even there no passenger for boarding/alighting and wait for passenger arrival. So, drivers stop longer at some stops for boarding/alighting and wait afterward for passenger arrival if the number of on-board passenger is not enough to earn satisfactory revenue, and skipped or made short stop in less demanded stops. This situation increases vehicle travel time and passenger-waiting time at skipped as well as longer stopped stops and also adversely affected to safety and traffic congestion around bus stops and stimulates unhealthy competition within bus drivers.

There have been a number of studies on DMA’s mass transit, among them Firdus (1984), Ahsan (1993), DITS (1993), and Zahir (1997) are mentionable. Most of the studies pointed out the overall problems on DMA’s mass transit and
passengers transport system. None of these studies dealt with analyzes of transit speeds, bus and passenger arrival process, their stopping and waiting times, stopping delays and drivers irregular behaviors at stops and on en route in peak and off-peak periods, which has strong influenced on transit performance characteristics. The purpose of this study is to investigate the effects of bus and passenger arrival patterns at stops, bus departure time at terminals and stops, stopping times, traffic congestion, passenger generation rates and drivers behaviors on en route in peak and off-peak periods on passenger waiting time and transit performance.

2 Data collection

We conducted four different types of field surveys in July 1999 at four important bus transit routes of DMA from 8:00am to 6:00pm having one hour break from 2:00pm to 3:00pm for three weekdays and one weekend. Firstly, we made bus stops survey along the transit routes and collected data on terminals departure time intervals; bus and passenger arrivals patterns; their boarding and departure times; the number of boarding and alighting passenger, and loading condition of buses at all bus stops. From this survey data, we could determine the transit stopping times and delays, passenger generation rates and waiting times at all stops along the route in peak and off-peak periods. Secondly, in bus speed survey, we used “YAZAKI IN-VEHICLE SPEED DETECTOR”, which read the practical speeds, acceleration and deceleration rates directly through the speed and clock pulse signals along the distance traveled of the vehicle at 0.5 sec intervals. Therefore, from this survey we determined the actual transit speeds, acceleration and deceleration rates, vehicle travel times, stopping times at stops and in traffic congestion, and stopping and congestion delays and locations along the routes. We estimated drivers’ irregular behaviors at stops and on en route in peak and off-peak periods through the analysis of stopping delays along the route. Thirdly, we made a questionnaire survey at stops and in-vehicle on our selected transit routes. And obtained data on passengers’ access/egress distances, modes and times and fares; average distance traveled by bus and bus fare; waiting time at stops; service regularity and reliability and passengers’ income level. Fourthly, in in-vehicle survey two surveyors board in each bus and moved all times with the bus. They recorded bus terminal departure times, terminal times, bus arrival and departure time at each stops, number of passenger board and alight and at stops; number of times bus faces congestion and its duration and remarked the drivers and conductor behavior closely from inside the vehicles.

3 Data analysis and study findings

We analyzed the filed data and determined the effects of bus and passengers arrival and departure patterns; drivers and conductors stopping and en route behaviors in peak and off-peak periods; irregular terminals departure intervals; stopping delays and congestion delays on passenger waiting time and vehicle travel time in the following section as under:
3.1 Passengers arrival patterns

A pattern of arrivals of passengers at a bus-stop depend upon the time schedule of buses and passengers’ knowledge of this, and upon the experience of passengers how well bus keep to their time table. In DMA, the time of arrivals of passengers and buses and departure of buses have been observed from 9:00am to 6:00pm at all the bus stops of route no. 1 of DMA in either direction to understand the bus and passenger and drivers characteristics in peak and off-peak periods. It’s found that passenger arriving at random as because there is no specific timetable and information on bus arrivals. The passengers arrival rates are significantly varied between different times of day, specially, peak and off-peak periods in either direction of flow. The passenger arrival data were collected under one minute time interval but under consideration of analysis it is considered to five minutes intervals. We analyzed the passenger arrivals patterns at all stops along the route no. 1 in either direction from 9:00am to 6:00pm having survey break 14:00pm to 15:00pm, however, we shown the results graphically for Farmgate (high demand stop) and Kazipara (low demand stop) in under section as examples.

3.1.1 Passenger arrivals patterns at Farmgate stop

Figure 1 and figure 2 showed the passenger arrivals patterns from 9:00am to 6:00pm having survey break 14:00pm to 15:00pm on July 19 and July 20, 1999 at highly passenger generated stop, Farmgate for Mirpur (Pollobi) to Gulistan and Gulistan to Mirpur (Pollobi) bus route no.1 respectively. We found from figures that the passenger generation rates is opposite in either direction of flow with the time of day. Passengers’ demand is found very large in the morning till noon and gradually reduces in the afternoon for Mirpur (Pollobi) to Gulistan direction.

Figure 1: Passenger arrivals at Farmgate stop for Mirpur (Pollobi) to Gulistan bus route no.1, July 19 and July 20, 1999.
The reverse passenger generation rate was observed in the morning small and in the afternoon large for Gulistan to Mirpur (Pollobi) direction of flow. It's because of the Gulistan terminal is located at around central business district (CBD) of DMA, so, passengers moved towards CBD in the morning and returned in the afternoon after completion of activities. Therefore, we observed the morning in-bound peak towards CBD from 9:00 am to 12:00 noon for Mirpur (Pollobi) to Gulistan route no. 1 and afternoon out-bound peak from 1:00 pm to 4:00 pm are reflected on figure 1 and figure 2 respectively. Conversely, we observed the morning out-bound off-peak from 9:00 am to 13:00 pm for Gulistan to Mirpur (Pollobi) route and afternoon in-bound off-peak from 1:00 pm to 4:00 pm. We also observed that the passenger arrival rates between different weekdays in not significantly different.

Figure 2: Passenger arrivals at Farmgate for Gulistan to Mirpur (Pollobi) bus route no. 1, July 19 and July 20, 1999.

3.1.2 Passenger arrivals patterns at Kazipara stop
Figure 3 and figure 4 showed the passenger arrivals patterns from 9:00 am to 6:00 pm on July 19 and July 20, 1999, having an one hour break from 14:00 pm to 15:00 pm at low passengers generated stop, Kazipara for Mirpur (Pollobi) to Gulistan and Gulistan to Mirpur (Pollobi) bus route respectively. We observed the same situation of out-bound off-peak and in-bound peak in the morning and out-bound peak and in-bound off-peaks in the afternoon as like the Farmgate stop. But the passenger generation rates at Kazipara stop are found very small in comparison with the passenger generation rates at Farmgate stop throughout the day. Interestingly, we found that the passenger board from at low demand stops are facing longer waiting time in either peak or off-peak periods as because of number of stopping made at low demand stops is very few in comparison with high demand stops. In peak periods buses skipped almost all low demanded stops as because of there are no empty space available for board additional passenger.
Again, in off-peak buses stop almost at all stops even there no passenger for boarding/alighting and waits for passenger arrival, especially, at large demanded stop where probability of passenger arrivals is high. So naturally, bus arrives in late at the next low demand stops and passengers experience longer waiting time. Therefore, passengers boarded from low demand stops are mostly experiencing longer waiting time than expected waiting time in both peak and off-peak period.

Figure 3: Passenger arrivals at Kazipara bus stop for Mirpur (Pollobi) to Gulistan to bus route no.1, July 19 and July 20, 1999.

Figure 4: Passenger arrivals at Kazipara bus stop for Gulistan to Mirpur (Pollobi) to bus route no.1, July 19 and July 20, 1999.

3.2 Bus arrival and departure times

In order to determine the passengers waiting time bus departure time is concerned rather than bus arrivals time. However, we recorded bus departure as well as arrivals times to determine the waiting time as well as actual stopping time at bus
stops, which is very important factors to be considered in DMA’s transit system. Usually, buses stop at stops for boarding/alighting passenger and leave for the next stop. This situation is quite different in DMA’s bus transit system. There is no specific time schedule and stopping criteria, so, buses are stopping and skipping stops randomly as drivers desire based on expected probable maximum boarding. The route owner associations are maintaining the terminal departure time interval throughout the day without considering the peak and off-peak demands. Individual drivers/operators are more concern to their interest rather than thinking to improve service quality and passenger services and does not obeyed scheduled departure time. The route association does not have enough power to enforce them to strictly maintain their schedule. So, the individual bus drivers in practice, plying on transit routes based on their own benefits. Therefore, extreme irregularities have been observed in DMA’s transit services including service frequency, overloading, route and time scheduling, reliability, number of stopping and duration of stooping and waiting time. Its found transit’s headways become increasingly irregular along the line as because of randomness of operating times, drivers irregular stopping behavior at stops in peak and off-peak periods, route and time scheduling, stopping and congestion delays, the number interactions between motorized and non-motorized transport, and the extent of traffic congestion. This randomness inevitably cause a sharp deterioration of passenger service by increasing average waiting time and the fraction of riders who must stand may be greatly increased.

3.3 Terminal departure interval times

We recorded the scheduled terminal interval times and actual terminal departure interval times between vehicles. We have seen the scheduled terminal interval between buses are allocated by the owner route association randomly at 7min, 6 min, and 9 min, respectively on observed route no 1, route no 8 and route no 9 throughout out the day even peak and off-peak periods in either direction. But we found the average observed terminal departure intervals varies from 5.25 to 9.13 min; 4.95 min to 8.23 min and 6.25 to 10.35 min respectively to route no 1, route no 8 and route no 9 from the Gulistan terminal. However, the average observed terminal departure intervals of respective services are found varies from Pollobi (route no 1), Mohammadpur (route no .8) and Mirpur Zoo (route 9) terminals were 4.95min to 7.10 min; 4.56 min to 6.16 min, and 5.93 to 9.35 min. Its revealed that the average observed headways at Gulistan terminal during out-bound off peak period (from 9:00am to 12:00pm) for Gulistan to Pollobi route no. 1, Gulistan to Mohammadpur route no. 8 and Gulistan to Mirpur Zoo route no.9 is more in comparison with the scheduled headway. Because the buses does not gets enough passenger during off-peak periods so drivers delayed at start terminal Gulistan (CBD) with a hope to board more passenger. It’s also found that after departure the terminal buses moves very slowly to board additional passengers before speedup. Again, during out bound peak-period (1:00pm to 4:00pm) it revealed that the average bus departure intervals times is less in comparison with the scheduled intervals as because of the buses becomes fully over loaded before the interval periods so its depart earlier than scheduled time.
3.4 Drivers stopping behavior in peak and off-peak period

Since the passengers travel demand is very high during peak-periods buses becomes fully loaded at the beginning of the journey, so, driver drives faster in comparison to off-peak periods and stop mostly at major stops and skip small stops even there passengers are waiting for boarding and alighting. In case of alight without boarding, conductor request the passenger to accumulate near the door and quickly alight them little far from usual bus stop on moving. Drivers have intention to earn maximum possible revenue by making more trips during peak period by reducing travel time. They also sure that they will get start queue for the next trip as quick as they return to the terminal as because of “first return first start” policy. On the other hand, during off-peak periods passengers volume is small so they stop almost all the stops even there is no passenger for boarding or alighting and wait for passengers arrival. In practice, drivers do not move without reasonable boarding. Therefore, the travel time in off-peak periods is found more in comparison with peak periods, which is very exceptional and unique situation is DMA’s bus transit service. This situation increases the passengers waiting times at longer stops as well as skipped stops. Therefore, in the following section we estimate the stopping delays at all stops along the route no.1 to determine the actual drivers behavior in peak and off-peak periods and its influenced on vehicle travel time and passenger waiting times.

3.4.1 Stopping delays

This is a very important aspect to measure the stopping delays at bus stops in assessing of its effect on passenger waiting time and transit performances. The stopping delays at all bus stops along the Gulistan to Mirpur (Pollobi) route no.1 during out-bound off-peak periods 9:53:10am to 10:48:27am and 12:16:09pm to 13:21:30pm, and peak periods 15:25:00pm to 16:06:29pm is shown in figure 5. It is observed that stopping duration significantly varies at different stops for the same service; at same stop for different services; and with the periods of operation, which is influenced on vehicle travel times and passenger waiting time. It’s revealed that vehicle travel times of two off peak services of 9:53:10am to 10:48:27am and 12:16:09pm to 13:21:30pm also differ by 10min 4 sec due to drivers of latter service made longer irregular stopping at some stops around GPO and Farmgate, where the probability of passenger arrival is high. In peak period 15:25:00pm to 16:06:29pm the vehicle made one longer stops at the beginning of journey at Press Club (PC) and boarded full to the capacity in the beginning of journey so, the drivers skipped all other stops with few exception of short stop for alighting passenger. So the vehicle travel time 41min 29sec which is remarkably less 13min 48sec and 23min 52sec in comparison with the both former and later off-periods services respectively. From figure 5 it is also observed that drivers of off-peak services made longer stopping delay at some important stops GPO, PC and Farmgate for Gulistan to Mirpur direction. And conversely, for Mirpur to Gulistan direction service drivers made longer stop at MP11, MP10 and Farmgate stops. We also have seen that numbers of buses are waited for passenger arrivals during off-peak at major stops like Farmgate. This uncertain and unexpected longer stopping time at stops increases passengers’ average waiting time, vehicle...
travel time and traffic congestion around bus stops which in turn adversely affected to the quality and levels of transit service and transit performances.

Figure 5: Stopping delays at bus stops along the route for Gulistan to Mirpur (Pollobi) route no.1 during peak and off-peak periods.

4 Waiting time

The waiting time depends on the bus headway and time schedule and bus and passenger arrival patterns, vehicle loading condition and traffic congestion. And the waiting time experienced by transit users is one of the most important elements of the level of service provided by a transit system. So, it is important to understand the effects of wait time to the changes in basic service characteristics, such as headway and schedule reliability. In peak periods buses get full to the capacity at the beginning of journey, so, drivers skipped or made short stop at many stops as there are no empty places for passengers boarding. The old and women passenger including children avoid to get on those buses. That results an increase of average expected waiting time of passengers. In off-peak passengers’ volume is very small so buses can not board reasonable number of passengers to earn satisfactory revenue easily. Therefore, after boarding waited passenger buses wait for an uncertain period with a hope of passengers arrival. This situation usually observed at the major bus stops where the probability of passenger arrival is more, which in turn increases passengers waiting time and user travel times. A shorter waiting time will make more likely to ride buses or become regular riders. One way to minimize waiting time is to have regular bus schedule time adherence. Once regular passengers are confident that the bus will arrive on time, they can plan their arrival at the stop so as to be there just before the bus arrives.
5 Conclusions

Analyses of field data showed that the headways of DMA’s bus transit become increasingly irregular along the route as because of extremely irregular stopping and en route drivers behaviors in peak and off-peak periods, randomness of operating times and absence of route and time scheduling. We observed that the vehicle travel time, passenger waiting times, vehicle stopping times, drivers’ en route behaviors, passenger generation rates, bus terminals departure intervals significantly influenced by the time and direction of transit operation. In peak and off-peak periods drivers en route and at stops behaviors are found remarkably different. Drivers stopped at few major stops in peak periods with a exception of short stop for alighting passengers, but in off-peak drivers stopped almost at all stop and waited longer after boarding the waiting passengers for passenger arrivals. So, the vehicle travel time and passenger waiting times in off-peak periods is found more in comparison with the travel times and waiting times in peak periods. Moreover, passenger boarding from at low demand stops were experienced more waiting times in both the peak and off peak periods in comparison with the high demand stop. We also found that terminal departure interval is randomly regulated by the route owner association regardless of peak and off-peak demands throughout the day in either direction of routes. Therefore, we found that the average observed departure headway is more in off peak and less in peak periods in comparison with scheduled departure headway respectively because of high and less demand in peak and off peak periods. These situations explained that drivers’ irregular stopping delays in off peak periods and skipping stops tendency in peak periods increases passenger waiting time and vehicle travel time to a great extent. The average waiting time and vehicle travel times can be reduced if there exist a published fixed time table and stopping time at stop, or the bus tend to run at certain fixed time so that frequently same trip maker’s arrivals at stops in association with bus arrivals. Further, introduction of varieties of scheduled transit services (local: stop at all stops; call-on: stop where passenger boarding/alighting demand exist; request-stop: stop anywhere along the route for a single boarding or alighting; accelerated: skipped different sets of predetermined stops and express: limited stop) with fixed stopping criteria as per peak and off peak demand could be reduced the passenger waiting time and vehicles travel times and increase the transit productivity, fleet size utilization and service quality, which in turn increase patronage.

References
