STUDY ON PUNCTUALITY INDEX FOR BUS OPERATION IN YANGON

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ABSTRACT: Public transportation service plays an important role in every nation. Even though public bus service is a main public transport in Yangon, the service performance of bus is low. Bus user and bus operators are facing with the main problems of long waiting times at the bus stops and low occupancy of buses. The punctuality of bus operation seriously effect on the passenger waiting time. The reliability of service is one important measure in determining the quality of bus service in Yangon. The objective of this paper is to evaluate the reliability performance of bus operation using punctuality index assessment. In this paper, bus operation data were collected by using Global Positioning System (GPS). Buses are equipped with smart phones and send location and time data of bus operation via wireless communication network and on board surveys are also used for data collection. An Integrated GPS and Geographic Information System (GIS) are used by measuring time and speed of the bus. Bus operation data sampled from Yangon bus system was analyzed to calculate punctuality indexes along one of its heavily utilized bus corridors, the blue-2 bus corridor of Adipadi. The punctuality index for selected route is about 61% for weekdays (LOS F), 73% for Saturday (LOS F) and 81% for Sunday (LOS D). The conclusion was that the service quality stage of buses can be evaluated based on punctuality index. The findings can be contributed to review the way the bus service is operated and the operators or authority can do something to improve the quality of bus service in Yangon.

1. INTRODUCTION

Yangon is not only former capital city but also commercial city in Myanmar with about 7.3 millions in the area of 10276.7km[2] (Wikipedia, 2014). Private car, taxi, rail and Bus are the four main types of transportation in Yangon. The modal share of public bus transportation is 49.4% (Takashi Shoyama, 2014). Bus transportation is major urban transportation in Yangon as driving personal cars is highly expensive for the most people, the low quality of rail service and regulation of motorcycles. Although the public bus transportation is important for people in Yangon, the nature for unreliability of public transport makes the service unattractive to bus users. The existing buses running in mixed traffic have many characteristics of operation. Different operating conditions and traffic circumstances affect the bus service. Moreover, traffic congestion in Yangon is worse and worse day by day. Traffic congestion also impacts the punctuality of bus service. The waiting times at bus stops are the main problem of the current bus system. In addition, public transport has an essential role in supporting to reduce private car usage.

Thus, it is important to evaluate the punctuality index of the buses. Measuring the punctuality of bus services is noticeable because reliable service is prized by both the bus passengers and providers. This paper analyzes the reliability of bus service performance using the punctuality index and to assess characteristics of bus route.

2. LITERATURE REVIEW

The number of researchers studied the various topics of quality of service. Reliability is one of key element in perceiving the quality of bus service and punctuality is one of the performance measures determining the service reliability (NoorfakhriahYaakub and MadzlanNapiah, 2011). Bus reliability performance was analyzed by various models, for instance on head way adherence (Jie Lin et al, 2007) and passenger load of public bus (M.Napiah et al, 2011). Moreover, it can be calculated by using the data of bus operation such as scheduled and actual departure time (Seaung-Young Kho et al, 2005). According to R.liu and S.Sinha, increasing congestion and passenger demand highly affect headway variation and number of boarding passengers (R.liu and S.Sinha, 2008). Factor affecting reliability can simplify into followings:

1. Traffic Characteristics, such as traffic composition in travel demand and traffic congestion levels.
2. Route Characteristics, such as the length of the route, number of lanes, location of the bus stops, and provision of bus lanes.
3. Passenger Characteristics, which include variability passenger volumes at stops, passenger route choice, and their arrival distribution.

4. Bus Operational Characteristics, such as Random scheduling system, number of staffs, fleet availability and maintenance, and ticketing system.

In addition, the punctuality index is defined an umbrella concept that contains on-time performance and headway adherence and suggested as three kinds of punctuality indexes for a scheduled headway (Kho et al, 2005). These are the magnitude of adherence (punctuality index PI), magnitude of regularity (punctuality index P2) and evenness (punctuality index P3). Table 1 shows the formulation of punctuality indexes.

Table 1. Punctuality Index

	P1	P2	P3
Punctuality Index	$P_1 = \dfrac{S_1^2}{h_t^2}$	$P_2 = \dfrac{S_2^2}{h_t^2}$	$P_3 = \dfrac{S_3^2}{\hbar^2}$
Variables	$S_1^2 = \dfrac{1}{I}\sum_{i=1}^{I}(t_i - \tau_i)^2$	$S_2^2 = \dfrac{1}{I-1}\sum_{i=2}^{I}(h_i - h_t)^2$	$S_3^2 = \dfrac{1}{I-1}\sum_{i=2}^{I}(h_i - \hbar)^2$
	h_t:Scheduled headways I : Number of operations t_i:Actual arrival time of i-th bus operation τ_i:Scheduled arrival time of i-th bus operation h_i:$t_i - t_{i-1}$ $(i = 2, ... I)$: Actual headway of i-th bus operation $\hbar = \frac{1}{I-1}\sum_{i=2}^{I}(t_i - t_{i-1})$:Average actual headway of successive bus operation		

Source: Kho et al, 2005

The punctuality index, P1 indicate the magnitude of a time gap between actual arrival time and scheduled arrival time, P2 is the magnitude of time gap between actual headway and scheduled headway, and P3 is the magnitude of time gap between average headway of a day and each headway of successive buses.

Many studies have been managed on punctuality index and used on-time performance analysis of public bus service. M.Napiah et.al studied that punctuality index and expected average waiting time of stage buses by using historic GPS data from an on-board survey .It was concluded that service quality of stage buses in the mixed traffic can be evaluated based on the punctuality index and expected average waiting time by using on-board survey data. It is also found that the punctuality index during weekdays and weekend has no significant difference (M.Napiah, I. Kamaruddin and Suwardo, 2011). Kho et al resulted that the punctuality index during weekend when there was no traffic congestion is higher than those of the weekdays (Kho et al, 2005). Moreover, VaniyapurackalJilu Joseph found that the punctuality indexes are not uniform due to traffic, driver, and passenger's characteristics, as the characteristics vary randomly throughout the week (VaniyapurackalJilu Joseph, 2015).

3. STUDY AREA: YANGON

The purpose of this paper is to understand reliability of bus operation service in Yangon using punctuality index. In Yangon, there are three main groups in the provision of bus services such as private bus companies, Bus Supervisory Committees (BSC) and Bus Line Committees (BLC). Five hundred and ninety five city buses are operated by two private bus companies. Eighty city buses are operated by Myanmar Golden City Link and Bandoola Transport Company operates 415 city buses. These companies own the buses and pay salaries to their drivers. Moreover about 5,000 large and medium buses owned by individual operators and controlled by one of the five Bus Supervisory Committees (BSCs). Nine hundred and sixteen mainly smaller buses (Dyna or Hilux) are controlled by one of the ten Bus Line Committees (BLCs), which is fulfilling similar functions as the BSCs. The regulation of all bus services is controlled by the Yangon Region's Central Supervisory Committee (Ma HtaTha) (YUTRA, 2014).

In this study, the bus line which operated by Bandoola transport company was selected because a few of buses are installed by GPS receiver. However, the Adipadi blue-2 (anticlockwise) route was chosen among the Parami line due to the time and budget constraint. The characteristic of selected route is shown in Table 2 and the study area is shown in Figure 1.

Table 2.Characteristics of Blue-2 Route

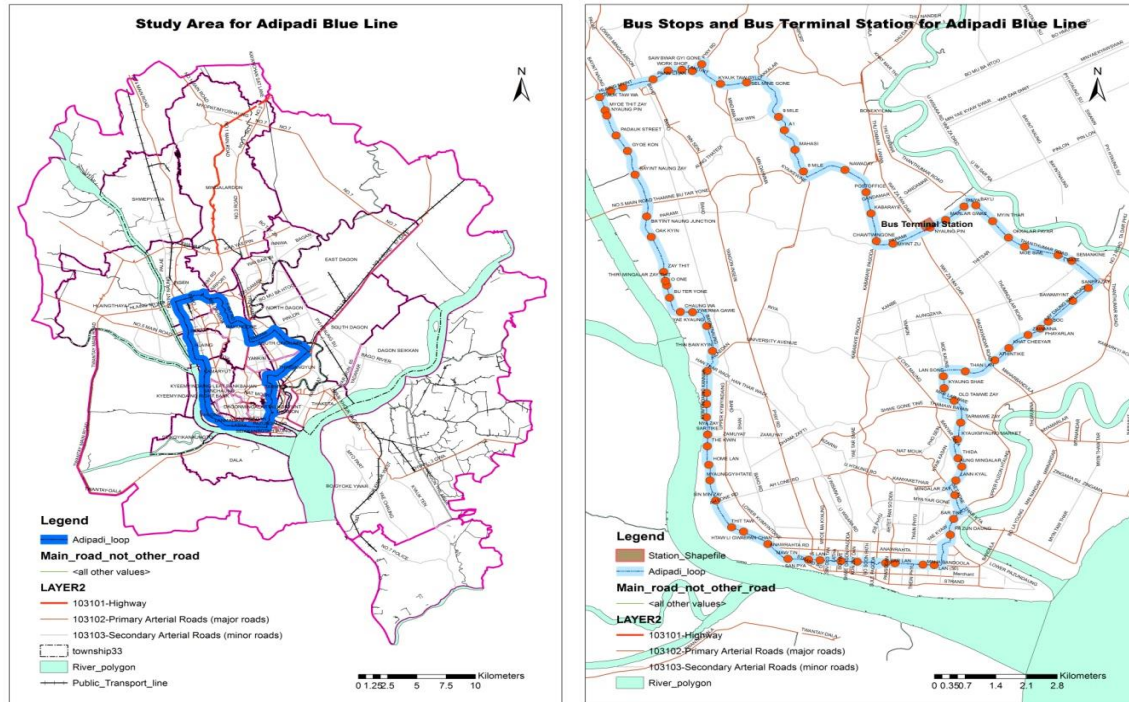| Characteristics	Direction
	Anticlockwise
Length(km)	45.434
Traffic Signals	56
Number of Bus-stops	83
Stop Spacing (m) Minimum, Maximum, Average	125, 1550, 547

Figure 1. Location of the Study Area

There are potential land uses in this corridor, such as universities, schools, residences, government buildings, public facilities, commercial and industrial areas, and tourism facilities. The selected route consists of thirteen major arterial roads and two minor arterial roads. Most of them are two ways six lanes while others are one way four lanes and two ways four lanes. Most of the roads are undivided and few roads are divided. There are also other bus services which operate on the closely resemble route.

4. METHDOLOGY

4.1 Data Collection

The selected route is loop type which start from Nyaungbin station and ends at same station. It is one of the busiest bus routes in Yangon. The primary survey of the selected route was carried out over five days, weekdays (Tuesday, Wednesday and Thursday) and weekends on August 2016, and during the morning peak period (7:00 a.m. to 11:00 a.m.), off peak period (11:00 a.m. to 2:00 p.m.) and evening peak period (2:00 p.m. to 8:00 p.m.). It avoid on Monday and Friday because they may not represent typical weekday data.

This paper used the GPS data of Adipadi blue-2 route in Parami line. A few buses are equipped with GPS receivers and send location, and time data of bus operation via wireless communication network. The data consists of travel time, speed of vehicle, arrival/departure times at stop points, bus ID, route ID, bus stop ID, latitude and longitude. In general, the special geographical environment and bad weather conditions may cause the loss or delay of GPS positioning signal. Specifically, there are some problems for GPS data in selected route of Parami line including duplicate data, irregular data and missing data. Therefore, not only GPS data but also on-board survey was used to evaluate the reliability of bus operation. The data were collected on the number of alighting/boarding passengers, as well as the arrival/departure time of buses at each stop points and environmental situation within the bus route during bus rides. Moreover, the spatial and timely data were recorded by using Handheld GPS. This task was conducted repeatedly between the two terminals of start and end points. Two observers were required to record boarding and alighting passengers, and located near the door because the blue-2 buses have two doors. The data are collected by student teams. In addition, secondary data were also used to help the surveyor on the primary data collection, such as road network map and other information on existing bus services.

4.2 Method of Analysis

From GPS data, the original data were divided into distinguishable trips to get the reliable trips. Original data were arranged in order of date, vehicle ID, recording time, and stop order. Each bus stop has a predefined 30m/60m stop circles around the bus stop. Figure 2 shows the two types of GPS data. The arrival time was recorded when the bus enters the stop circle and recorded the departure time when the bus departs the same circle.
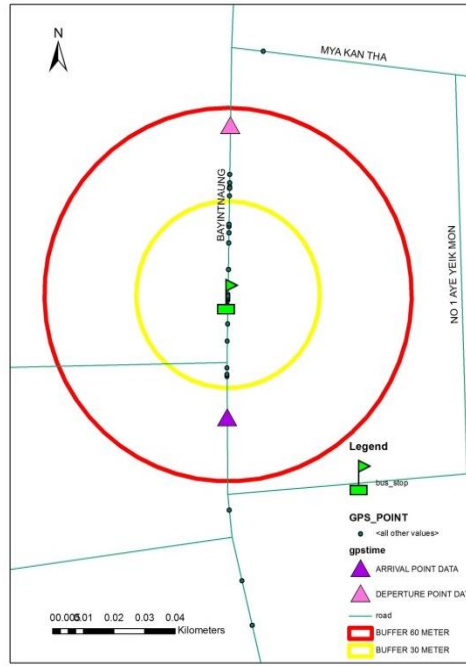
Figure 2. Two Types of GPS Data

The punctuality index P1 formulation was applied in this study because information got only follow with specific formula. The formulation consider with respect to departure time at the bus station. The reason is, sometimes a bus will arrive earlier than scheduled departure time. Therefore, the driver will wait until scheduled time before departing. Besides, bus timetable at the bus station is based on departure time, not arrival time. The formulation of punctuality index P1 is shown in equation 1 and 2.

$$P = \frac{S^2}{h_t^2} \tag{1}$$

Where
h_t: Scheduled headways and
S: Variable with formulation as in (2)

$$S^2 = \frac{1}{I}\sum_{i=1}^{I}(t_i - \tau_i)^2 \tag{2}$$

Where

I: Number of operations
t_i: Actual arrival time of i-th bus operation
τ_i: Scheduled arrival time of i-th bus operation

If all buses arrive at bus stops on time, the punctuality index P is zero and P=1 if complete random arrival. For convenience, it is suggested for P1 to be converted into percentage value, P as in equation (3).

$$P(\%) = (1 - P) \times 100 \tag{3}$$

This makes P=100% if all buses arrive on time, and P=0% for the worst service.
The standard of TCQSM Exhibit 3-29 was used for guidance to evaluate the level of service based on the punctuality index.

5. RESULTS AND DISCUSSIONS

5.1 Travel Time

As the operating service of the selected route is 15 hours from 5 a.m. to 8 p.m., the number of trips per bus is mostly 3 trips on weekdays and sometimes 4 trips on weekends. Travel time of the round trip is about from 2.34 hours to 3.40 hours long, about 3.02 hours on average during weekend. For during weekday, the route travel time is about from 2.88 hours to 3.97 hours long, about 3.48 hours on average. It was found that there is slightly difference in travel time between weekdays and weekends.

5.2 Operating Speed and Number of Bus Stops

The characteristics of the stage bus operation in mixed traffic is identified by the various operating speeds and number of stops of the bus during boarding and alighting passengers as shown in Figure 1.
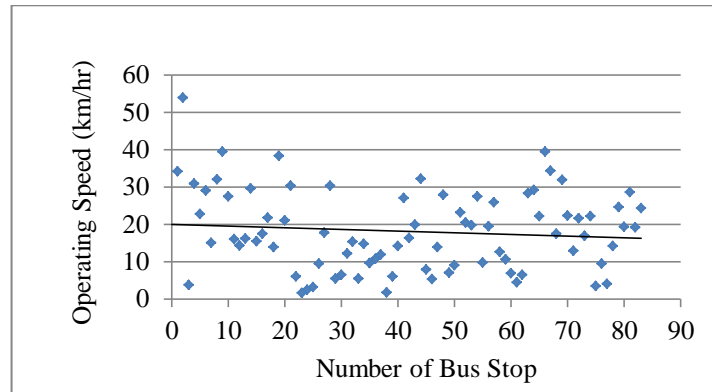

Figure 3. Relationship of Operating Speed and Number of Bus Stops

Both the speed and number of stops are the main determining factors of stage bus operation in mixed traffic. The average operating speeds is 18.29 km/hour. It was found that operating speed decreased as well as the number of stops increased. The various operating speeds were affected by the number of stops at which passengers get on and off.

5.3 Characteristics of Punctuality Indexes

The punctuality indexes P1 of each bus stop for 5 days are mentioned graphically in Figure 4. This figure show that the punctuality index of each bus stop decreases as the bus move farther from the starting point. The punctuality index of the starting stop is mostly on time and that of the last stop is variable from about 30% to nearly 100% in according to days. It can be seen that the bus arrive on time at the starting bus stops from the bus terminal.
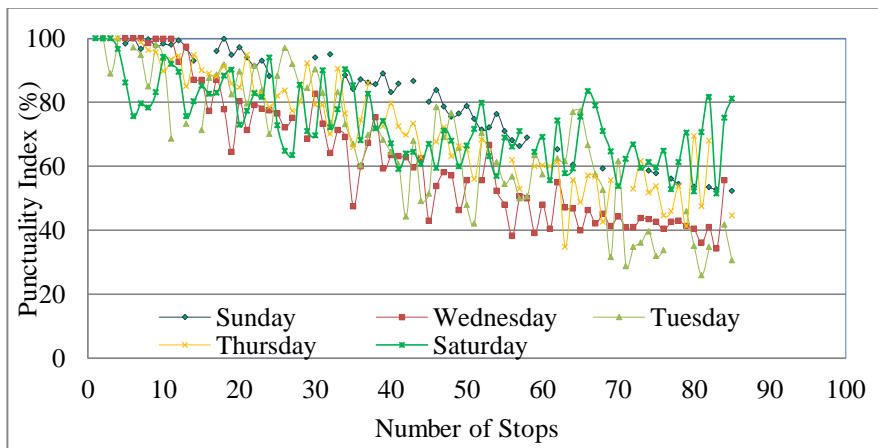

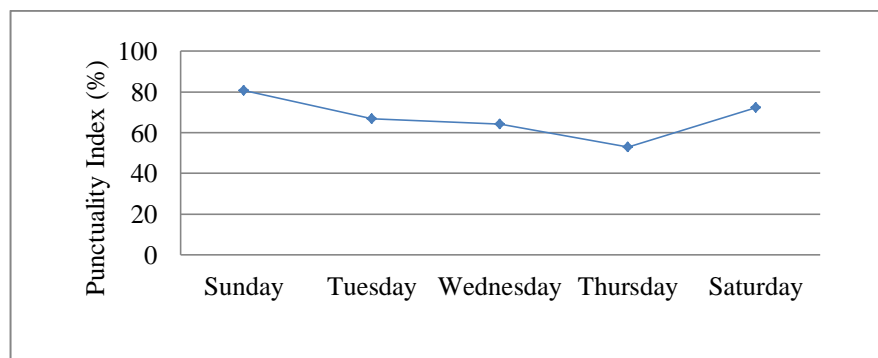Figure 4. The Punctuality Indexes of Each Bus Stop for 5 Days

Figure 5. The Average Punctuality Indexes for 5 Days

In addition, Figure 5 shows average punctuality index for different days. From the result of analyzing bus route, the punctuality index of Sunday, as there was no traffic congestion, is higher than those of the other weekdays.

Throughout the analysis, it was found that the punctuality of bus operation is influenced by many factors. Other factors affecting the punctuality index of public bus service such as road conditions, route length and number of stops, evenness of passenger demand, transit preferential treatments, operations control strategies, vehicle and staff availability, and difference in operator driving skills.

A lot of data are needed to make a model explaining the punctuality of bus operation because it is affected by many factors complicatedly. As insufficient data, the punctuality estimation model could not be constructed. However, the relations between punctuality of bus operation and some effective factors are determined.

Figure 6 plots the punctuality indexes with the route travel time. The punctuality of bus operation declined with the long travel time. The longer the route travel time, the lower the punctuality index is.
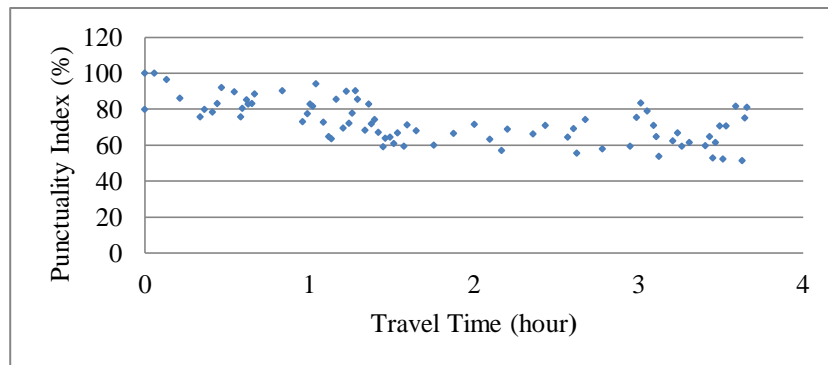

Figure 6. Punctuality Index with Travel Time

As shown in Figure 7, it can be seen that the relationship between punctuality index and the route length. As the route length of bus service is increased, the punctuality index for that service is declined. Therefore, longer route length and more number of stops cause the punctuality to be worse. It can be clearly seen that travel time, route length and number of bus of stops are significantly related to each other.
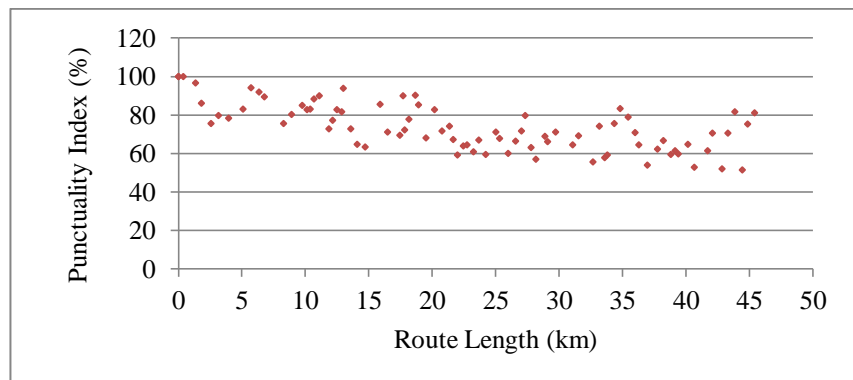

Figure 7. Relationship between Punctuality Index and Route length

6. CONCLUSION

The punctuality index of bus service is determined not only on board survey with using GPS but also data from GPS receiver equipped on buses. The operational measures of bus service characteristics have been identified, such as average travel time of 3.25 hour for one round trip and service frequency is 3 to 4 round trips per day. By examining the travel time, there is no significant difference in travel time between weekdays and weekends. In addition, punctuality index is mostly influenced by route length, travel time and number of bus stops. As mentioned above, the punctuality index is declined as those factors increased.

The reliability bus service can be evaluated based on the punctuality index. The analysis reveals that average punctuality index for blue-2 route in Parami line is about 61% for weekdays, about 73% for Saturday and about 81% for Sunday. It was found that as there is no traffic congestion on Sunday, the punctuality index of Sunday is higher than the punctuality index of weekdays. The punctuality index in Saturday is lower than in Sunday because the schools do not close in this August as it is the special month for the Buddhism to take Sabbath and the company staffs also need to go to their work.

Based on the punctuality index, the bus service reliability of the selected route is considered to LOS F in weekdays and Saturday while the route is considered to LOS D in Sunday by referring to the TCQSM Exhibit 3-29.

Therefore, it can be found that the punctuality index of the route is also depended on route characteristic and driver behavior, traffic condition and operation system of buses.

As for further studies, punctuality indexes on other routes will also be analyzed and the PI of each route will be compared. The questionnaire survey will also collect to investigate the passengers' satisfaction. From comparing the PI and questionnaire survey, the bus companies can evaluate their services and can find the needs to improve their services.

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