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Level of Service (LOS) and Bus Headways: A Case Study of George Town, Penang

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ABSTRACT

Bus ridership is affected by the quality of the bus service. Level of Service (LOS) and bus headways are among the key factors for the quality of bus service. This study aims to measure the quality of bus service based on Level of Service (LOS), the reliability of bus headway and its relationship with the number of private vehicles in George Town CBD of Penang. Several bus route for Rapid Penang bus services (11, 101, 201, 301, CAT and CT7) were selected according to the maximum headway (30 minutes) that calculated using the Transit Capacity and Quality Service Manual (TCQSM). Bus arrival time was observed at the bus stops and the traffic count was conducted to obtain the volume of private vehicles during peak hours. Level of Service (LOS) was determined using TCQSM on-time performance calculations. This study found that bus route No 11, 101, 201 and 301 did not comply with the estimated headway schedule. These bus routes were classified as LOS D and LOS E, whereas bus route CAT showed reliable service with LOS A and LOS B. Interestingly, the findings also reported that the high number of private vehicles affecting only LOS and the reliability of certain bus routes were significant. It shows that there are other limiting factors that cause the bus services unreliable and thus increase the waiting time of passengers.

Keywords: Quality of bus service; Level of Service (LOS)bus; bus headway; bus reliability; bus delay

INTRODUCTION

Cost, freedom, travel time, comfort, availability, and reliability were reported as the influencing factors for public bus ridership (De Luca, 2014; Imre & Çelebi, 2017; Jain et al. 2014; Olojede et al. 2017; Simons et al. 2014; Tilahun et al. 2016). Among these factors, reliability plays the most important role as bus delay proved to be the main factor that discourages road users from using public transport (Fonzone et al. 2015; Ishaq & Cats, 2020). Irregularities in bus arrival times increases the gap (headway) between two consecutive buses and lead to extra dwell time, thus delaying the bus arrival time (Bellei et al. 2010; Ruan et al. 2009). Headway is defined as the time interval between two consecutive bus departures from the first station (Hoesseini-Motlagh et al. 2015). Headway is also referring to the time interval in bus operations (Bellei & Gkoumas 2010). Meanwhile, a bus delay occurs when the gap (headway) between two consecutive buses is larger than the initial one which leads to extra dwell time (Bellei & Gkoumas 2010).

Bus delays are mentioned as one of the factors for the inconsistency of bus arrival times (Wahab et al. 2017). If the delay occurs, the buses will try to catch up with the schedule and it will cause the bunching event. Therefore, the rest of the schedule will be disrupted. This will prolong the waiting time for the bus passengers until the next bus arrives. One of the factors that disrupts bus reliability is the high volume traffic that caused traffic congestion (Chioni et al. 2020; Li et al. 2019; Chen et al. 2012; Daganzo 2009; Downs 2000).

Chee and Fernandez (2013) claimed that high usages on private vehicle ownership was the major cause of traffic congestion which contributes to environmental deterioration. In addition, the use of private vehicles also resulted in road accidents and air pollution (Kamba et al. 2007; Altef et al. 2013). Bian et al. (2015) found in their study that constructing more roads in urban areas might

have a significant influence on traffic congestion. They stressed that the key point to mitigate traffic congestion is by reducing car usage.

Therefore, it is important to encourage the road users to use public transport. However, the public transport service must be competitive enough to challenge the comfortability of private vehicles as the main transport mode (Borhan et al. 2019). Previous studies revealed that bus users are more interested in shorter waiting times, the accuracy of arrival times and frequency of bus arrivals (Berrebi et al. 2015; Minhans et al. 2015; Wagale et al. 2013; Yu et al. 2011). If bus arrival times are inconsistent, passengers are likely to feel anxious while waiting at the bus stop (Yu et al. 2011).

Based on the Malaysia Automotive Association (MAA) data in 2017, there were 26 720 293 vehicles registered in Malaysia which recorded an increment of 1.88 million from the year 2015 (Lee 2017). The statistic of the vehicles registered can be referred to in Table I. With the current population approximately 32 million, every person in Malaysia is estimated to own 3 cars (Muller 2020) which is considered as high. This situation portrays the lack of interest in the use of public bus services in Malaysia.

Penang is one of the most developing states in Malaysia which consists of a 301 square kilometer island and a 755 square kilometer mainland. The overall population in Penang was 1.647 million in 2013 (Ustadi et al. 2016) and started to grow from 1.76 million in 2015 to 2.00 million in 2020, and 2.45 million by 2030 (PTMP 2013). In addition, Penang was ranked 4th in 2017 as having the largest number of registered vehicles with the total number of motorcycles and cars reaching one million units (Lee 2017). Penang seems to struggle to cater for the growing number of private vehicles because of its limited square-foot area. If the public transit infrastructure does not support the demand for travel, traffic congestion in Penang will deteriorate.

In Penang, the main public bus service known as Rapid Penang was launched in 2007 and operated by the leading bus operator Prasarana Malaysia Berhad (Prasarana 2018). Rapid Penang used to increase the bus ridership after it was launched until the ridership became exacerbated with the increasing number of private vehicles. The criticism and complaints regarding Rapid Penang's bus schedule and services were among the top issues usually put forth by the bus passengers.

TABLE I. Private Vehicles Registration According to States in Malaysia Based on Malaysia Automotive Association Data (Lee 2017)

State	Private vehicles Motorcycles	Cars
Perlis	84,500	26,510
Kedah	954,751	341,197
Penang	1,408,528	1,130,601
Perak	1,359,771	772,591
Selangor	1,423,821	1,157,268
Federal territories	1,863,260	3,987,468
Negeri Sembilan	558,482	343,007
Melaka	472,701	344,459
Johor	1,873,005	1,498,587
Pahang	600,470	392,200
Terengganu	393,228	211,124
Kelantan	549,363	309,663
Sabah	402,237	697,541
Sarawak	798,227	813,569

As initiative to combat the congestion issue, The State Government of Penang has proposed a new alignment of Light Rail Transit (LRT). Therefore, the bus services need to be well-performed to serve as the feeder for the LRT services. This paper attempts to measure the reliability of the selected bus services as the feeder bus for proposed LRT stations by calculating the level of service (LOS) based on bus current arrival time at the bus stops. The selected bus stops located within an 800-meter radius from the proposed LRT station.

According to the proposal, one of the new LRT stations will be constructed near KOMTAR, a strategic location in the middle of George Town. (Refer to Figure 1). Thus, in this study, KOMTAR was taken as the basis for the collection of data. The methodology will explain the thorough description concerning data collection around KOMTAR.

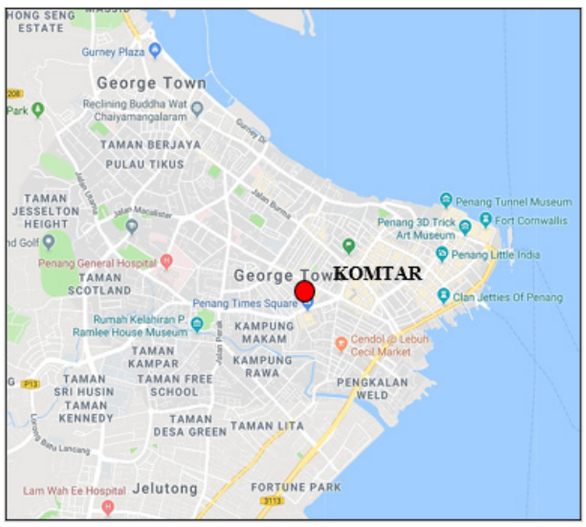

FIGURE 1. Location of KOMTAR in George Town

METHODOLOGY

Data collection in this study was conducted at the bus stops located within the 800-meter radius from the proposed LRT station near KOMTAR. Figure 2 shows the location of the 24 identified bus stops within the 800-meter radius from the KOMTAR area. To evaluate the reliability of the Rapid Penang bus, the arrival times and the headway of the buses that reached the bus stops were observed and reported. Table 2 shows the estimated timetable of bus frequencies for all bus services advertised by Rapid Penang. Bus routes No 11, 101, 201, 301, CAT and CT7 were selected based on 10–30 minutes expected headway which is suggested in the Transit Capacity and Quality Service Manual (TCQSM) as the maximum waiting time for bus passengers.

TABLE 2. The estimated timetable of bus frequency by Rapid Penang

Bus Route	Average Headway (min)
101	10-20
102	60-80
103	33-45
104	40-55
201	14-30
202	17-35
203	17-35
204	25-40
206	28-40
CAT (including CT7 route)	20-30
0	45-60
11	20-30
12	40-50
301	18-30
302	22-35
303	20-35
304	37-45
308	28-35
401E	23-35
401	30-45

Traffic data collection was conducted on three normal working days (Tuesday, Wednesday, and Thursday) from (6.30am to 9.30am and 5.15pm to 7.30pm) at the selected bus stops. In this study, the traffic count only involved cars and motorcycles representing private vehicles. Traffic count was conducted using manual counting and video recording methods. Figure 3 shows the routes for all selected bus routes in this study

FIGURE 2. Location of 24 Bus Stops Near the Proposed LRT Station, KOMTAR

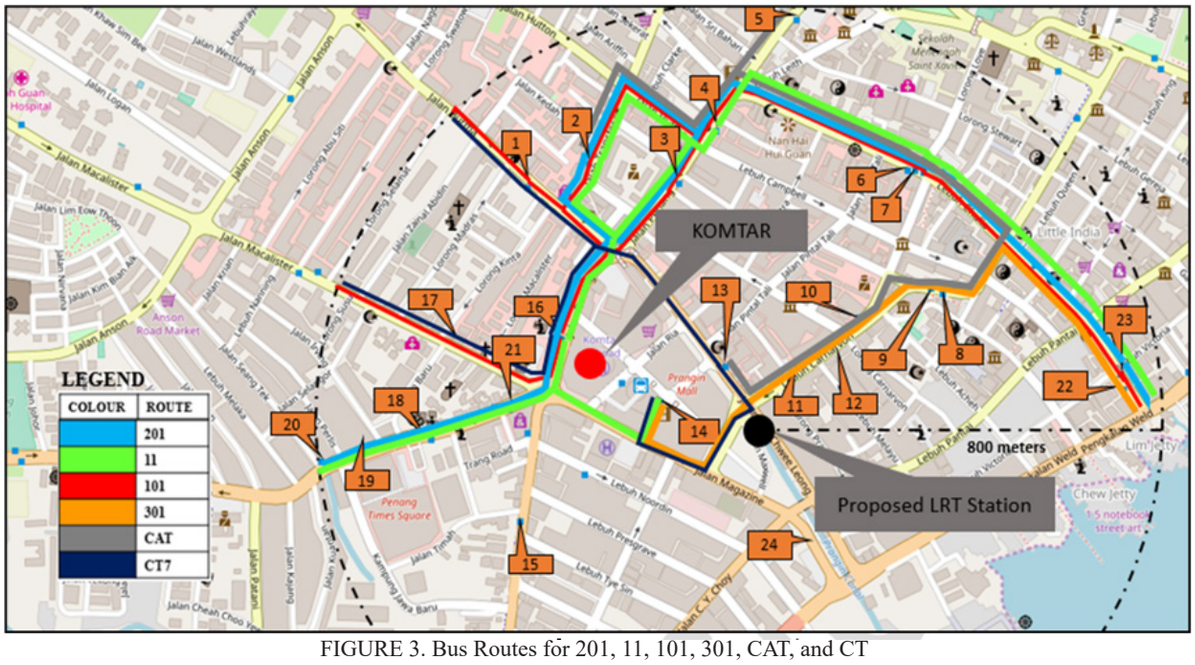

FIGURE 3. Bus Routes for 201, 11, 101, 301, CAT, and CT

ADAPTATION FROM TRANSIT CAPACITY AND QUALITY SERVICE MANUAL (TCQSM)

Transit Capacity and Quality Service Manual (TCQSM) is a manual produced by the Transit Corporation Research Program in 2013 (Chen et al. 2012). It provides alternatives to measure transit availability, comfort, and convenience from the point of view of passengers and transit providers. The manual suggested two types of calculations which are On-time Performance and Headway Adherence for measuring the reliability of bus headway based on LOS. On-time Performance is usually used for low-frequency bus service whereas the Headway Adherence method is applied to measure the high-frequency bus service that has less than 10 minutes headway.

Since the selected bus routes were estimated to have bus headway of more than 10 minutes, the On-time Performance method was selected to calculate the LOS for each bus route for this study. The results will also determine the reliability of the selected bus service. Based on TCQSM, headways of 20 to 30 minutes were acceptable for commuter bus service during commute hours. Previous studies claimed that the maximum waiting time at the bus stops was 30 minutes or lesser (Mishalani et al. 2006; Hess et al. 2004). Thus, this study referred 30 minutes as the maximum bus headway. Route 11, 101, 201, 301, CAT and CT7 were selected because these routes were expected to consume between 10 to 30 minutes of headway as advertised by Rapid Penang. Based on the manual, LOS has five categories that correspond to the average headway and number of vehicles per hour as shown in Table 3. It is stated that LOS A is the most satisfactory as the bus consumes less than 10 minutes of headway to arrive at the bus stop. At LOS B, service is considered frequent, but passengers need to adjust schedules to plan their waiting time at the bus stop.

TABLE 3. Los For Urban Transit Service in Transit Capacity and Quality Service Manual

LOS	Avg. Headway (min)	Veh/h	Justification
A	<10	>6	Passengers don't need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/ train missed
D	21-30	2	Service unattractive to riders' choice
E	31-60	1	Service available during hour
F	>60	<1	Service unattractive to all riders

AVERAGE HEADWAY CALCULATION

The on-time performance method requires the value of headway and average headway to determine the LOS for bus service. Therefore, from the definition of headway; the time interval between two consecutive buses (Hosseini-

Motlagh 2015; Wahab et al 2017), the headways value was calculated simply by Equation (1).

$$\Delta H = Tx - Ty \quad (1)$$

Where ΔH is the headway value, Tx and Ty are the actual arrival time (where x denotes the later bus arrival time whereas y denotes the previous bus arrival time). For the calculation of average headway, we added the headway values for the selected bus routes then divided with the total frequencies of the bus that arrived every 15 minutes. The 15 minutes is the time interval for traffic count. The equation is expressed as:

$$H(avg) = \frac{\sum H}{\Delta f} \quad (2)$$

Where H(avg) is the average headway, ∑ H denotes the summation of bus headway whereas Δf is the total frequencies of buses that arrived at the bus stop.

RESULTS AND DISCUSSION

Table 4 shows the total volume of private vehicles of all 24 identified bus stops during the morning and evening peak hours. The bus stop with the highest volume of private vehicles was bus stop 16, whereas bus stop 23 recorded the lowest volume of private vehicles.

TABLE 4. Total Volume of Private Vehicles At 24 Bus Stops During Peak Hours

Bus Stop ID	AM Peak Hours, (Veh/ 15min)	PM Peak Hours, (Veh/ 15min)	Bus Stop ID	AM Peak Hours, (Veh /15min)	PM Peak Hours, (Veh/ 15min)
1	4856	6456	13	5902	5186
2	3253	2548	14	3877	2375
3	3099	2900	15	2139	1552
4	2241	2915	16	9563	6591
5	2316	2260	17	1695	2115
6	504	609	18	5787	3013
7	672	1153	19	2715	17809
8	805	769	20	2763	2255
9	467	919	21	1777	3123
10	2508	1847	22	1174	682
11	3759	2254	23	191	250
12	886	1662	24	6357	2773

Therefore, in this section, the comparison will only focus on both bus stops. The results indicate that during morning peak hours, bus stop 16 recorded 9 563 cars and motorcycles per 15-minute intervals and a decline in evening peak hour which still recorded the highest volume of private vehicles; 6 591 veh/15min. Meanwhile, bus stop 23 recorded the lowest volume of private vehicles for both morning and evening peak hours which were 191 veh/15 min and 250 veh/15 min respectively. Bus stop 16 was situated in front of KOMTAR, with a total of four lanes with one-way direction. It indicates that the road was always in high capacity of vehicles. Meanwhile, bus stop 23 is in the tourist area known as Lebuh Victoria, a place with numerous hotels, street art, and shops. Nevertheless, the road was not as busy as the lanes in front of bus stop 16. Thus, during peak hours, the place is not affected by private vehicles from the people who rush to workplaces.

BUS HEADWAY, RELATIONSHIP WITH PRIVATE VEHICLES AND LEVEL OF SERVICE

The analysis in this subtopic will only consider bus stop 16 and bus stop 23 as these bus stops recorded the highest and the lowest volume of private vehicles during peak hours. A 30-minute maximum headway was set as the benchmark illustrated by one straight line in the scatter diagrams. Figure 4 shows the scatter diagram of bus headway and volume of private vehicles during morning peak hours for bus stop 16. During morning peak hours, bus 201 was detected to have the longest headway compared to the other bus services at bus stop 16. Bus 201 consumed about 74 minutes for the next trip. The volume of private vehicles at that time was 956 veh/15min. Therefore, irregularity occurred for bus 201 since the headways were dispersed irregularly.

Bus 11 and bus 301 also showed irregular dispersion with consuming 61 minutes and 55 minutes for the next trip. However, the results show different findings for bus CAT and bus CT7. Both bus services showed a uniform dispersion of headway even though the volume of private vehicles increased in the area.

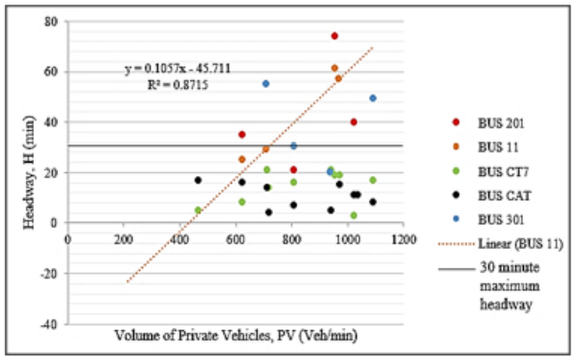

FIGURE 4. Scatter diagram of headway (H) and volume of private vehicles (PV) for morning peak hours at Bus Stop 16

In terms of the relationship between the increasing number of private vehicles and bus headways, only bus 11 shows a positive and strong correlation between the two variables by having an incline linear line with an R2 value of 0.8715. This means an increase in the volume of private vehicles will increase the bus headway for bus route 11. This correlation did not exist for other bus routes. In terms of disparity, the headways for bus CT7 and CAT showed a regular dispersion. However, both bus routes were not affected by the increasing volume of private vehicles. It is also indicated that both CT7 and CAT operated according to the estimated headways.

Table 5 shows the calculated headways, the average headways and LOS for every bus route during the morning peak hours at bus stop 16. Bus 201 and bus 11 obtained an average headway of 42.5 minutes and 40.4 minutes respectively. From the average headways, both bus routes obtained LOS E which means the service was once in an hour. Meanwhile, bus 301 obtained an average headway of 38.5 minutes which resulted in LOS D. This situation can cause the service to be unattractive to the passengers as the service exceeded the longest waiting time (30 minutes). However, bus CT7 and CAT obtained an average headway of 11.2 minutes and 9.6 minutes which resulted in LOS B and LOS A, respectively. Based on TCQSM, LOS A marked the most satisfactory service as the bus consumed less than 10 minutes of average headway to arrive at the bus stop whereas LOS B depicts the service was frequent. The findings also show that bus CT7 and CAT were able to reach the bus stop twice in 15-minute period. This is because the bus routes for CT7 and CAT are shorter than the other buses.

TABLE 5. Headway, Average Headway And Los At Bus Stop 16 During Morning Peak Hours

6.30-9.30 am Private Vehicles, PV (Veh/ 15min)		Headway, H (min)				
		Bus 201	Bus 11	Bus CT7	Bus CAT	Bus 301
6.30-6.45	(214)					
6.45-7.00	(467)			5	17	
				15		
7.00-7.15	(624)	35	25	8	16	
7.15-7.30	(718)			14	4	
					3	
7.30-7.45	(712)		29	21	14	55
					8	
7.45-8.00	(1022)	40		3	11	
8.00-8.15	(809)	21	30	16	7	30
				3	9	
8.15-8.30	(941)			21	5	20
					1	9
8.30-8.45	(1036)					11
8.45-9.00	(972)		57	19	15	
				1	5	
9.00-9.15	(1092)			17	8	49
				5	11	
9.15-9.30	(956)	74	61	19		
Average Headway, AH (min)		42.5	40.4	11.2	9.6	38.5
Level of Service (LOS)		E	E	B	A	D

Meanwhile, Figure 5 shows the scatter diagram of the headway and the volume of private vehicles for evening peak hours at bus stop 16. Based on the diagram, none of the bus routes showed a significant incline linear line. This shows that there was no correlation between the volume of private vehicles and bus headway.

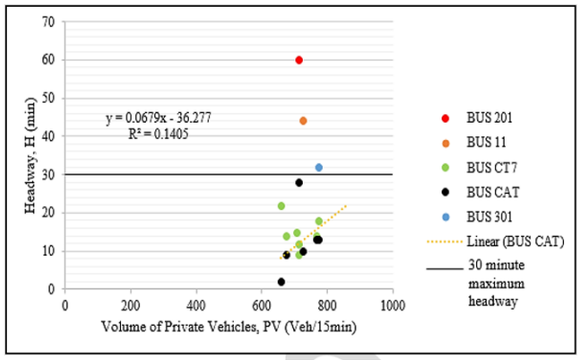

FIGURE 5. Scatter Diagram of Headway (H) and Volume of Private Vehicles (PV) for evening peak hours at Bus Stop 16

TABLE 6. Headway, Average Headway and Los At Bus Stop 16 During Evening Peak Hours.

5.15pm to 7.30pm Private Vehicles, PV (Veh/15min)		Headway, H (min)				
		Bus 201	Bus 11	Bus CT7	Bus CAT	Bus 301
5.15-5.30	(860)			2	7	
5.30-5.45	(705)			15		
5.45-6.00	(714)			9	28	
6.00-6.15	(767)			14	13	
				2	7	
6.15-6.30	(774)			18	13	32
					8	
6.30-6.45	(726)		44		10	
6.45-7.00 (657)				22	2	
				4	7	
					11	
7.00-7.15	(714)	60		12		

				4		
7.15-7.30	(674)			14	9	
Average Headway, AH (min)		60	44	10.6	10.5	32
Level of Service (LOS)		E	E	B	B	E

However, bus CT7 and bus CAT showed a regular dispersion pattern depicting that the bus headway for both routes were acceptable for morning peak hours. For evening peak hours, bus 201 obtained an average headway of 60 minutes whereas bus 11 obtained an average headway of 44 minutes. This caused bus 201 and bus Route 11 to obtain LOS E (Table 6). This was similar to bus 301. With an average headway of 32 minutes, bus 301 resulted in LOS E which means the bus operated only once in an hour. Meanwhile, bus CT7 obtained an average headway of 10.6 minutes which resulted in LOS B whereas bus CAT obtained an average headway of 10.5 minutes which resulted in LOS B. For bus stop 23, there were four selected bus routes available for this study which were bus 201, bus 11, bus 101, and bus 301. Bus CAT and bus CT7 were not serving this area. Based on Figure 6, bus 201 showed a positive and small correlation between the volume of private vehicles and bus headway with R2 equals to 0.436. This depicts that there is a possibility when the volume of private vehicles increases, the bus headway will increase. Other bus routes did not show any correlation between the two variables.

The uneven dispersion was detected for bus 11 and bus 201. Bus 11 recorded the longest headway which was 77 minutes when the volume of private vehicles was 11 veh/15 min, whereas bus 201 consumed 45 minutes when the volume of private vehicles was 23 veh/15min. The findings for bus 101 and bus 301 showed that both buses operated regularly.

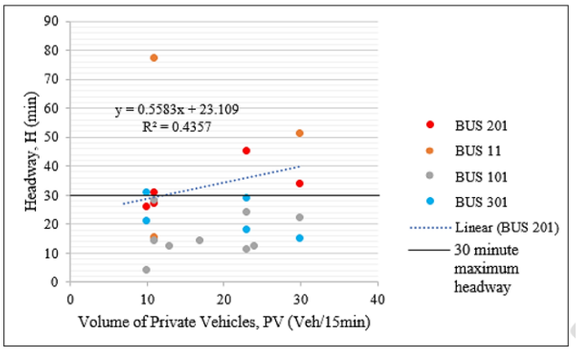

FIGURE 6. Scatter Diagram of Headway (H) And Volume of Private Vehicles (PV) for Morning Peak Hours at Bus Stop 23

Table 7 shows the calculated headway, the average headway, and LOS for every bus route. For morning peak hours, bus 201 and bus 11 obtained an average headway of 32.6 minutes and 47.7 minutes respectively, which resulted in LOS E. Meanwhile, bus 101 and bus 301 obtained an average headway of 13 minutes and 10.4 minutes respectively, which resulted in LOS B. LOS B means the buses operated frequently but passengers still need to consult the schedules. The results proved that the actual headways did not comply with the estimated headway scheduled by Rapid Penang except for bus 101 and bus 301.

Figure 7 shows a scatter diagram of headway and volume of private vehicles at bus stop 23 during evening peak hours. The slope is 1, depicting the strongest linear relationship. From the graph, the value of R2 is equal to 1 which means when one variable increases by one, the other variable will increase by the same amount. Bus 11 was the only bus route that showed a positive and strong correlation between two variables; volume of private vehicles and headway. It showed that the volume of private vehicles on the road influenced the headway for bus route 1. However, other bus routes did not show any correlation between the two variables. Bus 201 recorded the highest headway compared to the others. Bus 201 consumed 68 minutes which was more than one hour for the next trip. Bus 201 and bus 301 had only one trip for the whole duration of the evening peak hours. Meanwhile, bus 11 had only two frequencies. Bus 101 recorded the irregularity of the headways with more than 30 minutes for two trips.

TABLE 7. Headway, Average Headway, And Los At Bus Stop 23 On Morning Peak Hour

6.30-9.30 am Private Vehicles, PV (Veh/15min)		Headway, H (min)				
		Bus 201	Bus 11	Bus CT7	Bus CAT	Bus 301
6.30-6.45	(7)					
6.45-7.00	(12)					
7.00-7.15	(10)			4	21	
7.15-7.30	(11)	31	15	14		
7.30-7.45	(17)			14		
7.45-8.00	(30)	34	51	22	15	
8.00-8.15	(24)			12		
8.15-8.30	(23)			11	29	
				2		
8.30-8.45	(23)	45		24	18	
8.45-9.00	(13)			12		
9.00-9.15	(10)	26			31	
9.15-9.30	(11)	27	77	28		
Average Headway,AH(min)		32.6	47.7	13	10.4	
Level of Service (LOS)		E	E	B	B	

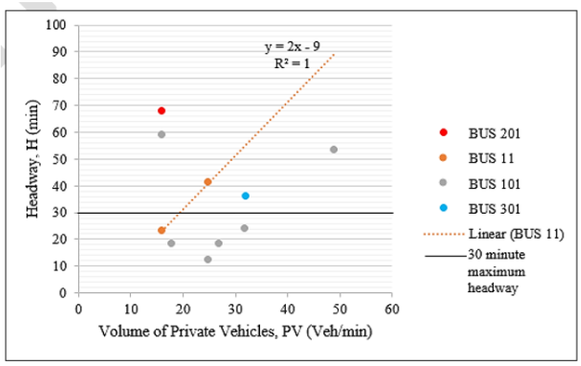

FIGURE 7. Scatter Diagram of Headway (H) And Volume of Private Vehicles (PV) for Evening Peak Hours at Bus Stop 23

Table 8 shows the calculated headway, the average headway, and the LOS for every bus at bus stop 23 during evening peak hours. For evening peak hours, bus 201 and bus 11 obtained an average headway of 68 minutes and 32 minutes respectively, which resulted in LOS E. Similar to that, bus 301 obtained LOS E for an average headway of 36 minutes. Meanwhile, bus 101 resulted in LOS D for an average headway of 27.4 minutes which means the service started to be unattractive to the passengers. Based on the results, bus 201, 11, 101 and 301 consumed almost 30 minutes or more that did not comply with the estimated headway advertised by Rapid Penang.

TABLE 8. Headway, Average Headway, And Los At Bus Stop 23 On Evening Peak Hours.

5.15-7.30pm Private Vehicles, PV (Veh/15min)		Headway, H (min)				
		Bus 201	Bus 11	Bus CT7	Bus CAT	Bus 301
5.15-5.30	32					
5.30-5.45	26					
5.45-6.00	18			18		
6.00-6.15	49			53		
6.15-6.30	32			24	36	
			41	12		
6.30-6.45	25					
6.45-7.00	16	68	23	59		
				8		
7.15-7.30	27			18		
Average Headway, AH (min)		68	32	27.4	36	
Level of Service (LOS)		E	E	D	E	

However, other bus routes did not show any correlation between the two variables. Bus 201 recorded the highest headway compared to the others. Bus 201 consumed 68 minutes which was more than one hour for the next trip. Bus 201 and bus 301 had only one trip for the whole duration of the evening peak hours. Meanwhile, bus 11 had only two frequencies. Bus 101 recorded the irregularity of the headways with more than 30 minutes for two trips.

CONCLUSION

Based on TCQSM, the headway of the bus should not exceed 30 minutes. At bus stop 16, only bus 201 was affected by the increase of private vehicles during morning peak hours. Meanwhile, bus CAT and CT7 were found to follow the estimated headway stated by Rapid Penang. Meanwhile, at bus stop 23, the increased volume of private vehicles affected the bus headway of bus 201 Nevertheless, bus 101 and 301 were the only bus routes that complied with the estimated headway by obtaining LOS B during morning peak hours. However, during evening peak hours, these buses became worse by obtaining LOS D and LOS E respectively, whereas bus 201 and 11 did not meet the requirements at all by obtaining LOS E for both morning and evening peak hours. This means that the increased volume of private vehicles was strongly affected by the headway of bus 11.

From the results, the difference between good performance buses such as bus CAT and CT7 and poor performance buses (bus 201, 11, 301 and 101) is the regularity of bus headways. This is also due to the frequency of bus services. Bus CAT and CT7 were found to have frequent trips that produced smaller values of average headway and good values of LOS. The strong correlation between the volume of private vehicles and bus headway was shown by bus 11 on morning peak hours (bus stop 16) and on evening peak hours at bus stop 23. On the other hand, a compact development that does not contribute to a bigger bus headway was found. Bus stop 16 which was in the middle of KOMTAR area managed to display good performance bus service even though the location was busy compared to bus stop 23. Diab et al. (2016) also depicted that scheduling more time between trips will decrease the service delay.

As conclusion, this study has successfully investigated the current headway of Rapid Bus service in George Town CBD. However, the results can be improved by comparing more samples. The results can be used by bus operators, state government and other researchers to find alternatives to increase the level of public bus service in Penang. It includes shortening and repudiating the inconsistency of bus headway which highly affect the ridership of public buses.

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DECLARATION OF COMPETING INTEREST

None.

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