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Transit Priority Signal Control Method of Isolated Intersection

Abstract. *Method of transit priority signal control of isolated intersection is researched in the paper for an intersection at east door south road and spring breeze road in Shenzheng. In which, the delay of each passenger is used as new index to evaluate the control effect. The results show that the method of transit priority signal control of isolated intersection is better than the before, which could reduce the delay and give expression to the ideal "people first".*

Streszczenie. *W pracy opisano metodę sterowania sygnałem pierwszeństwa w izolowanym przekroju na przykładzie wycinka drogi w Shenzheng. Opóźnienie każdego pasażera juest użyte jako indeks do oceny kontroli. Metoda pierwszeństwa tranzytu okazała się być najbardziej efektywną. (**Metoda kontroli pierwszeństwa tranzytu w izolowanym obszarze**)*

Keywords: Traffic engineering; Transit priority; Signal control; Isolated intersection.
Słowa kluczowe: inżynieria ruchu, pierwszeństwo tranzytu.

Introduction

Related delay, raises public transportation's running rate effectively, improves the service level, Promote the development of public transport, It will have great significance to alleviates traffic pressure and guaranteed that the urban future sustainable development [1]. Because China's national condition and overseas different, China's pedestrians and the non-motor vehicle are much bigger than overseas, moreover China's public transportation proportion also relatively big [2]. These factors had decided in the domestic implementation about transit priority, Can not directly use these management and software, We must on the basis of learn the advanced experience of foreign, consideration to the actual traffic situation then do it. Therefore, the study about the signal control method in transit priority that meets our Realistic has some theoretical and practical significance. In this paper, Shenzhen City, East Gate Road - Spring Road intersection as an example, Optimized the control scheme of transit priority in intersection, and after improving the road intersection parameter control and the original parameter control vehicles on the comparison take passenger's average delay as the basis. After finally obtains the improvement the road intersection parameter control may reduce passenger's delay greatly, manifests "humanist" thought.

Urban Public Transportation System

The essence urban public traffic priority is to change unfair resources allocation situation in current urban traffic, and is to reflect its economic rationality. It no only contains public transport vehicles priority infrastructure, but also includes appropriate management measures. Urban public transport priority system is consists of the following elements:

(1)Public transport priority measures at the intersection: vehicle delaying contains two parts, road delaying and intersection delaying. The proportion of intersection delaying is lager than road delaying. So public transport priority measures are at the intersection become the key link. The priority at the intersection includes import road public transport priority and intersection signal control priority.

(2) Road public transport priority facilities: Usually there are public transport priority bus lanes and bus priority lane and other forms. Bus lane which is a lane exclusively for buses has certain exclusivity.

(3) Overtaking facilities at bus station: in the large demand road of public transport vehicles, there are some transportation facilities allowing overtaking each other at bus stop, in order to reduce time of queuing delays and traffic congestion at one bus line, and protect normal operation of the major stations bus (only stop some bus stop).

(4) Optimize bus lines: The optimize bus line contains station distance, site location, and so on.

(5) Related road traffic management: supporting the implementation of the relevant road traffic management measures and to regulate traffic flow in and out of driving and parking no only can ensure the bus lane (road) fully and effectively to perform their functions, but also guarantee Bus Priority System implementation smooth.

Design Of Bus Lanes

Bus lanes is separate bus traffic and motor vehicle traffic in road,This can effectively improve the operating efficiency of bus. The bus lanes of enter the intersection set to be divided into the following 4 ways [3]:

 Lanes of bus, bus lanes will be extended to the intersection. Generally located in the middle of the road or the road side, and must set the lane lights and dedicated left / right phase.

 Indented bus Channel, is the number of imported Road be equipped. All zigzag of Intersection is all imported Road are set to zigzag to the bus, part of the zigzag channel is equipped with some of the imported intersection to the bus.

Feedback line settings, is bus lanes. Stop at a certain distance before the Stop line of intersection, so that society vehicle can use the vehicle that originally belonged to bus.

 weaving section is set. Between the bus lanes of stopped before the import channel and the feedback line, set up a weaving section, so vehicles and buses can vehicle Interleaving.

Sign Control Of Transit Priority

Because of traffic reach the intersection is a random distribution model, so the signal parameters received by fixed timing signals can not accurately reflect the status quo of this intersection, especially the intersection of transit priority. Therefore, To get a better performance for the "transit priority " concept and "people-oriented" thinking [4], Use sensor control for intersection that based on bus lanes have been set.

Sensor control as the principle is that a phase starting at the green light, A" initial-green time" (Gmin) is default in the controller of sensor signals. To the end of the initial green light, If no follow-up vehicles to arrive in a default space of time , you can replace the phase; if it detect follow-up

vehicles arrived, each measured a vehicle, the green light to extend a pre "unit green extension of time "(G0), as long as in this preset time interval, vehicle break and replace the phase; continuous vehicle, the continuous extension of the green sign, it has been extended to a preset" extreme extension of time "(Gmax), Even if vehicles detected is still in the back, but also interrupt the opening of this phase, conversion to another phase. All inductive flow chart of intersection was shown in Figure 1.

Signal configuration design that can still use this method of Webster [5]. Accordingly, taking into account the capacity of buses is 10 times the number of vehicles, when the delay analysis, the analysis of traffic flows into traffic.

Webster's method goal is to minimize the vehicle delay, the index need to calculate has the following [6]

$$C_0 = \frac{1.5L + 5}{1 - Y} \tag{1}$$

In which:C0- Best Period, Units, Seconds; L- The total delay, Units, Seconds; Y- the maximum flow rate of all the phase ratio in Intersection.

②the maximum flow rate Y:

$$Y = \sum_{i=1}^{n} Y_i = \sum_{i=1}^{n} y_{ik} = \sum_{i=1}^{n} \max(y_{i1}, y_{i2}, \ldots\ldots, y_{im^i}) \tag{2}$$

In which, Y- the maximum flow rate of all the phase ratio in Intersection; i=l,2……n, n-Number of phase; mi-Lanes number of the i-phase; yij -Flow rate of j-lane from the i-phase; Yi -the maximum flow rate of i-phase; Yik - the maximum flow rate of lane in i-phase, The key lane of this phase is k-lane.

Effective green time for each phase:

$$G_i = \frac{Y_i}{Y} * (C_0 - L) \tag{3}$$

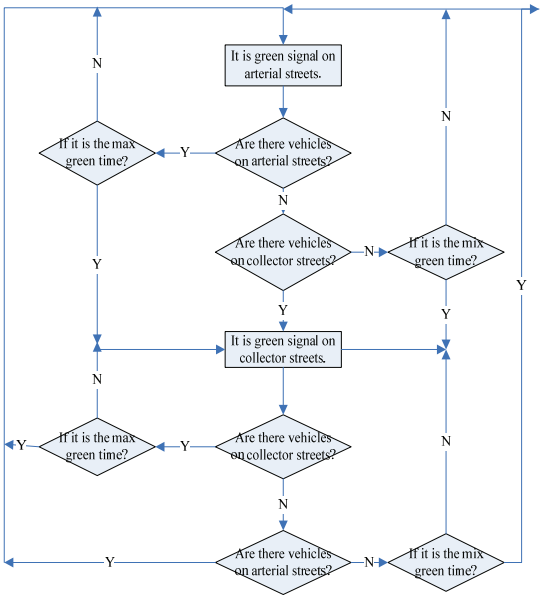

Fig.1 All Inductive control flow chart of intersection

In which: Gi- Effective green time for each phase; Yi- the maximum flow rate of i-phase; Y –the maximum flow rate of all the phase ratio in Intersection; C0–Best Period for phase; L –The total delay[7].

$$\lambda_i = \frac{G_i}{C_0} \tag{4}$$

④Split λ :

In which:λi-Split of each phase （i=1,2,3……）;Gi-effective green time of each phase; C0-Signal period

Delay of each vehicle ω:

$$\omega = \frac{C(1-\lambda)^2}{2(1-\lambda X)} + \frac{X^2}{2q(1-X)} - 0.65\left(\frac{C}{q^2}\right)^{\frac{1}{3}} X^{(2+5\lambda)} \tag{5}$$

In which's- Delay of each vehicle' s）; C- Cycle time; λ- Split of the Corresponding phase;

q- Actual traffic flow from the import; X- Degree of saturation, or split [8].

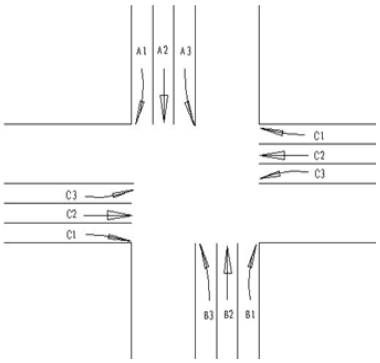

Fig.2 Flow Diagram of The Intersection.

Analysis Of Examples

Basic Data

In this paper, East Gate Road - Spring Road Shenzhen intersection is as an example, Two-way six lanes in this intersection, shown in Figure 2. The saturation of all traffic flows are 2000pcu / h. Public transportation vehicles converted into equivalent conversion factor of vehicles f = 2, the average passenger a vehicle Pa = 3 people / vehicles, the average passenger a bus Pb = 30 persons / vehicles ,per hour traffic through the intersection of the saturation 12,000 people. The total lost time L = 12s. The shares of traffic and the traffic of vehicles and traffic arrival rate ratio in Table 1.

Table 1 Vehicle Arrival Rateand Split

Direction		arrival rate of vehicle /pcu·h-1	arrival rate of bus /pcu·h-1	passenger flow /person·h-1	Split
N	right(A1)	374	36	2202	0.18
	straight(A2)	324	8	1212	0.10
	left(A3)	216	18	1188	0.10
S	right (B1)	78	10	534	0.04
	straight(B2)	320	5	1110	0.09
	left (B3)	130	18	930	0.08
E	right (C1)	162	36	1566	0.13
	straight(C2)	310	14	1350	0.11
	left (C3)	84	6	432	0.04
W	right (D1)	78	10	534	0.04
	straight(D2)	264	4	912	0.08
	left (D3)	194	10	882	0.07

Results Analysis

(1) The current signal control plan

Figure 3 showed the intersection phase blueprints at present. With survey, current signal cycles of the intersection can be got, C = 55s; Each phase of the green time respective is G1=13s, G2 = 8s, G3 = 13s, and G4 = 9s; Each phase of green ratio is : λ1=0.23, , λ2=0.15, , λ3=0.23,and λ4=0.17 . So the signal timing showed in figure 4.

(2) Bus priority signal control

Design bus lane in the intersection and extend in road intersection that is designed at the side. and bus lane is as shown in figure 5. It have 6 phases, respectively the east-

west straight , east-west bus left turn, east-west vehicles left turn, north-south straight, north-south t bus left turn, and north-south vehicles left turn, as shown in figure 6.

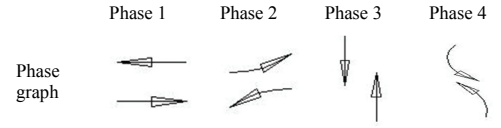

Fig.3 The Intersection phase blueprints at present

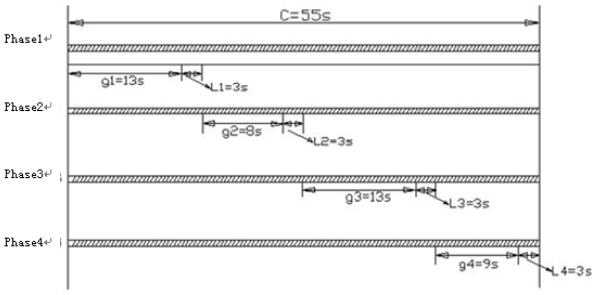

Fig.4 Signal timing at present

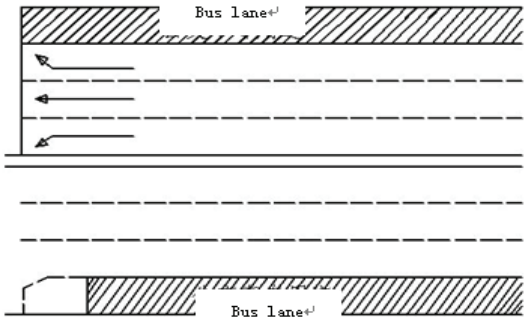

Fig.5 The bus lane that is at road side

Choose one day at 18:00-19:00 an hour traffic volume of this intersection, every 10min statistics once for example analysis. The intersection data at 18:00-18:10 period are as the calculating examples, the same with the other 5 period.

Table 2 is for statistical data of this time.

Fig.6 The intersection phase schemes of bus priority

Table 2 The Statistical Data Of 18:00-18:10 Period

Direction		The bus passenger flow of turn left /person • 10min-1	The vehicle passenger flow of turn left /person • 10min-1	The others passenger flow /person • 10min-1	Ratio
north	right(A1)	/	/	390	0.2
	straight(A2)	/	/	228	0.11
	left(A3)	240	105	/	0.12(0.05)
south	right (B1)	/	/	105	0.05
	straight(B2)	/	/	195	0.1
	left (B3)	120	60	/	0.06(0.03)
east	right (C1)	/	/	261	0.13
	straight(C2)	/	/	249	0.12
	left (C3)	30	45	/	0.02(0.02)
west	right (D1)	/	/	126	0.06
	straight(D2)	/	/	162	0.08
	left (D3)	120	93	/	0.06(0.05)

According to Webster method, cycle C0 can be got by formula (1), in which L = 12s, Y = 0.12 + 0.06 + 0.05 + 0.11 + 0.12 + 0.05 = 0.51, so C0 = 47s. Effective green time of each phase Gi can be got by formula (3), in which Y1 = 0.12, Y2 = 0.06 Y3 = 0.05, Y4 = 0.11, Y5, Y6 = 0.05 = 0.12,; Y = 0.51; C0 = 47s; L = 12s, so G1 = 8s, G2 = 4s, G3 =4s G4 = 7s, 8s, G6 and G5 = = 4s. Green letters than lambda type (4) solution, will the G1 = 8s, G2 = 4s, G3 =4s ,G4 = 7s, G5 =8s, and G6 = 4s. C0 = 47s is as input and got that λ 1=0.15, λ 2=0.09, λ 3=0.09, λ 4=0.15, λ 5=0.15, λ 6=0.09. So the signal timing showed in figure 7. The other five time signal timing respectively showed in figure 8 to 12.

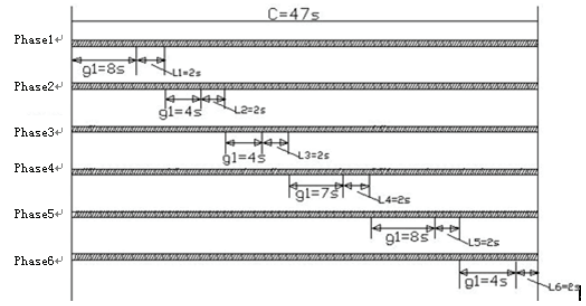

Fig.7 The phase timing scheme at 18:00-18:10

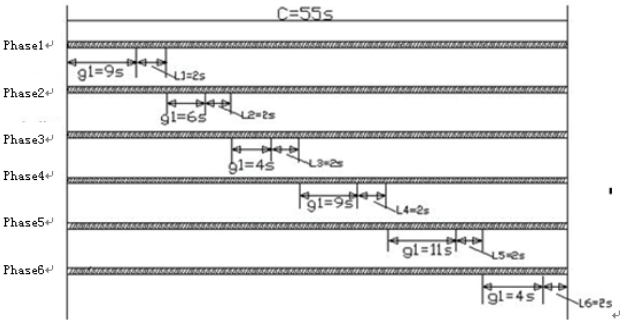

Fig.8 The phase timing scheme at 18:10-18:20

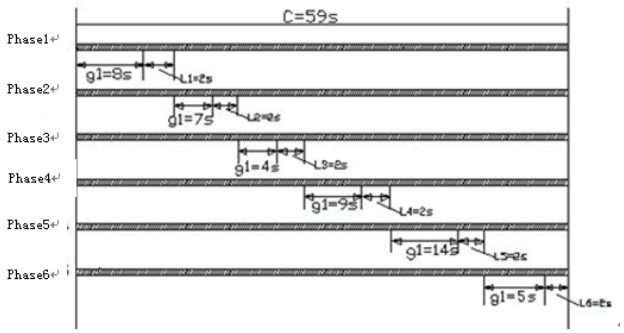

Fig.9 The phase timing scheme at 18:20-18:30

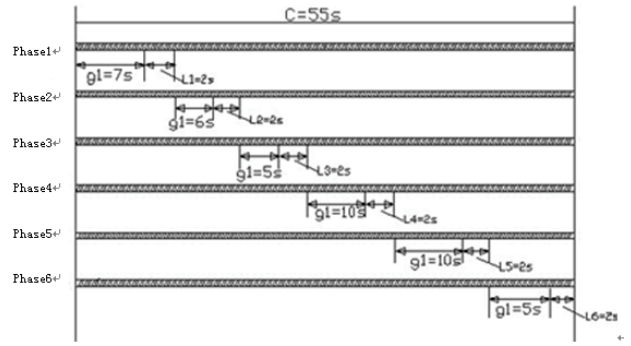

Fig.10 The phase timing scheme at 18:30-18:40

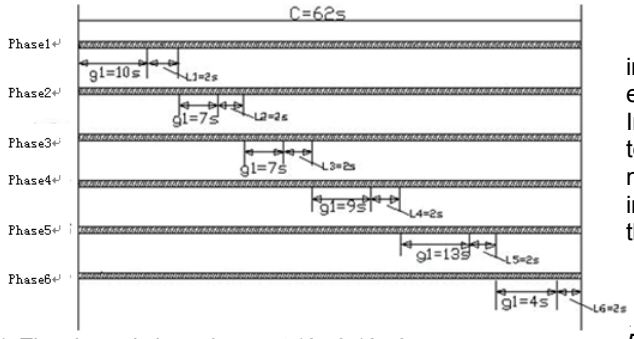

Fig.11 The phase timing scheme at 18:40-18:50

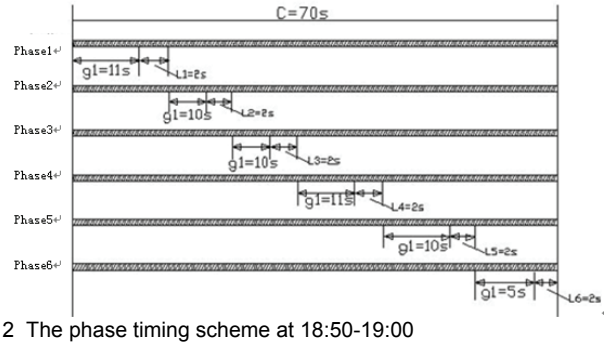

Fig.12 The phase timing scheme at 18:50-19:00

(3)Delay analysis

This intersection 18:00-19:00 an hour of traffic delay in accordance with the current scheme value calculation formula (5), input λ1=0.23, λ2=0.15, λ3=0.23, λ4=0.17; q1=610, q2=310, q3=670, q4=418; x1=0.17, x2=0.11, x3=0.17, x4=0.13 to calculate the average delay of every vehicle at respective phase: ω1=22.98s,

ω2=21.21s, ω3=23.70s, ω4=21.60s.

So the average delay of every vehicle at the intersection is that ω=1/4（ω1+ω2+ω3+ω4）=22.37s. Turn into the per capita delay at the intersection ω=25.34s.

The intersection that implement bus priority plan executed change cycle signal control. The per capita delay of 6 signal parameters is

ω=1/6(ω1+ω2+ω3+ω4+ω5+ω6)

=1/6（19.45+22.54+24.21+21.80+25.15+28.18）

=23.56s. The delay is effectively reduced

Conclusion

Method of transit priority signal control of isolated intersection is researched in the paper for an intersection at east door south road and spring breeze road in Shenzheng. In which, the delay of each passenger is used as new index to evaluate the control effect. The results show that the method of transit priority signal control of isolated intersection is better than the before, which could reduce the delay and give expression to the ideal “people first”.

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