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Proper Travel Schedule of Traffic Flow of a Signalized Intersection in Urban Network with a Special Barrier

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Abstract

The purpose of this research is to build the proper travel schedule of traffic flow at a signalized intersection that has a special barrier. There exists a train track on one arm. The closure of the railway gate is longer than the duration of a cycle of traffic lights which causes congestion. This research uses graphs representation method. It is based on the reason that a directed of the planar graph can devote conflict-free of the traffic flow in the urban network. The result is a graph model traffic flow and a proper time travel schedule. The benefits can be used by relevant agencies as basic of vehicle traffic regulation especially while the railway gate closing and after the train crossing completely.

Keywords: planar graph, signalized intersection, train track, travel schedule

1 Introduction

According Khisty in [4] intersection can be defined as a public area where two or more roads joining or intersecting, including roads and roadside facilities for traffic movement in it. The intersection is an important part of the road network. In urban areas usually have many intersections, where drivers have to decide to go straight or turn and move into another lane to reach their destinations [4].

In connection with the reason that the volume of traffic flow is always increasing, the intersections are signaled. According [5] signalized intersection is defined as the movement of crossroads that traffic is regulated by traffic lights to pass through the intersection in a sequence of different time intervals. The purpose of the use of traffic signals is to separate the flow of traffic movement coming from different directions that intersect.

Generally, in Indonesian standard, signals at an intersection employs three types of primary colors i.e. red, yellow, and green. The meaning is as the following: 1. Red: while this signal, the vehicles are not allowed to move forward. 2. Yellow: in this phase, the vehicles are allowed to move forward and immediately stopped to empty intersection. 3. Green: in this phase the traffic of vehicles allowed to move forward to cross the intersection [3].

An intersection as the research subject consists of four arms. The vehicles flow on the east arm as the main road moves in one direction entering the intersection and the current in the western arm aways from the intersection only. We modify the flow of vehicles on the north and south arms according to regulations of related agencies. It left-hand traffic (LHT). It means that the regulation keeps the vehicle traffic always moves on the left-side of the road.

There is a railway crossing on the southern arm. While there is a train crossing, the gate must be closed until the train finishes passing. The closure of the railway gate always longer than the duration of a traffic lights cycle and causes a heavy congestion.

The purpose of this research is to build the proper travel schedule of traffic flow mainly in connection with the closure of the railway gate. The schedule of traffic light should be able to resolve the congestion that occurs, especially at peak hours during the day.

$$x = a.t + b \tag{1}$$

While we assume that the number of vehicles arriving at the intersection in a particular period has a normal distribution, the queues of vehicles on each arm increases linearly. *x* is the numbers of vehicles queue. *t* is time interval of red signal or duration of railway gate closure. a and b are positive constants.

$$x = c.e^{-d.t} + f \tag{2}$$

The Eq (2) presents the number of vehicles leaving the intersection when green signals in a particular period that has a negative exponential distribution. c, d, and f are positive constants, e is a natural number.

2 Method

The type of research is descriptive analytical. It bases on a case study of a signalized intersection with railway gate in Jombang – East Jawa island. We studied the subject in detail quantitatively, and it looked like a case that must be found a way out.

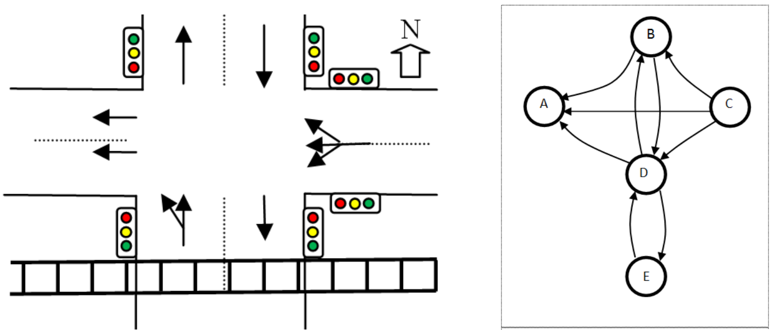
The graph that each arc given direction is called as a directed graph or digraph [2]. A graph G = (V, E) consists of a set of points V that should not be empty and the set of E edge. An arc to be a sequential pair of points (v, w) is called a directed graph [1]. These points are commonly referred to as nodes or vertices. While the number of arcs (edge) connecting a node with other nodes are called degrees [2].

The Planar Graph for traffic flow needs additional requirements that the traffic flow is not allowed to enter a vertex at the same time. At first, we begin to draw the graph model of the origin and the destinations. The second step is to split the model vertex at the north arm for vehicle traffic in the left lane and the right lane. It is to split also the south arm model vertex to three vertices. The third step is to draw the traffic conflicts that occur and separating. The fourth is to describe the graph conflict-free models to construct traffic light phases. Last is to describe while a train is passing.

3 Result

In Fig. 1. is the directed graph model of the traffic flow. The graph model consists of six vertices. The vertex A represents the western arm, B for the northern arm, and C as the eastern arm. The vertex D is the part of the southern arm that located at the northern of train track, and E is the area at southern of railway gate.

We must split vertex B to vertices BE and BW. The vertex BE represents for the east-side of the road and BW as the west-side. DE, DC, DW, EE, EC, and EW are vertices D East, D Center, D West, E East, E Center, and West, respectively. DE and EE are the separation lanes that are provided for the traffic coming from the east arm. Vertices DC and EC are for the traffic coming from BE.



	A	*B*	*C*	*D*	*E*
A	0	0	0	0	0
B	1	0	0	1	0
C	1	1	0	1	0
D	1	1	0	0	1
E	0	0	0	1	0

Figure 1. The signalized intersection, the train track, its representation in directed graph model of their origins and destinations, and the matrix of connectivity.

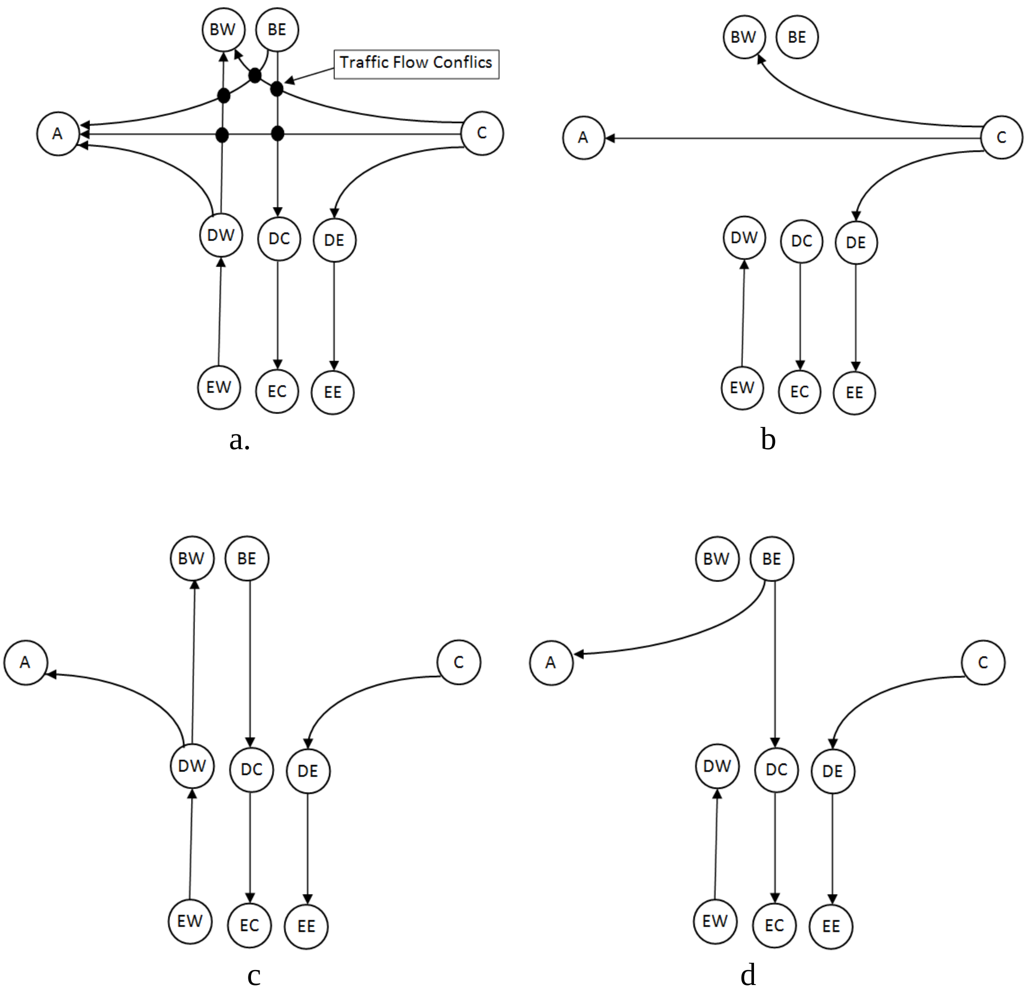
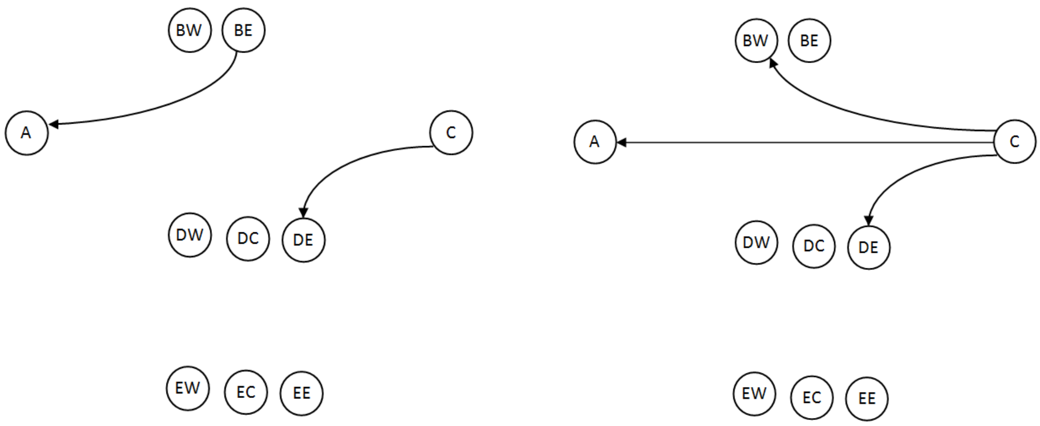


Figure 2. Graph with the traffic flow conflict and its phases to eliminate.

Based on the graph in Fig. 2a., the regular of traffic flow has five conflicts. It must apply three phases of traffic lights to eliminate the conflicts. In Fig. 2b. depicting a phase of the east-west traffic. In Fig. 2c. depicting a phase of the south-north traffic and south turn to the west arm. In Fig. 2d. depicting a phase of the north-south traffic and north turn right to West arm.

Based on the Fig. 3., the traffic flow when the train is passing. It has two phases of traffic lights only. The first is the phase of east-west and east turn right to North arm. The second phase is north that turns right.



a. b.

Figure 3. Two phases of graph models of traffic while a train is passing

4 Discussion

According to data from the 2010 census of BPS [6], the Jombang district population is 1,201,557 inhabitants with the population growth of 0.64% per year.

The passing vehicles are classified into four types: 1) low vehicles (LV) include private cars, passenger cars, pick-ups, MPU, city transport. 2). heavy vehicles (HV) include mini buses, large buses, trucks with two axles and truck, truck three axles, dump truck, and trailers, 3) motorcycles (MC), 4) the vehicles are unmotorized (UM) include bicycles, rickshaws, and handcarts. Exceptions for pedestrian are not discussed, they should refer to the existing signal.

The heavy vehicles (HV) and low vehicles (LV) dominates the east-west flow. Motorcycles (MC) and low vehicles (LV) dominates the flow of north-south arms. Survey results indicate a time interval of the first peak hours at 6:00 to 09:00 a.m. i.e. while the students go to school and employees want to work. The second hours of the time interval at 1:00 p.m. to 5:00 p.m. while the students and employees are going home. The railway gates closure occurs at least 42 times a day. Six times the closure of a railway gate at the first peak hours in the morning and eleven times in the afternoon. The closure of railway gate at least 90 seconds and the longest time recorded was 10 minutes. The average duration approximately 120 seconds. This time interval is longer than the duration of a traffic lights cycle.

The closure of the gate too long in north-south lane due to passing trains will cause a long queue of vehicles and jams. Based on the observation result, motorcycles (MC) always been at the forefront of the queue of vehicles. Please also note that the behavior of motorcyclists must have a high standart level of discipline to comply with traffic signs. Conceivably, how very dangerous if this happens, the flow of motorcycles (MC) in large quantities to cut the flow of heavy vehicles (HV) coming from the east arm which is moving toward the west arm.

Considering of the observations that the traffic coming from the north arm toward the west arm very little. The traffic lights apply two phases only. The vehicles from the northern arm is allowed to move toward the southern arm only. The vehicles are prohibited to turn right. The east-south traffic, they left turn on red (LTOR).

While a train passes, then requests an extension schedule. The signal east-west and east-north must always green. After the closure of the railway gate, traffic lights require a duration extension to resolve a long queue of vehicles. while uses extension schedule, the congestion does not occur, traffic flow remains orderly and hopes the safety aspects of road users remains guaranteed.

Table 1. Normal Time Interval of Traffic Lights Schedule

Phases		Green	Inter Green		Red	Cycles
			Yellow	All red		
		Second				
1.	South-North (SN)	24	3	3	40	67
2.	East-West (EW)	31	3	3	33	67

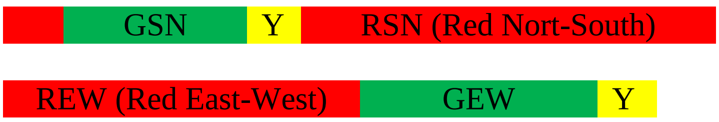


Figure 4. Normal Time Interval of Traffic Lights Schedule.

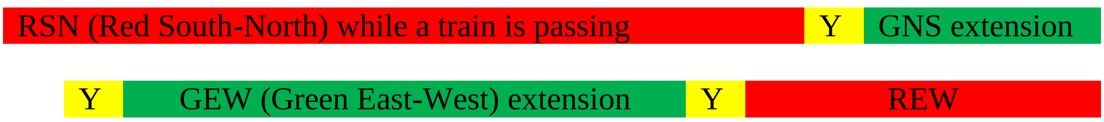
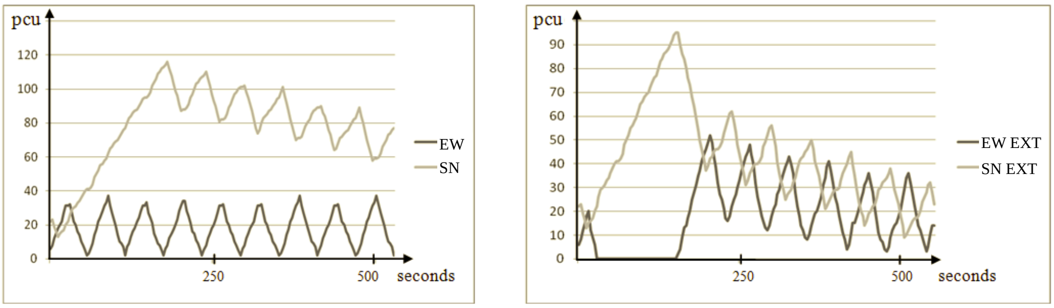


Figure 5. Extension Schedule of Traffic Lights.



a. b.

Figure 6. a. Curve queue of vehicles that do not implement the extension schedule. b. Simulation curve of vehicles queue that implement an extension schedule after railway gate closure for 135 seconds. A time interval of green extension of south-north traffic lights is 48 seconds, and return again to the normal time interval. It has better performance to solve the congestion. As a note, we have to be careful because the green extension that is too large cause congestion on the east arm. It uses pcu (passenger car unit) as the standard metric measurements of vehicles passing on the road when it compared to a passenger car. The extension schedule able to solve the vehicles queue after a railway gate closure in the six cycles of traffic lights. Note: EW traffic at the graph is all traffic coming from east arm. SN traffic is all traffic coming from south arm and north arm.

5 Conclusion

Graph model the flow of vehicular traffic may reflect the presence of many conflicts flow of vehicles coming from all directions. The main concern of this study focused on the graph model, especially shortly after the closing of the gates of the train at peak hours because there is a passing train. The traffic usually becomes uncontrollable. It can be extremely dangerous. The great conflict occurred between the flow of low vehicles (LV) and motorcycles (MC) coming from the south, and north arms must cut the east-west flow which is dominated by low vehicles (LV) and heavy vehicles (HV). It should create a proper schedule that implements the extension time interval while a train passes and shortly after the railway gate reopened.

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References

[1] A.V. Aho, John E. Hopcroft, Jeffrey D. Ullman, *The Design and Analysis of Computer Algorithms*, Addision-Wesley Publishing Company, New York, 1974.

[2] Y.D. Astuti, *Logic and Algorithms, Logika dan Algoritma*, Andi, Yogyakarta, 2009.

[3] Direktorat Bina Sistem Lalu-Lintas dan Angkutan Kota, *Indonesian Highway Capacity Manual (IHCM), Manual Kapasitas Jalan Indonesia* (MJKI), Jakarta, 1997.

[4] Juniardi, *Analysis of Traffic Flow at The Unsignalized Intersection, Analisis Arus Lalu-Lintas di Simpang tak Bersinyal*, Magister Thesis (S-2) UNDIP, Semarang, 2006.

[5] D.M. Putranto, L.I.R. Lefrandt, J.A. Timboeleng, E. Lintong, Signalized Intersection Capacity Optimization Using Method IHCM 1997, Optimasi Kapasitas Persimpangan Bersinyal dengan Menggunakan Metode IHCM 1997, *Jurnal Sipil Statik*, **1** (2013), no. 2, 112-118.

[6] Statistics Center Bureau, Badan Pusat Statistik, *Census Data 2010*, 2010. https://www.bps.go.id

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