Thursday (03 June 2010)		
Time	**Program**	
07.30 - 08.30	Registration	
08.30 - 09.30	Opening Ceremony	
09.30 - 10.00	Coffee Break	
10.00 - 10.40	Keynote Speech 1: Dr. Bambang Susantono	
10.40 - 11.20	Keynote Speech 2: Prof. Fwa Tien Fang	
11.20 - 12.00	Keynote Speech 3: Prof. Pichai Taneerananon	
12.00 - 13.00	Lunch	
13.00 - 13.25	Parallel Room 1: TG4 - 1	Parallel Room 2: TG6 - 1
13.25 - 13.50	Parallel Room 1: TG4 - 2	Parallel Room 2: TG6 - 2
13.50 - 14.15	Parallel Room 1: TG4 - 3	Parallel Room 2: TG6 - 3
14.15 - 14.40	Parallel Room 1: TG4 - 4	Parallel Room 2: TG6 - 4
14.40 - 15.05	Parallel Room 1: TG4 - 5	Parallel Room 2: TG6 - 5
15.05 - 15.30	Coffee Break	
15.30 - 15.55	Parallel Room 1: TG1 - 6	Parallel Room 2: TG6 - 10
15.55 - 16.20	Parallel Room 1: TG1 - 7	Parallel Room 2: TG6 - 11
16.20 - 16.45	Parallel Room 1: TG1 - 8	Parallel Room 2: TG6 - 12
16.45 - 17.10	Parallel Room 1: TG1 - 9	Parallel Room 2: TG6 - 13
17.10 - 17.35		Parallel Room 2: TG6 - 14

Friday (04 June 2010)		
Time	**Program**	
08.00 - 08.25	Parallel Room 1: TG2 - 1	Parallel Room 2: TG5 - 1
08.25 - 08.50	Parallel Room 1: TG2 - 2	Parallel Room 2: TG5 - 2
08.50 - 09.15	Parallel Room 1: TG2 - 3	Parallel Room 2: TG5 - 3
09.15 - 09.45	Coffee Break	
09.45 - 10.10	Parallel Room 1: TG1 - 10	Parallel Room 2: TG6 - 6
10.10 - 10.35	Parallel Room 1: TG1 - 11	Parallel Room 2: TG6 - 7
10.35 - 11.00	Parallel Room 1: TG1 - 12	Parallel Room 2: TG6 - 8
11.00 - 11.25	Parallel Room 1: TG1 - 13	Parallel Room 2: TG6 - 9
11.25 - 13.00	Lunch	
13.00 - 13.25	Parallel Room 1: TG3 - 1	Parallel Room 2: TG1 - 1
13.25 - 13.50	Parallel Room 1: TG3 - 2	Parallel Room 2: TG1 - 2
13.50 - 14.15	Parallel Room 1: TG3 - 3	Parallel Room 2: TG1 - 3
14.15 - 14.40	Parallel Room 1: TG7 - 1	Parallel Room 2: TG1 - 4
14.40 - 15.05	Parallel Room 1: TG7 - 2	Parallel Room 2: TG1 - 5
15.05 - 15.30	Coffee Break	
15.30 - 15.55	Parallel Room 1: TG7 - 3	Parallel Room 2: Safety Forum (TG4 - 6)
15.55 - 16.20	Parallel Room 1: TG7 - 4	Parallel Room 2: Safety Forum (TG4 - 7)
16.20 - 16.45	Parallel Room 1: TG7 - 5	Parallel Room 2: Safety Forum (TG4 - 8)
16.45 - 17.10	Parallel Room 1: TG7 - 6	Parallel Room 2: Safety Forum (Discussion)
17.10 - 17.35	Parallel Room 1: TG7 - 7	Parallel Room 2: Safety Forum (Discussion)
18.30 - 22.00	Conference Banquet	

Topic Group 1: Environmental Issues in Transportation Development		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG1-1	Denny HERMAWANTO; Achmad SUWANDI; Daryono RESTU	Building of Software System and Utilizing GPS which is used for Tracking the Position of Train
TG1-2	Juanita; Bintang Haldianto	The Study of Service Quality Transjakarta Bus
TG1-3	Grant G. SCHULTZ; Jason McGEE; Mitsuru SAITO	Economic Development Criteria for Use in the Project Prioritization Process of Utah
TG1-4	Xiaobo Qu; Qiang Meng	Impact Analysis of the Straits of Malacca and Singapore to Global Shipping and Trade
TG1-5	Abu Hassan ABDULLAH , B.Eng (Civil); Mohd Rosli HAININ, PhD	Challenges in Data Capturing for Digital Road Datasets and Other Related Features Using Integrated Network Survey Vehicle for South Zone Federal Roads of West Malaysia
TG1-6	H.R.Pasindu; T.F.Fwa	Methodology for Incorporating Structural Failure Risk into Runway Pavement Maintenance Management of Cracks
TG1-7	Chang Yong CAO; Tien Fang FWA; Ghim Ping ONG	Hydroplaning Analysis of Wide-Base Truck Tire on Wet Pavements
TG1-8	Ari Sandyavitri	Managing Geotechnical Assets Utilizing RHRS and RMCE Approaches
TG1-9	R. Didin KUSDIAN	Rotary Wing Transportation System Alternative Supply for Steep Mountain Range at Papua
TG1-10	Ari Wibawa ADIPRATAMA; Tri Basuki JOEWONO	Visitors Preference at Shopping Center Areas regarding Pedestrianization Scenarios
TG1-11	Ferry HERMAWAN; Himawan INDARTO; Hanggoro TRI CAHYO	Access Road in the Extreme Condition on the Infrastructure Challenge Perspective (Case Study in Gunungpati Semarang)
TG1-12	Karina Kusumawardani; Pradono; Tommy Firman	Marunda Special Economic Zone Impact on Jalan Pelabuhan and Jalan Marunda Makmur Capacity Performance
TG1-13	Adityawarman; Hendro Atmodjo	Vehicle Operating Cost Saving on Jagorawi Toll Road in Comparison with Arterial Road

Topic Group 2: Freight Transportation Impacts on Environment		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG2-1	Sutanto SOEHODHO; Gatot F. HERTONO; NAHRY	Optimization of Freight Distribution System Using Network Representation
TG2-2	Thomas G. JIN; Mitsuru SAITO	Evaluating the Accuracy of Truck Traffic Data on State Highways
TG2-3	Ghim Ping ONG	Multimodal Freight Transport Infrastructures in the United States: Major Policies and Lessons Learned

Topic Group 3: Public Transportation		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG3-1	Mochamad Riza RAMDHANNI; Tri Basuki JOEWONO	Characteristics of Trip Chains of Public Transport Users in Bandung, Indonesia
TG3-2	Dimas B. Dharmowijoyo; Ofyar Z. Tamin	Development of Shifting Mode Model Using BRT at Corridor Jakarta- City of Bogor and Jakarta-City of Bekasi with Stated Preference Approach
TG3-3	Erika BUCHARI; Gandhi Indra PERMANA	Enhancing Public Transport System in Bogor towards Multimodal Public Transport System

Topic Group 4: Transportation Safety		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG4-1	Gary NG; Mitsuru SAITO	Spatial and Temporal Analysis of Crashes Involving Trucks on Interstate Highways in Utah
TG4-2	Vatanavongs RATANAVARAHA, Ph.D.; Ponlathep LERTWORAWANICH,Ph.D.; Pramuk PRABJABOK; Yongyuth TAESIRI, Ph.D.	The Study on the Effectiveness of Profile Marking Shoulder Rumble Strip to Prevent the Truck Driver Falls Asleep
TG4-3	Piti CHANTRUTHAI; Santi KHOMTREE; Sulkiflee MAMA; Opas SOMCHAINUEK; Napaswan SUWAN; Pichai TANEERANANON	Evaluation of Road Safety Measures at a University Located on Main Highway
TG4-4	Opas SOMCHAINUEK; Sulkiflee MAMA; Phayada PRAPONGSENA; Pichai TANEERANANON; Piti CHANTRUTHAI; Saravut JARITNGAM	Development of a System for Assessing Crash Risk on Thai National Highways
TG4-5	Lasmini Ambarwati; Amelia Kusuma Indriastuti	Disadvantage for Pedestrian and Vehicle Caused by Inappropriate Activities on Sidewalk at Central Business District in City of Developing Country
TG4-6	Achmad Wicaksono; Amelia Kusuma Indriastuti; Harnen Sulistio	Review on the Safety Belt Use Compliance Case Study of the Urban Areas in Greater Malang
TG4-7	Amelia Kusuma Indriastuti; Harnen Sulistio; Deni Wijananto	Influencing Factors on Motorcycle Accident Concerning the Motorcycle Rider Characteristics in Urban And Rural Area
TG4-8	Sulkiflee MAMA; Opas SOMCHAINUEK; Saravut JARITNGAM; Piti CHANTRUTHAI; Pichai TANEERANANON	Safety Assessment of Motorcycles on Thai Highways

Topic Group 5: Evaluation Methodology of Environmental Impacts		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG5-1	N. Agya Utama; Keichii N. Ishihara; Miguel Esteban; Tetsuo Tezuka; Qi Zhang	Environmental impact from transportation in building sector; present and the future
TG5-2	Budi Hartanto Susilo	Policy for Bengkulu East Outer Ring Road in 'Dusun Besar' Preservation Area
TG5-3	Xinchang Wang; Qiang Meng	A Mixed-Integer Programming Model for Shipping Hub-and-Spoke Network Design with CO2 Emission Constraint

Topic Group 6: Benefits of Transportation Management		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG6-1	Leksmono Suryo PUTRANTO	The Evaluation of Space Mean Speeds of Road Links Surronding New Developments in Jakarta
TG6-2	Warit Wipulanusat	Business Process Reengineering for Airfield Pavement Management: A Case Study of Suvanabhumi Airport
TG6-3	Ghim Ping ONG; Tommy E. NANTUNG; Kumares C. SINHA	A Framework for Implementing Pavement Preservation Concept within a Pavement Management System
TG6-4	Anissa Nur IRMANIA; Wimpy SANTOSA; Tri Basuki JOEWONO	Determination of Strategic Roads in the Province of West Java
TG6-5	Endang WIDJAJANTI; Sutanto SUHODHO; Tri TJAHJONO	A Signalized Traffic Control Strategy for Road Closure Area on Oversaturated Two Way Two Lanes Roads
TG6-6	Judiantono TONNY	Trip Generation Model from Shopping Center in Bandung, West Java, Indonesia
TG6-7	Sik Sumaedi	Developing Excellent Quality Service and Environmental Friendly Autobus Company Using ISO 9001 and ISO 14001 Based Integrated Management System
TG6-8	Tri TJAHJONO	Macroscopic Traffic Flow Study on Indonesia Toll Roads for Determining the Use of Shoulder Running
TG6-9	Purnawan	Study of Effect On-Street Parking Stall Design Using Microscopic Simulation

Topic Group 6: Benefits of Transportation Management (continuation)		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG6-10	Agus Taufik MULYONO; Max Antameng; Muslich Zainal ASIKIN	National Road Widening using Regional - Environmental Approaches and Road-Safety Deficiency (Case Study: National Road Network in Java Island)
TG6-11	Javed FARHAN; Tien Fang FWA	Pavement Maintenance Management of Cracks Using Mechanistic Approach
TG6-12	Weeradej CHEEWAPATTANANUWONG; Pichai TANEERANANON; Takashi NAKATSUJI	Development of a New ITS Technology for Traffic Management in Thailand
TG6-13	Hitapriya Suprayitno; Indrasurya B. Mochtar; Achmad Wicaksono; Bambang Riyanto	Road Network Quality Components, Case of a Rural Road Network with a Low Traffic
TG6-14	Syafi'i; Setiono; Slamet Jauhari Legowo; Nurmalia	Estimation of Dynamic Origin-Destination Matrix (Time-Dependent OD) from Traffic Counts

Topic Group 7: Green Technologies in Pavement Construction		
Paper Code	**Name of Author(s)**	**Title of Paper**
TG7-1	Mohamed Abdel Raouf; R. Christopher Williams	Temperature Susceptibility of Non-petroleum Binders Derived from Bio-oils
TG7-2	Soewignjo Agus NUGROHO; Syawal SATIBI; Ferry FATNANTA	Local Correlation of Hand Cone Penetrometer Test to Field California Bearing Ratio Test for Pekanbaru Soils
TG7-3	Saravut JARITNGAM; Woraphot PRACHASAREE; Opas SOMCHAINUEK; Pipat THONGCHIM; William.O.YANDELL; Pichai TANEERANANON	The Analysis of Pavements Deflections using Finite Element Method and KENLAYER's Program
TG7-4	Michael LEE; TAN Poi Cheong; DAUD; WU Dong Qing	Green Approach to Rural Roads Construction – Stabilization of In-Situ Soils and Construction Wastes
TG7-5	EDWARD Ngii; Masykur KIMSAN	The Influence of Filler Type on Asphalt Ageing Process (STOA Condition) of the Asphalt Concrete Based on Marshall's Characteristic
TG7-6	Desy YOFIANTI; Bambang Sugeng SUBAGIO; Harmein RAHMAN	The Performance of Stabilization Using Foam Bitumen with In-Place Method in the Cirebon-Losari Road
TG7-7	Syahril; Bambang Sugeng Subagio; Ilyas Suratman; Siegfried	Study of Soil Properties and Swelling Influences on Subgrade of High Plasticity Clay towards the Damages of Road Pavement (Case Study on Jakarta-Merak Toll Road)

Application of Ratio Cumulative Arrival to Cumulative Discharge as a Switch Over Point on Oversaturated Two Lane Two Way Road Closure Area Signalized Traffic Control Strategy

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ABSTRACT

The study developed a signal-control strategy and its application for Road Closure Area (RCA) on two way two lanes roads which is treated as an isolated intersection during severe over saturation.
This study applied a new method by introducing a ratio between cumulative departure and cumulative arrival (R). The results of the study showed that switch over of green time was effectively discharged all the vehicles of the two approaches in the same cycle and the optimal green time happened if one of the approach has reached R>0.95. With the same arrival and saturation flow data, the method introducing in this study improved the performance results comparing with the previous methods, i.e. the Discrete Minimal Delay Model and the Maximum Throughput Model.

Key words: signalized traffic control, oversaturated, cumulative arrival, cumulative discharge, road closure areas.

1. INTRODUCTION

Road activities usually require the closure of one of the undivided two ways two lane roads, which need a special effort to maximize the capacity of bottleneck areas, especially on over saturation traffic condition. To overcome the problems arises on an oversaturated two way two lane road closure areas, this study developed a new method by introducing a ratio between cumulative departure and cumulative arrival (R) on its signalized traffic control strategy.

2. RESEARCH OBJECTIVE

The objective of the research is to evaluate the application of a ratio of vehicle's cumulative departure to cumulative arrival (R) value as a switch over point parameter on oversaturated two way two lane road closure areas signalized traffic control strategy.

3. LITERATURE REVIEW

3.1 Work Zone Traffic Control

Portable traffic signals make use of the red clearance interval, or "all red" period to allow vehicles that have entered a RCA under a green or yellow indication to safely pass through and exit the one-lane RCA. The factor that determine the duration of the red clearance interval is the speeds at which motorists will drive through the one lane RCA. The lay out of signalized traffic control on two way two lane RCA installation is shown on Figure 1, whilst Figure 2 displays the time needed in both directions to clear the road closure areas.

Red Clearance Interval = Work Zone Travel Time
= total work zone length (Lw)/work zone speed (Sw) (1)

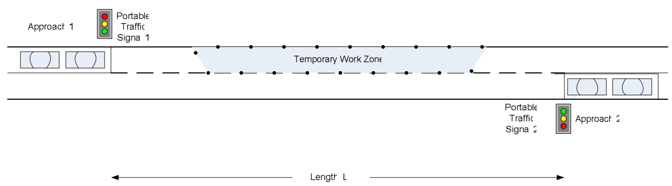


Figure 1 : Portable Traffic Signal Installation for Road Closure Area Control

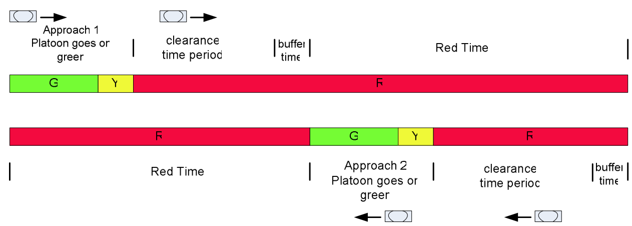


Figure 2: Complete Signal Cycle for Portable Traffic Signal Installation

The following equations can be used to compute the maximum wait time for each direction.
Maximum Wait Time (each direction) = $2Y + 2R + 2B + G_{nax}$ (2)

where

Y	=	yellow clearance time (applies to both directions), seconds
R	=	red clearance time (applies to both directions), seconds
B	=	buffer time (applies to both directions), seconds
$G_{\max}$	=	maximum green time in the opposing direction, seconds

Ginger et al (1999) indicates from experiences that the maximum wait time (i.e., before driver confusion and possible violation) is approximately four minutes.

3.2. Signalized Traffic Control on Oversaturated Traffic Flow

3.2.1. Demand and Service Approach

The traffic signal service equation is describing the service rate from the beginning until the end of the oversaturated period. The cumulative service function of the two movements at time t is as follows:

$$G = G_1 + G_2 = \int_0^t (\gamma_1 + \gamma_2).t \quad (3)$$

where

G	=	Total Cumulative service function, pcu
$G_{1,2}$		Total Cumulative service function of movement 1 and 2, respectively, pcu
$\gamma_{1,2}$.	=	Service rate (throughput) of movement 1 and 2 respectively, pcu/hour

While Q is the cumulative demand function of both movement, which in this research assumed as a polynomial function, as follows:

$$Q = Q_1 + Q_2 = -(a_1 + a_2).t^2 + (b_1 + b_2).t \quad (4)$$

where

Q	=	Total Cumulative service function, pcu
$Q_{1,2}$	=	Total Cumulative service function of movement 1 and 2, respectively, pcu
$a_{1,2}, b_{1,2}$	=	Constants of the polynomial functions

The curve of cumulative arrival of vehicle and service of traffic signal control at oversaturated period presented at Figure 3. Beginning of oversaturated period happened at the time of T=0 and oversaturated period end at the time of T=*n.c*. (*n*=total number of cycle time and *c*= cycle time).

At $T = n.c$, $Q = G$

$$-(a_1 + a_2).t^2 + (b_1 + b_2).t = (\gamma_1 + \gamma_2)t$$

$t=n.c$, then

$$-(a_1 + a_2).(n.c)^2 + (b_1 + b_2).(n.c) = (\gamma_1 + \gamma_2).(n.c) \quad (5)$$

$$\gamma_1 = \frac{g_1 s_1}{c} \;,\; \gamma_2 = \frac{g_2 s_2}{c} \text{ and } g_1 + g_2 = c$$

$$\gamma_1 = \frac{(c - g_2).s_1}{c}$$

$$-(a_1 + a_2).(n.c)^2 + (b_1 + b_2).(n.c) = \frac{(c - g_2)s_1 + g_2 s_2}{c}.(n.c)$$

$$-(a_1 + a_2).n.c + (b_1 + b_2) = \frac{(c - g_2)s_1 + g_2 s_2}{c} \quad (6)$$

c is an input value, whilst the value of $a_1, a_2, b_1, b_2, s_1, s_2$ is determined based on field data. If the equation fulfill the equation $g_1 + g_2 = c$, the value of n, T and γ can be calculated. . Based on the assumption that both approaches discharge the queues at the same cycle, hence the value of γ_1, γ_2 g_1 and g_2 also can be calculated.

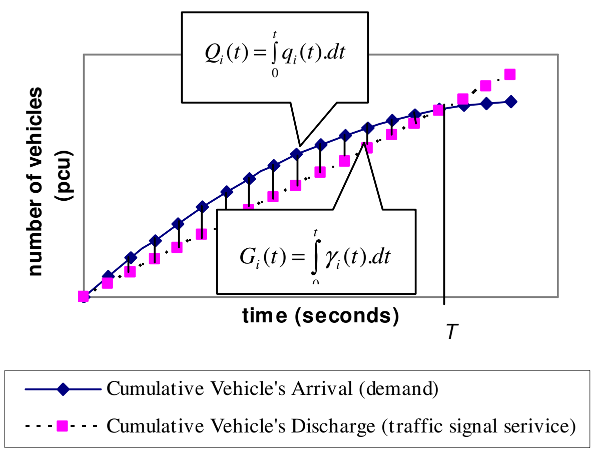
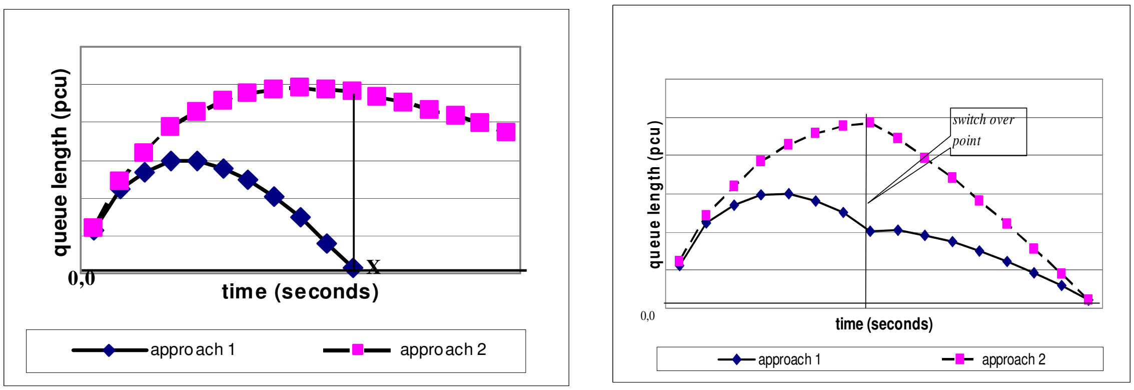


Figure 3: Vehicle's Cumulative Arrival and Cumulative Service of Traffic Signal Control at Oversaturated Period

3.2.2. Switch Over Point Approach

Figure 4 show the queue length in an intersection with 2 phase signalized traffic control along the oversaturated period. The first phase serves the movement from the left of RCA (will be termed as first movement) and the first phase serves the movement from the left of road closure area (will be termed as first movement). As shown on Figure 4a, the traffic signal control on oversaturated period with single green time often cannot disperse the queue at both approaches concurrently. It can be seen that at T=X, the all queue at 1st movement has been discharged, but at the 2nd movement the queues still exist. To overcome the problems, the two step green time method with the switching of green time at certain point has been developed. This point is called as switch over point (Figure 4b).



(a) Without Green Time Switch Over (b) With Green Time Switch Over

Figure 3: Queue Discharge on Oversaturated Signalized Traffic Control

4. METHODOLOGY

Traffic signal control on the oversaturated period has the aim of dispersing all of the vehicle queues at time T , where T is consist of n numbers of cycle time

The application of traffic signal control on two way two lane RCA are as follows:

- Traffic signal control on two way two lane RCA is identical with traffic signal control on two phase isolated intersection.
- Oversaturated saturation traffic condition is indicated based on the value of total Degree of Saturation (DS).
- The speed on the road closure area is the average space mean speed when vehicles pass by the RCA
- The length of the RCA is the total length between the stop lines of the two approaches.

4.1. Ratio Of Cumulative Vehicle Arrivals to Cumulative Vehicle Discharge

The study developed a parameter to determine the switch over point named R, which is defined as ratio of cumulative vehicle arrivals to cumulative vehicle discharge.

Performance parameter calculated at any cycle time (iteration) is :

1. Vehicle discharge on the ith of green and jth iteration ($VD_{i;j}$)

$$VD_{i;j} = \frac{s_m}{3600} XG_i(m) \qquad m = 1,2 \tag{7}$$

where

$VD_{i;j}$	=	Vehicle discharge on the ith of green and jth iteration j , pcu
s_m $m = 1,2$	=	Saturation flow of approach 1,2 pcu/hour
$G_i(m)$	=	Green time of approach m on the i th green time , $i = 1,2$ (1 for before switching and 2 for after switching)

2. Queue length on the ith of green time and jth iteration ($Q_{i;j}$)

$$Q_{i;j} = CA_{i;j} - CA_{i;j-1} + Q_{i;j-1} - VD_{i;j} \tag{8}$$

where

$Q_{i;j}$ = queue length on the ith of green time and jth iteration, pcu

$CA_{i;j}$ = cumulative vehicle arrivals on the *i*th of green time and *j*th iteration, pcu
$CD_{i;j}$ = cumulative vehicle discharge on the *i*th of green time and *j*th iteration, pcu

3. Ratio of cumulative vehicle arrivals to cumulative vehicle discharge on the *i*th of green time and *j*th iteration ($R_{i,j}(m)$)

$$R_{i,j}(m) = \frac{CD_{i;j}}{CA_{i;j}} \qquad (9)$$

Switch over point will be done if the value of $R_{i,j}(m)$ at one of the two approaches has already achieved the determined value of $R_{i,j}(m)$. the value of R is in the range of zero to one (0< $R_{i,j}(m)$ <1)

4.2. Algorithm

Algorithm to determine the optimal green time and performance of traffic signal control on two way two lanes RCA consists of seven steps as follows,

Step 1
Cumulative arrival input;
a. $q_{cumulative1}$ = Cumulative arrival input data per period of detection time on approach 1 (pcu)
$q_{cumulative2}$ = Cumulative arrival input data per period of detection time on approach 2 (pcu) The twos data above are input by detector per period of detection time.
b. t_p = period of detection time.(seconds)
c. s = saturation flow of approach 1 and 2.
d. c = cycle time (seconds)

Step 2
Determine green time initial / initialization of green time.

Clearance time = $2.\left(\frac{L_w}{S_w}\right)$

$c_{eff} = c - clearancetime$

$G_{i=0}\{1\}(1) = 1/4Xc_{eff}$

$G_{i=0}\{1\}(2) = c_{eff} - G_{i=0}\{1\}(1)$

Step 3
Calculation of queue variables:
m = phase of green time
$CA_{i;j}$ =cumulative vehicle arrivals on the *i*th of green time and *j*th iteration..
$VD_{i;j}$ = vehicle discharge on the *i*th of green time and *j*th iteration...
$= \frac{s_m}{3600} \times G_i\{1\}(m)$, m =1, 2
$Q_{i;j}$ = queue length on the *i*th of green time and *j*th iteration
$= CA_{i;j} - CA_{i;j-1} + Q_{i;j-1} - VD_{i;j}$
when j = 0, then $Q_{i;j=0} = CA_{i;j=0} - VD_{i;j=0}$
$CD_{i;j}$ = cumulative vehicle discharge on the *i*th of green time and *j*th iteration...
$R_{i;j}(m) = \frac{CD_{i;j}}{CA_{i;j}}$

D_{ij} = total queue on the *i*th of green time and *j*th iteration..(pcu)

for the first green time (before switch over) and for the first iteration. $D_{ij} = Q_{ij}.c/2$ for the next iteration. $D_{ij} = (Q_{ij} + Q_{ij-1})/2.c$

$$D_{total} = \sum D_{ij}$$

γ_{ij} = rate of throughput on the *i*th of green time and *j*th iteration (pcu/hour)

$$\gamma_{ij} = VD_{ij}.3600/c$$

$$\gamma average_i = \frac{1}{j}\sum VD_{ij}.3600/c$$

$$\gamma average_{total} = \gamma average1 + \gamma average2$$

Step 4

If $R_{i;j-1}(m) \leq 1$, for m=1,2, $j = j+1$ then update the value of $CA_{i;j}$, $Q_{i;j}$, $VD_{i;j}$.,$CD_{i;j}$,
else update $i = i+1$ and update the green time as follows:

$$G_i\{1\}(1) = G_{i-1}\{1\}(1) + 1$$

$$G_i\{1\}(2) = G_{i-1}\{1\}(2) - 1$$

Repeat to step 3.

Continue the calculation until $R_{i;j-1}(m) \geq 0.95$, for m = 1 or 2 . If $R_{i;j-1}(m) \geq 0,95$ for m = 1 or 2 is achieved, then go to step 5.

Step 5

Green time initiation after switching.

$$G_{i=0}\{2\}(1) = 1/4Xc_{eff}$$

$$G_{i=0}\{2\}(2) = c_{eff} - G_{i=0}\{2\}(1)$$

variable i is repeated from the beginning for the reason of obtaining the green time after switching.

Step 6

Repeat the calculation of $R_{i;j-1}(m)$ using the green time after *switching*. If $R_{i;j-1}(m) \leq 1$, for m=1,2, $j = j+1$ and update values of $CA_{i;j}$, $Q_{i;j}$, $VD_{i;j}$., $CD_{i;j}$. Repeat until $R_{i;j-1}(m) \geq 1$, for m = 1 or 2. Otherwise update $i = i+1$ and update green time as follows:

$$G_i\{2\}(1) = G_{i-1}\{2\}(1) + 1$$

$$G_i\{2\}(2) = G_{i-1}\{2\}(2) - 1$$

If $i \leq G_0\{1\}(2) - G_0\{1\}(1)$ repeat step 3 with the value of $i=i+1$ and update green time:

$$G_i\{1\}(1) = G_{i-1}\{1\}(1) + 1$$

$$G_i\{1\}(2) = G_{i-1}\{1\}(2) - 1$$

Else go to step 7

The above step has the aim to ensure that the inreasing G doesn't exceed maximum cycle time.

Step 7

If in the last iteration j, queue length Q on both phase at j and j-1 are negative and at j-2 is positive, the green time becomes the solution to disperse the queues of the both approach at the same cycle..
Solutions with the lowest minimum total delay (lowest D_{total} t) is the optimal solution.
The process to define the lowest minimum total delay are as follows;

a. Compare the value of *j and* j_{opt} . The value of j_{opt} for initialization is 100

b. Compare the value of D_{total} with $D_{total\ opt}$.
The value of $D_{total\ opt}$ for initialization is 1,000,000

c. If $j < j_{opt}$ and $D_{total} < D_{total\ opt,}$ then the value of G pair of approach 1 and 2 before and after switching, which are *G{1}(1), G{1}(2), G{2}(1)* and *G{2}(2)*, are the optimal; solution.

Returns to step 4 with the following condition :

$$G_i\{1\}(1) = G_{i-1}\{1\}(1) + 1$$

$$G_i\{1\}(2) = G_{i-1}\{1\}(2) - 1$$

System will terminate if $G\{1\}(1) > 3/4.c_{eff}$

5. SIMULATION SCENARIO

The simulation were done on the varies value of $R_{i,j}(m)$ as follows :

$R_{i,j}(m) \geq$ 0,1; 0,4; 0,5; 0,65; 0,75; 0,85; 0,9; 0,95; 0,97

The example of Chang and Lin (2000) and Talmor and Mahalel D (2007) paper is applied in the simulation as shown on Table 1. The example assumed an intersection of two one way streets with a two-phase signal control. One street is denoted as approach 1, and the other street as approach 2. No left turn is considered. Approach 1 has a saturation flow of 1400 veh/h and approach 2 has a saturation flow 1000 veh/h. In this study the saturation flow was converted into 1400 pcu/hour and 1000 pcu/hour, respectively. The cycle time is 150 seconds.

In order to compare with the other model, the simulation was done with the value of zero in the length of RCA.

Table 1:Input Data

Cumulative time period (second)	Cumulative vehicle arrival (pcu)	Arrival flow (pcu/hour)	Saturation flow (pcu/hour)	Degree of Saturation	Cumulative vehicle arrival (pcu)	Arrival flow (pcu/hour)	Saturation flow (pcu/hour)	Degree of Saturation
Approach 1					Approach 2			
300	121	1452	1400	1.04	86	1032	1000	1.03
600	205	1008	1400	0.72	147	732	1000	0.73
900	268	756	1400	0.54	192	540	1000	0.54
1200	318	600	1400	0.43	227	420	1000	0.42
1500	359	492	1400	0.35	257	360	1000	0.36
1800	396	444	1400	0.32	283	312	1000	0.31
2100	430	408	1400	0.29	307	288	1000	0.29
2400	462	384	1400	0.27	330	276	1000	0.28
2700	492	360	1400	0.26	352	264	1000	0.26
3000	523	372	1400	0.27	373	252	1000	0.25
3300	552	348	1400	0.25	394	252	1000	0.25
3600	582	360	1400	0.26	415	252	1000	0.25
3900	611	348	1400	0.25	436	252	1000	0.25
4200	640	348	1400	0.25	457	252	1000	0.25

Source :Extracted from Chang and Lin (2000) and Talmor and Mahalel D (2007)

6. SIMULATION RESULTS

6.1 Green Time Determination Based on Minimum Total Delay

The first simulation chose a pair of green time based on the performance of minimum total delay. The simulation results on Table 2 and Figure 4 show that the various of R give the similar result of throughput but different result of total delay. The simulation results also show that total delay has a minimum value on the value of R$\geq$ 0.95. The total delay increases following the decreasing of the value of R.

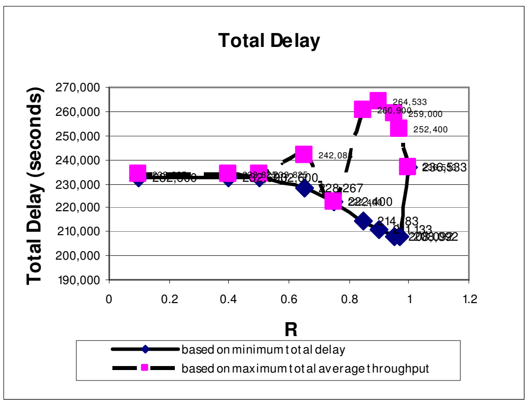
6.2 Green Time Determination Based on Maximum Total Average Throughput

The second simulation chose a pair of green time based on the performance of maximum average throughput. The simulation results on Table 3 and Figure 4 show that the various of R do not give a significant trend of both average throughput and total delay. The simulation results also show that although average throughput has a maximum value on the value of R$\geq$ 0.95, but the difference is very small. The two performance indicators, those are average throughput and total delay, do not have any special trend in result regarding with the difference of the R value.

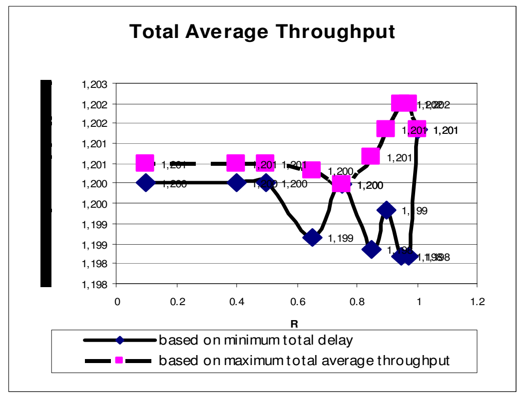
6.3 Performance Indicator and R value

Based on the simulation results, it can be concluded that regarding the difference of R value, green time determination has a significant difference if be chosen based on the minimum total delay value. The minimum total delay was happened on the value of R $\geq$ 0.95.

The detail simulation result based on the value of minimum total delay at switch over point of green time happened on R $\geq$ 0.95 is shown on Table 4.



(a)



(b)

Figure 4: Total Delay and Total Average Throughput of Various R Values

6.4. Comparison With The Other Models

Table 5 shows the performance results of the study and the two other methods, i.e. Discrete Minimal Delay Model (Chang and Lin, 2000) and Maximum Throughput Model (Talmor and Mahalel D, 2007)based on the same input data. The results then compared to the based result, which is Minimal Delay Model (Chang and Lin, 2000). The difference in percentage to the based result was done also presented in this Table.

As shown on Table 5, comparing with Discrete Minimal Delay Model (Chang and Lin, 2000), the research in this study has improve some of performance indicators of signalized traffic control, those are 5,88% better in length of over saturation period, 1.46% in average *throughput* , 13,57% in number of vehicles in the queue and 12,80% in total delay. This performance also better than Maximum Throughput Model (Talmor and Mahalel D, 2007)

Table 5 : Performance Results

Performance Indicator	Discrete Minimal Delay Model	Maximum Throughput Model	Research, R=0,95
Over saturation period (second)	2550.00	2434.80	2400.00
throughput (pcu/hour)	1181	1195	1198
Number of vehicles in the queue (pcu)	1609	1566	1391
total delay (second)	238,625	233,035	208,092
Comparison to Discrete Minimal Delay Model			
Over saturation period (second)	-	4.52%	5.88%
throughput (pcu/hour)	-	1.16%	1.16%
Number of vehicles in the queue (pcu)	-	2.69%	13.57%
total delay (second)	-	2.34%	12.80%

Source : Talmor I & Mahalel D (2007) & Result of the Study (2009)

Tabel 3 : Performance Comparison Based on Minimum Total Delay and Maximum Total Average Throughput

Indicator	switch of green time at R=									
	1	0.97	0.95	0.9	0.85	0.75	0.65	0.5	0.4	0.1
	Based on Minimum Total Delay									
Over saturation period (second)	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
throughput (pcu/hour)	1,201	1,198	1,198	1,199	1,198	1,200	1,199	1,200	1,200	1,200
Number of vehicles in the queue (pcu)	1,581	1,391	1,391	1,411	1,431	1,487	1,525	1,555	1,555	1,555
Length og queue, approch 1,2 (pcu)	68,92	38,127	38,127	37,123	34,116	56,95	71,83	83,74	83,74	83,74
total delay (second)	236,533	208,092	208,092	211,133	214,183	222,400	228,267	232,600	232,600	232,600
	Based on Maximum Total Throughput									
Over saturation period (second)	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
throughput (pcu/hour)	1,201	1,202	1,202	1,201	1,201	1,200	1,200	1,201	1,201	1,201
Number of vehicles in the queue (pcu)	1,568	1,568	1,715	1,768	1,744	1,487	1,618	1,563	1,563	1,563
Length og queue, approch 1,2 (pcu)	92,68	115,53	136,45	174,25	160,25	56,95	102,61	86,72	86,72	86,72
total delay (second)	236,533	252,400	259,000	264,533	260,900	222,400	242,083	233,825	233,825	233,825

Table 4 : Simulation Results on R$\geq$ 0,95

no of cycletime	cycle time	Approah 1	*g11=107.5 second*	quue length	throughput	cum. Throughput	Approah 2	*g12=42.5 second*	quue length	throughput	cum. Throughput	Approah 1	Approah 2
		cumulative arrival	cumulative arrival/ cycle				cumulative arrival	cumulative arrival/ cycle				delay/cycle	delay/cycle
	second	pcu	pcu	pcu	pcu/cycle	pcu	pcu	pcu	pcu	pcu/cycle	pcu	second	second
1	150	61	61	19	42	42	43	43	31	12	12	1402	2340
2	300	121	61	37	42	84	86	43	62	12	24	4206	7019
3	450	163	42	38	42	125	117	31	81	12	35	5623	10760
4	600	205	42	38	42	167	147	31	100	12	47	5652	13565
5	750	237	32	27	42	209	170	23	110	12	59	4894	15769
6	900	268	32	17	42	251	192	23	121	12	71	3348	17373
7	1050	293	25	0	42	293	210	18	127	12	83	1315	18602
			g21=48.5 second					*g22=101.5 second*					
8	1200	318	25	7	19	312	227	18	116	28	111	515	18227
9	1350	339	21	8	19	330	242	15	103	28	139	1098	16435
10	1500	359	21	10	19	349	257	15	90	28	167	1344	14456
11	1650	378	19	9	19	368	270	13	75	28	195	1440	12327
12	1800	396	19	9	19	387	283	13	59	28	224	1385	10048
13	1950	413	17	7	19	406	295	12	43	28	252	1219	7694
14	2100	430	17	5	19	425	307	12	27	28	280	940	5265
15	2250	446	16	2	19	444	319	12	10	28	308	585	2798
16	2400	462	16	0	19	462	330	12	-6	28	336	156	294
				(no queue)					*(no queue)*		total	35,121	172,971
											total delay	208,092	
		Approach 1					Approach 1						
		No.of vehicles in the queue (pcu)		234			No.of vehicles in the queue (pcu)		1156				
		average throughput (pcu/hr)		694			average throughput (pcu/hr)		505				
		Total average throughput (pcu[hr)			1198								
		Total no.of vehicles in the queue (pcu)			1391								

7. SUMMARY OF FINDINGS

- Green time determination has a significant difference if be chosen based on the minimum total delay value.
- The minimum total delay was happened on the value of $R \geq 0.95$.
- The ratio of vehicle's cumulative departure to cumulative arrival (R) value as a switch over point parameter could be applied on a two phase oversaturated signalized traffic control strategy.
- The research method, which was applied a ratio of vehicle's cumulative departure to cumulative arrival (R) value of 0.95, has improved the performance of the previous methods, i.e. the Discrete Minimal Delay Model and the Maximum Throughput Model.
- The research method could be applied to oversaturated two way two lane road closure areas signalized traffic control strategy by inputting the length of road closure area and the average journey speed in the road closure area.

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