Evaluation of a Left Turn Prohibition Policy in Urban Signalized Intersection Under Dynamic Traffic Flow

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Abstract: Nowadays, a left turn prohibition policy is widely applied in a signalized intersection because of a traffic congestion of an intersection especially in urban areas. But it is not certain that the left turn prohibition policy is always good alternative proposal to reduce traffic congestion. The left turn prohibition policy should be applied after the effect analysis of this policy considering the traffic situation in a study area. The methods of the effect analysis divide into the method using a signal optimizing models and the method using a route choice model. But all of these have a problem to estimate the effect of this policy under a real time traffic situation. The one is not able to forecast a traffic congestion diversion on an alternative path in a network; the other is not able to estimate the delay and the congestion according to the change of a phase time of the directional traffic flow in an intersection. So, the consolidated model, to be composed of a dynamic route choice model and a signal optimizing model, should be developed to analyze the effect of a left turn prohibition. In this study, the consolidated model, to be composed of an instantaneous dynamic user optimal route choice model and AAP (signal optimizing model) is developed through developing a network representation scheme. It is certified through a sample network-applying test that this model can express not only a real traffic situation well, but also the effect of a traffic congestion diversion with providing the MOE for evaluating a network performance.

Key Words: Left Turn Prohibition, Signal Optimizing Model, Traffic congestion diversion, Dynamic Route Choice Model, Network Representation Scheme

1. INTRODUCTION

In urban areas, a left turn prohibition policy is widely applied in a signalized intersection because of a traffic congestion of an intersection. But it is not certain that the left turn prohibition policy is always good alternative proposal to reduce traffic congestion. The left turn prohibition policy should be applied after the effect analysis of this policy considering

the traffic situation in a study area.
The methods of the effect analysis divide into the method using a signal optimizing models and the method using a route choice model.
The one is carried out by two step including the signal time analysis using SOAP(Signal Operations Analysis Package), Passer Ⅱ-90(Progression Analysis and Signal System Evaluation Routine), and TRANSYT-7F, and the network analysis using simulation modal. This method is useful to estimate the delay and the congestion according to the change of a phase time of the directional traffic flow in an intersection, not to forecast a traffic congestion diversion on an alternative path in a network.
The other is carried out by using EMME/2, TRANPLAN with setting a infinitely great(∞) on a left turn penalty. This method is useful to forecast a traffic congestion diversion on an alternative path in a network, not to estimate the delay and the congestion according to the change of a phase time of the directional traffic flow in an intersection
In short, all of these have a problem to estimate the effect of this policy under a real time traffic situation. The objective of this study is developing the consolidated model to estimate the effect of a left turn prohibition in a signalized intersection under a real time traffic situation, which is externally jointed of a dynamic route choice model and a signal optimizing model.
In this study, the consolidated model, to be composed of an instantaneous dynamic user optimal route choice model and AAP (signal optimizing model) is developed through developing a network representation scheme. It is certified through a sample network-applying test that this model can express not only a real traffic situation well, but also the effect of a traffic congestion diversion with providing the MOE for evaluating a network performance.

2. THEORETICAL BACKGROUND

2.1. Instantaneous dynamic user optimal route choice model

The Instantaneous dynamic user optimal route choice model systemized by Ran (1993) and jointly by Ran and Boyce (1994) may be summarized as follows:

$$\min_{u,vx,eE} \int_0^T \sum_a \{ \int_0^{u_a(t)} g_{1a}[x_a(t), w]dw + \int_0^{v_a(t)} g_{2a}[x_a(t), w]dw \} dt$$

Here, the first term is instantaneous cruise time on link a, and the second term is delay in waiting queue on link a. Both are assumed to be non-negative, and they are assumed to be differentiable for $[x_a(t), u_a(t)]$ and $[x_a(t), v_a(t)]$, respectively.

2.1.1 Definitions

Instantaneous Travel Time
Instantaneous link travel time at t is defined as the travel time experienced by a vehicle passing the link when the traffic condition does not change.

Definition of Instantaneous Dynamic User Optimal Condition

If the instant travel time for all the routes used, on every pair of origin and destination at each decision node at every instant on every pair of O/D, is same as the minimum instantaneous route travel time, the dynamic traffic flow on the network is in the state of dynamic user-optimal based on the link performance.

2.1.2 Constraints on Model Development

- **State Equation**

State Equation for the Link

With $x_a(t)$ representing the number of vehicles on link a at t hour, and $x_{ap}^{ij}(t)$ the number of vehicles on link a of route p departing at t hour from origin i for destination j, and $u_a(t)$ the inflow rate, vehicles/hour, to link a at t hour, and also $v_a(t)$ exit from link a, the condition equation for link a becomes as follows:

$$\frac{dx_{ap}^{ij}(t)}{dt} = u_{ap}^{ij}(t) - v_{ap}^{ij}(t) \qquad \forall a, p, i, j \tag{1}$$

State Equation for Destination

With $e_{ap}^{ij}(t)$ representing the instantaneous flow departing at t hour from origin i for destination j on route p, and with $E_p^{ij}(t)$ the cumulative number of vehicles arriving at destination j form origin I over route p by time t, the condition equation for the destination is:

$$\frac{dE_p^{ij}(t)}{dt} = e_p^{ij}(t) \qquad \forall p, i, j; i \neq j \tag{2}$$

- **Constraints on Flow Conservation**

Flow Conservation at Intermediate Node

The flow conservation equation at node n (n ≠ ij) on route p between the O-D pair i - j may be expressed as follows:

$$\frac{dE_p^{ij}(t)}{dt} = e_p^{ij}(t) \qquad \forall n \neq i, j; p, i, j \tag{3}$$

Where, A(n) denotes a set of the links that has n as its tail node, while B(n) that of the links which has n as its head node.

Equation for Flow Conservation at Origin

$$\sum_{a \in B(j)} \sum_{p} v_{ap}^{ij}(t) = f^{ij}(t) \qquad \forall i \neq j; j \tag{4}$$

Where, $f^{ij}(t)$ denotes the instantaneous flow from origin i to destination j at t hour.

Equation for Flow Conservation at Destination

$$\sum_{a\in B(j)} \sum_{p} u_{ap}^{ij}(t) = e^{ij}(t) \qquad \forall i \neq j; j \tag{5}$$

■ Constraints on Flow Propagation

For not only the flow but also inflow and exit on a link, the time to pass the link must be identical to the link performance. For static network model, it is assumed that flow propagates instantaneously throughout the route from its origin to destination and, therefore, no waiting queue is formed on the link, and so no constraints on flow propagation are necessary.

With regard to an intermediate node n (n≠ i) on route p, suppose subroute $\tilde{p}$ is part of route p between node n and destination j. With $\tau_a(t)$ denoting the actual travel time on link a (in B(n)), the vehicles on link a using route p at t hour are either of the following:

1. The number of vehicles increased on the downstream link of subroute $\tilde{p}$ at time [t $+\tau_a(t)$]
2. The number of vehicles that exited from the destination at time [t + $\tau_a(t)$]. This is formulated as follows:

$$x_{ap}^{ij}(t) = \sum_{b\in\tilde{p}} \{x_{bp}^{ij}[t+\tau_a(t)] - x_{ap}^{ij}(t)\} + \{E_p^{ij}[t+\tau_a(t)] - E_p^{ij}(t)$$

$$\forall a,n,p,i,j; n \neq i; a \in B(n) \tag{6}$$

2.1.3 Model Formulation

The instantaneous travel time $c_a[x_a(t),\ u_a(t),\ v_a(t)]$, or simply $c_a(t)$ on link a consists of:

$$c_a(t) = g_{1a}[x_a(t), u_a(t)] + g_{2a}[x_a(t), v_a(t)] \tag{7}$$

Where, $g_{1a}[x_a(t), u_a(t)]$: instantaneous cruise time on link a;
$g_{2a}[x_a(t), v_a(t)]$: Delay in waiting queue on link a.

It is assumed that $g_{1a}[x_a(t), u_a(t)]$ and $g_{2a}[x_a(t), v_a(t)]$ are not negative, and that they may be differentiated for $x_a(t)$, $u_a(t)$ and $x_a(t)$, $v_a(t)$ respectively.

Using optimal control theory, optimized model corresponding to instantaneous dynamic user optimal route choice model is formulated as follows:

$$\min_{u,vx,eE} \int_0^T \sum_a \{\int_0^{u_a(t)} g_{1a}[x_a(t), w]dw + \int_0^{v_a(t)} g_{2a}[x_a(t), w]dw\}dt \tag{8}$$

The following constraints in addition to the equations (1) - (6) are added to the above.

- **Constraints dependent upon definition of variables:**

$$\sum_{ijp} u_{ap}^{ij} = u_a(t) \qquad \sum_{ijp} v_{ap}^{ij} = v_a(t) \qquad \forall a \tag{9}$$

$$\sum_{ijp} x_{ap}^{ij} = x_a(t) \qquad \forall a \tag{10}$$

$$\sum_{p} x_{ap}^{ij} = x_p^{ij}(t) \qquad \sum_{ij} x_a^{ij} = x_a(t) \qquad \sum_{p} e_p^{ij} = e^{ij}(t) \tag{11}$$

- **Non-negativity constraints:**

$$x_{ap}^{ij}(t) \geq 0 \qquad u_{ap}^{ij}(t) \geq 0 \qquad v_{ap}^{ij}(t) \geq 0 \qquad \forall a,p,i,j \tag{12}$$

$$e_p^{ij}(t) \geq 0 \qquad E_p^{ij}(t) \geq 0 \qquad \forall p,i,j \tag{13}$$

- **Initial conditions:**

$$E_p^{ij}(t) = 0 \qquad \forall p,i,j \tag{14}$$

$$x_p^{ij}(t) = 0 \qquad \forall a,p,i,j \tag{15}$$

The control variables of the problem are $u_{ap}^{ij}(t)$ $v_{ap}^{ij}(t)$ and $e_p^{ij}(t)$ while its state variables are $x_{ap}^{ij}(t)$ and $E_p^{ij}(t)$. This model can be solved by converting the problem into nonlinear one through separation of time, and by estimating $\tau_a(t)$ the travel time $\bar{\tau}_a(t)$ for each link in the form of iterative diagonalization.
It also can be proved that the solution to this problem using optimal control theory is the instantaneous dynamic user optimal condition based on the travel time.

2.1.4 Model Algorithm

To convert instantaneous dynamic user optimal route choice model into a nonlinear problem, the time spaces [O, T] is divided into small time interval.
Then, optimal control problem can be reformulated as time dispersed nonlinear problem as follows:

$$\min_{u,v,x,e,E} Z = \sum_{k=1}^{K} \sum_{a} \{ \int_0^{u_a(k)} g_{1a}[x_a(k),w]dw + \int_0^{v_a(k)} g_{2a}[x_a(k),w]dw \} \tag{16}$$

Where,

$$x_{ap}^{ij}(k+1) = x_{ap}^{ij}(k) + u_{ap}^{ij}(k) - v_{ap}^{ij}(k) \qquad \forall a,p,i,j; k = 1,\dots,K \tag{17}$$

$$E^{ij}(k+1) = E^{ij}(k) + \sum_{a\in B(j)} \sum_{p} v_{ap}^{ij}(k) \qquad \forall i; j \neq i; k = 1,\dots,K \tag{18}$$

$$\sum_{a\in A(i)} \sum_{p} u_{ap}^{ij}(k) = f^{ij}(k) \qquad \forall i \neq j; k = 1,\cdots K \tag{19}$$

$$\sum_{a\in B(n)} v_{ap}^{ij}(k) - \sum_{a\in A(n)} u_{ap}^{ij}(k) = 0 \qquad \forall n,p,i,j; n \neq i,j; k = 1,\dots,K \tag{20}$$

$$x^{ij}_{ap}(t) = \sum_{b\in\bar{p}} \{x^{ij}_{bp}[k+\bar{\tau}_a(k)] - x^{ij}_{ap}(k)\} + \{E^{ij}_p[k+\bar{\tau}_a(k)] - E^{ij}_p(k)$$

$$\forall a,n,p,i,j; n \neq i; a \in B(n); k = 1,\ldots,K \qquad (21)$$

$$x^{ij}_{ap}(k+1) \geq 0 \quad u^{ij}_{ap}(k+1) \geq 0 \quad v^{ij}_{ap}(k+1) \geq 0 \quad \forall a,p,i,j; k = 1,\ldots,K \qquad (22)$$

$$e^{ij}_p(k+1) \geq 0 \quad E^{ij}_p(k+1) \geq 0 \quad \forall p,i,j; k = 1,\ldots,K \qquad (23)$$

$$E^{ij}_p(1) = 0 \quad x^{ij}_p(1) = 0 \quad \forall p,i,j \qquad (24)$$

This nonlinear problem is solved using diagonalization procedure and Frank-Wolfe algorithm.

2.2. Network Representation

A Real network is converted by various network representation method according to the object of study in the analysis of Network level.

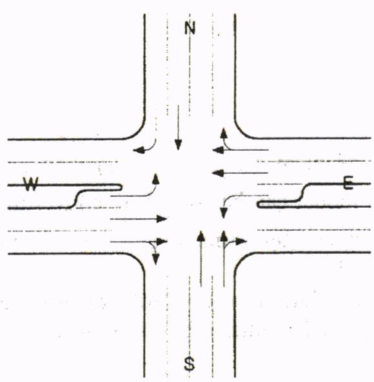

Figure 1. A single intersection (Sheffi, 1985)

A Real network as Figure 1 can be converted to figure 2-A or Figure 2-B. An intersecting point is a single node in Figure 2-A, but it is divided into 4 nodes for reflecting a real traffic flow situation as turning in a modeling work in Figure 2-B.

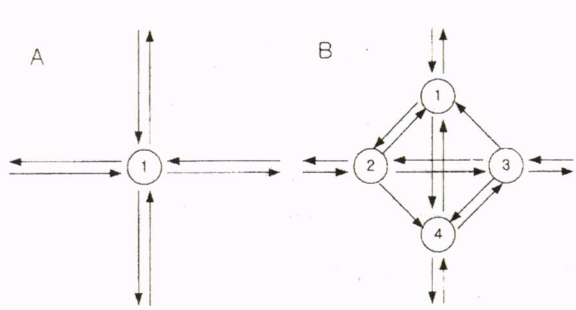

Figure 2. Examples of a single intersection representation

The network presentation method of Figure 2-A looks simple. Nevertheless, it has weak points: (a) difficulty in presenting the turning in an intersection, (b) difficulty in distinguishing between left-turn and right-turn in the view of travel cost (Sheffi, 1985). On the other hand, the method of Figure 2-B needs numerous CPU time in an analysis, result from increased nodes and links.

Mid-block node system, it is applied in several transportation planning models, has nodes in mid block as following Figure 3 in difference way of the above methods. It also has pretty many nodes and links, but has an advantage in reading easily total turning traffic flow rate in each direction.

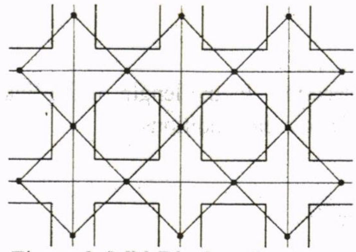

Figure 3. Mid-Block node system

The network presentation method of Figure 4 is known as SDI (Stochastic Dynamic Incremental) model. It has 3 nodes in the right side of approach road of an intersection as following figure. It also has pretty many nodes and links, but has an advantage in presenting the direction of traffic flow in more detail comparing with mid-block node system.

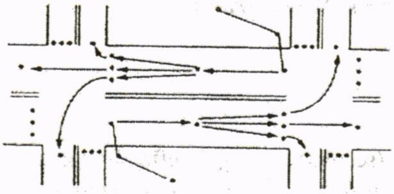

Figure 4. SDI (Stochastic Dynamic Incremental) model

The network presentation method of Figure 5 is developed for presenting U-turn traffic flow in TRANPLAN (Gi Ju Choi, 1995).

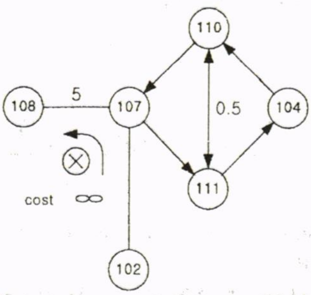

Figure 5. Network presentation considering U-turn

3. MODEL STRUCTURE

3.1 Link Performance Function For Dynamic Route Choice Model

3.1.1 Link Cruise Time

Cruise speed is dependent on the road and area conditions of the network involved. Accordingly, link travel time at cruise speed may be expressed simply as follows:

$$g_{1a}(k) = 3600\frac{l_a}{\overline{w}_a} \tag{25}$$

Here, g_{1a} is link cruise time (second), l_a the length of the link, and $\overline{w}_a$ the cruise speed (km/h) as determined by the road and area conditions.

3.1.2 Delay Time at Intersection

$$g_{2a}(k) = g_{2a_1}(k) + g_{2a_2}(k) \quad \forall a \tag{26}$$

Here, the first term is uniform delay, while the second term is overflow delay. The latter includes delay due to over-saturation during a specified travel period and random arrival effect.

- **Uniform delay by Webster's (1958) formula:**

$$g_{2a_1}(k) = \frac{0.5C[1 - g_e / C]^2}{1 - \rho_a(k) g_e / C} \tag{27}$$

Where, C is the signal cycle (second), and g_e is effective green time during time space k. The above expression is developed using Taylor's series as follows:

$$g_{2a_1}(k) = 32 + 1.13 \times A[1 + (\lambda\rho(k)) + (\lambda\rho(k))^2 + (\lambda\rho(k))^3 + (\lambda\rho(k))^4] \tag{28}$$

Where, $g_{2a_1}(k)$ is uniform delay, while $g_{2a_2}(k)$ is overflow delay, within the range where $\rho_a(k)$ can normally take ($0 < \rho_a(k) < 2$), then

- **Overflow delay:**

$$g_{2a_2}(k) = 900\,\Delta k[(\rho_a(k) - 1)^n + \sqrt{(\rho_a(k) - 1)^2 + \frac{m(\rho_a(k) - \rho_{a_0}(k))}{Q_a \Delta k}}] \tag{29}$$

Where, $[\rho_{a0}(k) = a + b \cdot s_a g_e]$ is saturated flow rate of link a, and $s_a g_e$ is capacity per cycle. And a, b, m, and n are calibrated parameters.
The delay function at intersections may be expressed as follows:

$$c_a(k) = g_{1a}(k) + g_{2a_1}(k) + g_{2a_2}(k) = 3600\,\frac{l_a}{w} +$$

$$32 + 1.13 \times A[1 + (\lambda\rho(k)) + (\lambda\rho(k))^2 + (\lambda\rho(k))^3 + (\lambda\rho(k))^4] +$$
$$900\,\Delta k[(\rho_a(k))^n \left[(\rho_a(k) - 1) + \sqrt{(\rho_a(k) - 1)^2 + \frac{m(\rho_a(k) - \rho_{a_0}(k))}{Q_a \Delta k}} \right]$$

Where, $-1 \le n \le 4$, $2 \le m \le 4$, n and m are integral numbers

3.2. Network Representation Scheme

3.2.1. Node System

Node system should satisfy following needs for being adapted for Instantaneous dynamic user optimal route choice model: (a) Possibility of presenting turning flow. (b) Equality of delay value between real network and presented network. (c) Preservation of shape of the cost function including link cruise time and delay time of an intersection

Applied network presentation method is as following Figure 6 based on Mid-Block node system. Where, link(1→ 5) has half length of link(a→ e), link(5→ 6) has such attributes as link(5→ 14) including number of lane and distance, link(6→ 7) and link(13→ 7) have same attributes also.

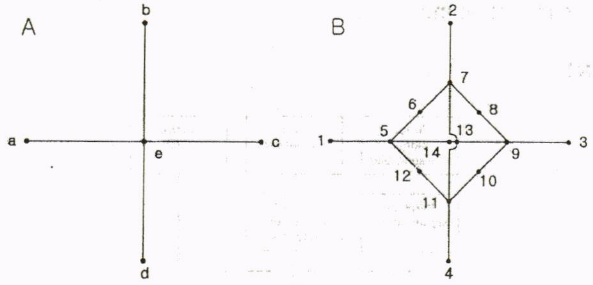

Figure 6. Real network and applied network

3.2.2. Lane Division

A lane division should be achieved, because the presented network has isolated lanes per each direction for satisfying needs for being adapted for Instantaneous dynamic user optimal route choice model. But there are no clear research results about how each turning flows use a lane in approach road. In this study, the lane division follows following assumptions: (a) Num. of lane allocated to left-turn traffic flow has such value as num. of left-turn lane when left-turn lane is. Otherwise it has 0.5lane. (b) Num. of lane allocated to right-turn traffic flow follows the same rules as left-turn traffic flow. (c) Num. of allocated through lane is total num. of lane minus num. of allocated lanes for left and right-turn traffic flows. In Figure 7, left-turn flow has 1lane, right-turn flow has 0.5, through lane has 2.5lane in east bound

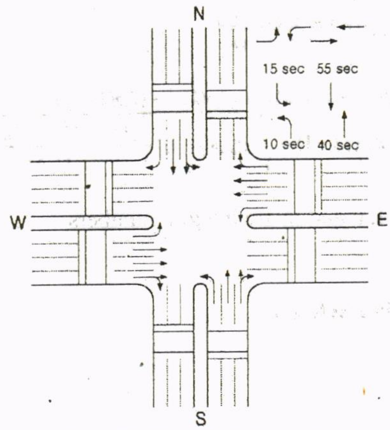

Figure 7. Sample intersection

3.2.3. Phase Division

A phase Division also should be achieved, because the presented network has isolated lanes per each direction. The phase division follows following assumptions: (a) left-turn and through flows cross the intersection only in each green time with not disturbing other direction flows. (b) Right-turn flow cannot cross the intersection in the green time of conflicted flows. In Figure 7, left-turn flow(link 5→ 6) has 15sec green time, right-turn flow(link 5→ 12) has 77sec green time (132sec - 40sec - 15sec), through lane(link 5→ 14) has 55sec green time in east bound

3.3. Applied Model

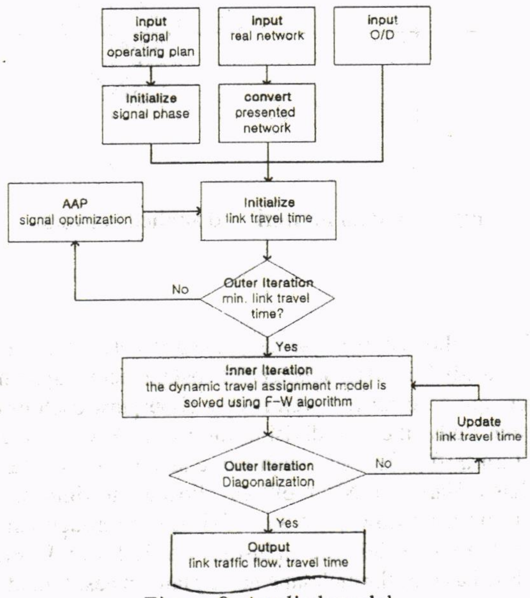

Figure 8. Applied model

4. MODEL APPLICATION

4.1. Preparation of the Basic Data

4.1.1. Composition of Transportation Network

The study network is composed of 32 nodes, which include 16 nodes (from 1 to 16) generating trips, and 40 links (two ways) and 16 intersections as following Figure 9-A. Each intersection has 4 approach roads with left-turn lane, 500M distances each other. The roads of study network are composed of 2 arterials (7-14, 3-10) with 8 lanes and 6 sub-arterials with 6 lanes. The presented network converted from study network is composed of 136 nodes, which include 16 nodes (from 1 to 16) generating trips, and 384 links as following Figure 9-B.

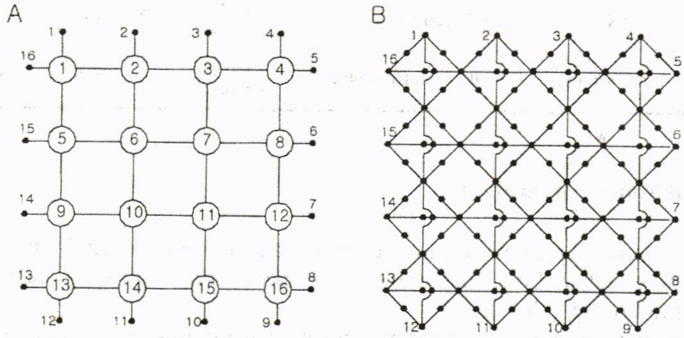

Figure 9. Study network and presented network

4.1.2. Preparation of O/D Data

The trips (O/D) are artificially generated with 10min intervals as following assumptions: (a) Tips of long distance are more generated then ones of short distance. (b) Trips using arterial are more generated then ones using sub-arterial. (c) Trips are generated according to percent of daily traffic of weekday morning (HCM 1994, pp2-22) from 7:00AM to 8:00AM.

4.1.3. Preparation of Scenarios

Scenarios are prepared for model evaluation in the view of the effect analysis of a left-turn prohibition in a signalized network. All scenarios are operated under the same network, trips (O/D), fixed cycle time (132sec) in all intersections. But each scenario have different phasing plan including left-turn prohibition for the purpose as following Table 1.

Table 1. Characteristics of each Scenario

Scenario	Left Turn Prohibition	Phase	Optimal Time Slice	Notes
S# 111	N.A	4 phases	N.A	Initialization
S# 124	N.A	4 phases	7:30-7:40	Optimization
S# 134	Intersection 9, 10, 11, 12 in south & north bound	3 phases 4 phases	7:30-7:40	Optimization
S# 144	Intersection 9, 10, 11, 12 in south & north bound Intersection 3, 7, 11, 15 in east & west bound	2 phases 3 phases 4 phases	7:30-7:40	Optimization
S#154	Intersection 11 in all directions	2 phases 4 phases	7:30-7:40	Optimization
S# 164	Intersection 11 in south & north bound	3 phases 4 phases	7:30-7:40	Optimization

4.2. Result of Model Application

The result of model application each scenario can be summarized in the views of tips including inflow and outflow, total travel time, leaved flows (inflow - outflow), and link Efficiency as following Table 2.

All Scenarios show good performance except for scenario 144 in the view of tips including inflow and outflow. Scenario 144 has a good value in total travel time, but this don't mean it is better scenario then others because the leaved flows after 1 hour are as many as 5054 vehicles. Scenario 134 has a good value in average travel time (total travel time / total outflow) and link Efficiency which means flows are widely distributed in network, calculated from increased trips omitted decreased trips of each scenarios based on scenario 124.

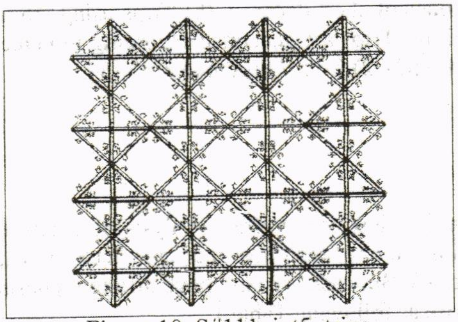
Figure 10. S#111, int5, trips

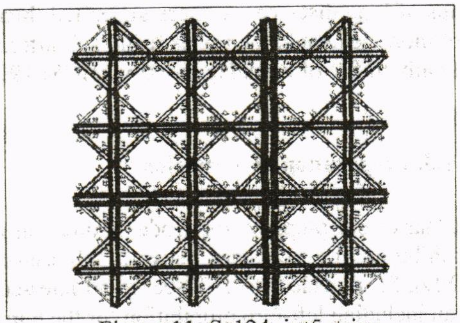
Figure 11. S#124, int5, trips

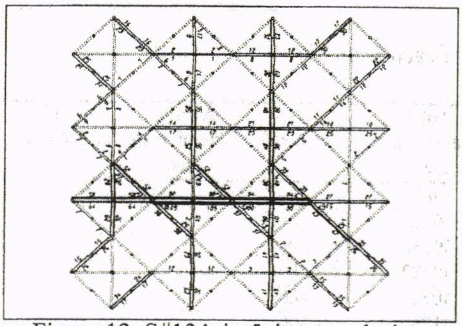
Figure 12. S#134, int5, increased trips

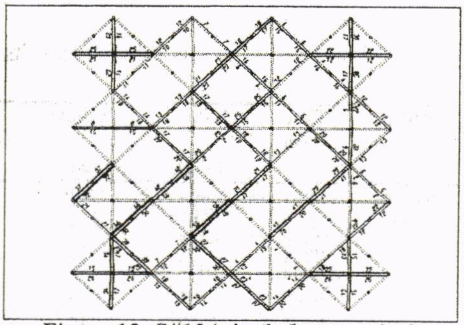
Figure 13. S#134, int5, decreased trips

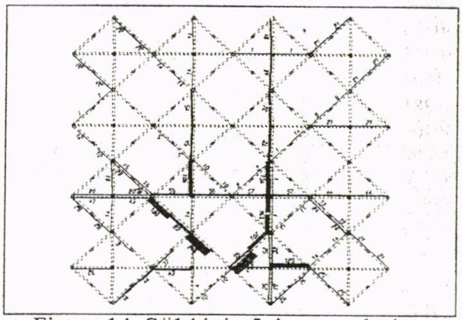
Figure 14. S#144, int5, increased trips

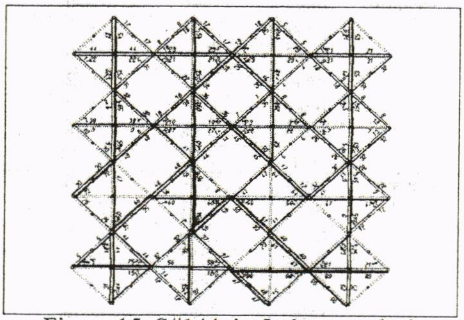
Figure 15. S#144, int5, decreased trips

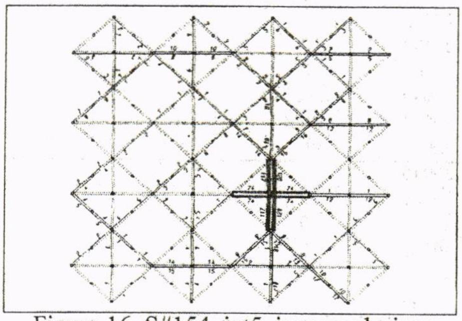
Figure 16. S#154, int5, increased trips

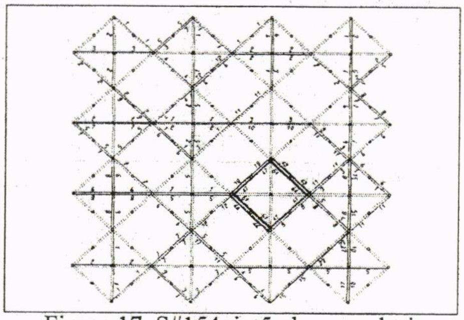
Figure 17. S#154, int5, decreased trips

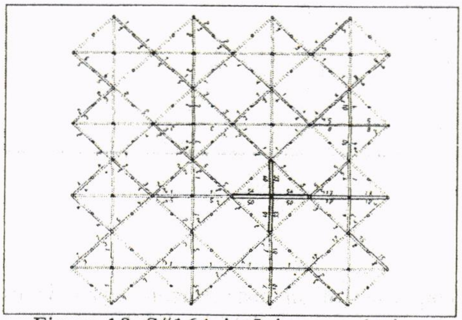
Figure 18. S#164, int5, increased trips

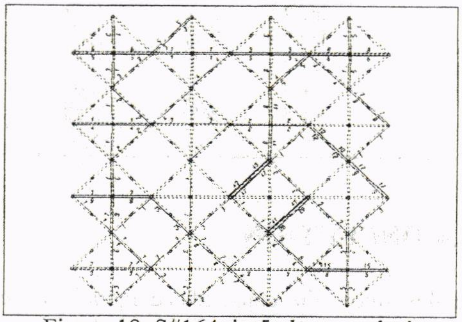
Figure 19. S#164, int5, decreased trips

Table 2. Results of each Scenario

Scenario	Time Slices	Inflow (veh)	Outflow (veh)	Total Travel Time (sec)	Inflow-Outflow (veh)	Average Travel Time (sec)	Link Efficiency
Scenario 111	Int#1	1864	1846	38809	0		
	Int#2	2352	872	36222	1480		
	Int#3	2349	781	39632	1568		
	Int#4	3072	781	40482	2291		
	Int#5	3507	965	40767	2542		
	Int#6	2688	944	41769	1744		
	Sum	15814	6189	237681	9625	38.4	
Scenario 124	Int#1	1846	1846	29766	0		
	Int#2	2352	2352	30258	0		
	Int#3	2349	2349	30258	0		
	Int#4	3072	3072	31504	0		
	Int#5	3507	3507	33281	0		
	Int#6	2688	2688	30700	0		
	Sum	15814	15814	185767	0	11.7	0
Scenario 134	Int#1	1846	1846	28269	0		
	Int#2	2352	2352	28736	0		
	Int#3	2349	2349	28733	0		
	Int#4	3072	3072	29981	0		
	Int#5	3507	3507	31812	0		
	Int#6	2688	2688	29177	0		
	Sum	15814	15814	176708	0	11.2	284
Scenario 144	Int#1	1846	1846	26885	0		
	Int#2	2352	2352	27345	0		
	Int#3	2349	2349	27332	0		
	Int#4	3072	3072	28566	0		
	Int#5	3507	2405	28630	1102		
	Int#6	2688	736	29512	1952		
	Sum	15814	12760	168270	3054	13.2	-5171
Scenario 154	Int#1	1846	1846	29046	0		
	Int#2	2352	2352	29561	0		
	Int#3	2349	2349	29550	0		
	Int#4	3072	3072	30781	0		
	Int#5	3507	3507	32604	0		
	Int#6	2688	2688	29985	0		
	Sum	15814	15814	181527	0	11.5	10
Scenario 164	Int#1	1846	1846	29399	0		
	Int#2	2352	2352	29901	0		
	Int#3	2349	2349	29898	0		
	Int#4	3072	3072	31098	0		
	Int#5	3507	3507	32809	0		
	Int#6	2688	2688	30334	0		
	Sum	15814	15814	183439	0	11.6	-4

5. CONCLUTION

In this study, the consolidated model, to be composed of an instantaneous dynamic user optimal route choice model and AAP (signal optimizing model) is developed through developing a network representation scheme. It is certified through a sample network-applying test that this model can express not only a real traffic situation well, but also the effect of a traffic congestion diversion with providing the MOE for evaluating a network performance. This model can be helpful for decision making of left turn prohibition policy under the policy is not always good alternative proposal to reduce traffic congestion.

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