A DYNAMIC TRAFFIC ASSIGNMENT MODEL USING THE CELL TRANSMISSION

Seungjae Lee
Assistant Professor
Department of Urban Engineering
University of Seoul
8-3, Jeon-Nong Dong, Dongdaemun Gu,
Seoul, 130-743, Korea
Fax: +82-02-215-5097
E-mail : sjlee@uoscc.uos.ac.kr

Juyoung Kim
Researcher
Department of Urban Transportation
Seoul Development Institute
San4-5, Yejang-dong, Chung Gu,
Seoul, 100-250, Korea
Fax: +82-02-726-1921
E-mail : jykim@www.sdi.re.kr

Euiyoung Shon
Assistant Professor
University of Seoul

Sinhae Lee
Researcher
Seoul Development Institute

Abstract : The purpose of this study lies in the development of the dynamic traffic simulation model describing traffic flow characteristics realistically on expressways. This model has various characteristics in comparison with the existing dynamic traffic simulation models. Firstly, the travel cost can be divided into free travel times and delay times. Secondly, it enables to model effects of an HOV lane operation. Thirdly, a heuristic method that traffic flows are assigned based on shortest path every time slice, is adopted according to destinations, the kind of vehicles and waiting times existed in the diverging cell. Fourthly, the modal split module decides a real time ratio by means of applying O-D demands, which are produced by the dynamic O-D generation module, to utility function of each mode. The developed model in this study can be used in expressway operation and management through some verification and modification steps.

1. INTRODUCTION

The number of vehicles in Korea has been continuously increased since 1980's. In addition, the demand on the roads and other transportation facilities has been in overflow. Therefore, travel demand management and traffic operation policies should be applied to improve current transportation problems. In order to do so, it is necessary to develop a dynamic traffic simulation model which is enable to analyze congestion sections, effects of improvement alternatives and HOV lane operation.

The purpose of this paper is modeling of a dynamic traffic simulation and development of a dynamic traffic assignment technique, which is suitable to the dynamic traffic simulation. This dynamic traffic simulation model is enable to analyze congestion sections on expressway and effects of HOV lane. In this study, some outputs that are obtained using test network are analyzed. The results of the bottleneck sections and the HOV lane are almost similar to realistic situations. And the dynamic traffic assignment procedure every time slice maintains the similar average cost on each path.

This paper is organized as follows; Section 2 introduces existing traffic flow theories. Section 3 describes dynamic traffic simulation modules. Section 4 estimates an organized dynamic traffic simulation model. Finally section 5 discusses conclusion and future studies.

2. A STUDY OF EXISTING TRAFFIC FLOW THEORIES

The traffic flow theory, which is suitable to be used in a dynamic traffic simulation model, is a dynamic traffic flow theory such as *Continuum Model* and *Cell Transmission Model*. This chapter shows strong and weak points of each theory.

2-1. The Continuum Models

The continuum model considers traffic flow as dividing expressway into road sections and time slices. Conservation equation in this model is as follow.

$$\frac{\partial q}{\partial x} + \frac{\partial k}{\partial t} = g(x,t) \tag{1}$$

Where, g(x,t) is the generation(dissipation) rate in vehicles per unit time per unit length

This model analyzes the current section density using the upstream and downstream section's density of previous time slice and analyzes velocity and traffic flow rate using equation $q = uk$. The continuum model consists of the simple continuum model and the high order continuum model.
The simple continuum model has shortcomings which can not describe acceleration and deceleration of vehicles and which can not cover hysteresis phenomenon of dynamic behaviors of traffic flow. The simple continuum model is not adequate in the status of overflows. In order to cover these shortcomings, the high order model that has applied a momentum equation and viscosity model is proposed. This model has merits that can describe complex phenomenon of a lane change, a merging section, a diverging section and a weaving section. But parameters used in this model are too complex in calculation to be used adequately in dynamic simulation models.

2-2. Cell Transmission Model

A cell transmission model, which has been modeled by *Daganzo,* describes traffic flows based on macro model by dividing a link into sections that have same characteristics. The relation between flow rate and density is considered as linear. This model can not analyze in detail as much as the high order continuum model. But this model can describe traffic flow easily and realistically and is adequate to a dynamic traffic assignment model, for it can be adopted to large networks as a dynamic assignment model easily. Because of these reasons, we will use the *CELL TRANSMISSION MODEL* as the traffic flow theory that is used in a dynamic traffic simulation model.

3. MODELING OF DYNAMIC TRAFFIC SIMULATION MODEL

The purpose of this chapter is modeling the dynamic simulation using the cell transmission theory and the special lane theory as the traffic flow theory.

3-1. Dynamic O-D Generation Module

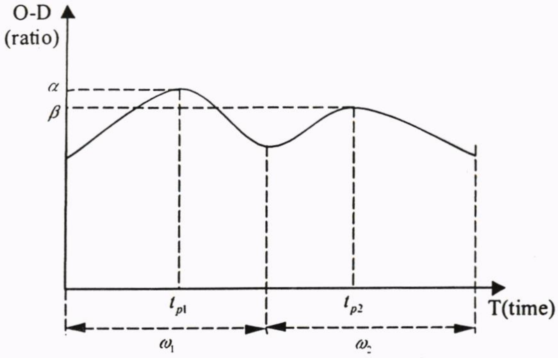
The travel pattern of within-day can be obtained using the historical data on expressways. Thus the travel pattern is modeled as the following function.(2)

The dynamic O-D generation equation ;

$$P_{rs}(t) = \alpha \exp\left(-\frac{(t-t_{p1})^2}{\omega_1}\right) + \beta \exp\left(-\frac{(t-t_{p2})^2}{\omega_2}\right) \tag{2}$$

Where, $P_{rs}(t)$: The O-D ratio between origin r and destination s at time t
ω_1, ω_2 : The degree of dispersion on peak-hour (t_{p1}, t_{p2})
t_{p1}, t_{p2} : The first and second peak-hour
α, β : The maximum flow rate ratio of each peak-hour

The O-D ratio is calculated by value of $\alpha, \beta, t_{p1}, t_{p2}, \delta_1$ *and* δ_2. And these values can be estimated using the historical data of each O-D.



Assumption ; the travel pattern on the expressway has two peak-hours in a day and parameters used in the function are time slice, a maximum flow rate ratio and a degree of dispersion.

Figure 1. Dynamic O-D demand generation

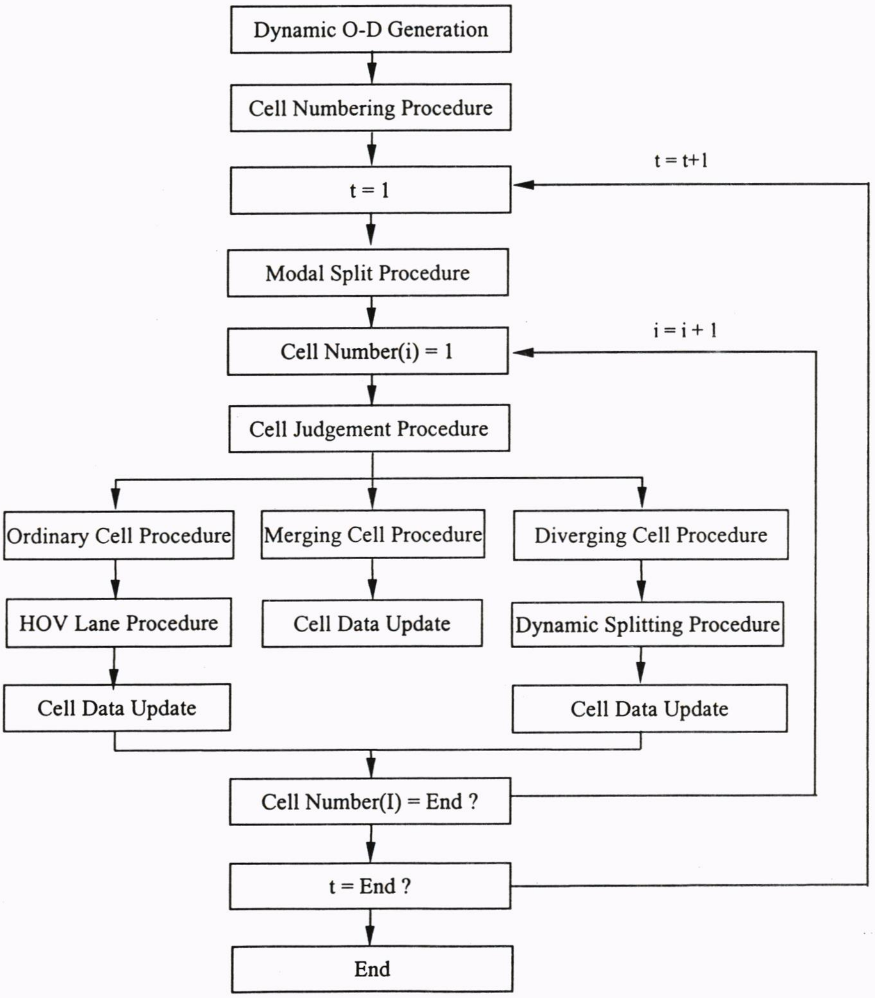


Figure 2. Flowchart of procedure

3-2. Modal Split Moduleuu

The binary logit mode' is adopted in this model for calculating modal split of two modes (bus and auto). The ratios of choice and captive riders are defined by user. In order to calculate a modal split ratio of choice riders, we use the following parameters : in-vehicle travel time (IVTT), fare and out-vehicle travel time(OVTT). The IVTT of each time slice is calculated by means of a link performance function in the traffic simulation model. The fare of each mode consists of oil cost, fare and additional cost. The OVTT consists of access time and average waiting time of service interval.

The generalized cost of vehicle by O-D pair and by mode is calculated using the above variables. And the modal split ratio of bus is calculated by means of the following equation (3).

$$P_{bus} = \frac{1}{1+\exp\{-\lambda(C_{auto}+\pi+C_{bus})\}} \qquad (3)$$

Where, λ is the dispersion parameter (it is supposed as 0.75 in this model)
π is the modal penalty (it is supposed as 3.5 in this model)
C_{auto}, C_{bus} are the generalized costs of auto and bus respectively

3-3. Traffic Flow Procedure Rule

1. Ordinary cell

In this model, the traffic flow is described by means of *CELL TRANSMISSION MODEL* and *SPECIAL LANE THEORY.*

(1) Transmission rule

The *CELL TRANSMISSION MODEL* can advance vehicles by means of rule that transmit the minimum vehicles between maximum flows $S_i(t)$ sent by upstream cell and maximum flows $R_{i+1}(t)$ received by downstream cell.

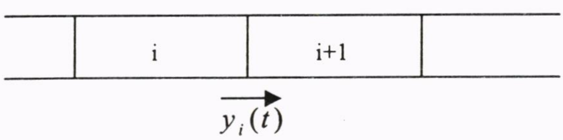


Figure 3. Transmission of ordinary cell

$$\begin{aligned} S_i(t) &= \min\{Q_i, n_i\} \\ R_{i+1}(t) &= \min\{Q_{i+1}, \delta_{i+1}[N_{i+1}-n_{i+1}]\} \\ y_i(t) &= \min\{S_i(t), R_{i+1}(t)\} \end{aligned} \qquad (4)$$

Where, Q_i is the maximum number of vehicles that can flow into cell i
= The capacity of cell i times time slice length
n_i is the number of vehicles contained in cell i
N_i is the maximum number of vehicles that can be present in cell i
= The cell length times jam density of cell i
$S_i(t)$ is the maximum number of vehicles that can be advanced from cell i
$R_{i+1}(t)$ is the maximum number of vehicles that can be advanced to cell $i+1$

If the inflow $y_i(t)$ of every cell has been calculated using the above equation, the waiting time a_{BK} should be calculated. And the every cell data should be updated using the following equation (5).

$$n_i^{'}(t) = n_i(t-1) - y_i(t) + y_{i-1}(t) \tag{5}$$

(2) HOV lane module

This module defines transmission rules based on Daganzo's special lane theory when HOV lane exists in expressway.

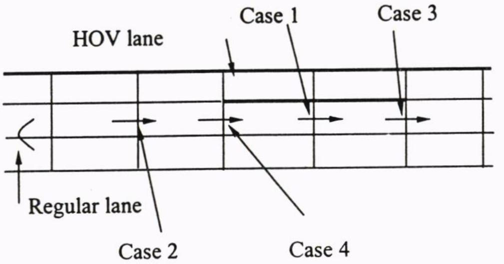


Figure 4. Transmission of HOV lane

<Case 1>
The case which transmission takes place between cells in which HOV lane exist;

$$y = \min\{s(k^u)\ ;\ r(k^d)\}$$
$$Y = \min\{S(K^u); R(K^d)\} \tag{6}$$

<Case 2>
The case which transmission takes place between sections in which HOV lane doesn't exist;

$$(Y, y) = (\gamma^u; 1-\gamma^u)\ \min\{S_T(K_T^u); R_T(K_T^d)\} \tag{7}$$

<Case 3>
The case which transmission takes place between sections in which HOV lane exists and sections in which doesn't exist ;

$$K^d = (0\ ,\ 0) \qquad if\ K^d < K^o$$
$$K^d = (\gamma^u, 1-\gamma^u) K_T^d \quad if\ K^d > K^o \tag{8}$$

The <Case 3> is applied to <Case 1> using the density of downstream sections which were calculated in equation (8).

<Case 4>
The case which transmission takes place between sections in which HOV lane doesn't exist and section in which exists ;

$$Y_T = r(k^d) + R(K^d)$$
$$Y = \min\{R(K^d); Y_T\gamma^u\} \qquad if\ S_T(K_T^u) > R(K^d) + r(k^d) \tag{9}$$
$$y = Y_T -- Y$$

$$y = s(k^u)$$
$$Y = S(K^u) \qquad if\ S_T(K_T^u) \le R(K^d) + r(k^d) \tag{10}$$

Where, Y, y are HOV and regular vehicles flow rate which transmit from upstream section to downstream
K^u, k^u are the density of HOV and regular vehicle at upstream section
K^a, k^a are the density of HOV and regular vehicle at downstream section
K_T^u, K_T^a are the total density of at upstream and downstream section
K^o is the optimal density
γ^u are the proportion of HOV vehicles in the traffic stream of the upstream and downstream section.

2. Merging cell

It is important to decide a priority ratio in the merging section. In this model, merging ratio is defined as the number of lane.

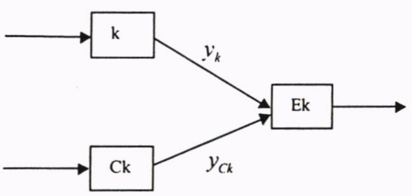


Figure 5. Merging cell

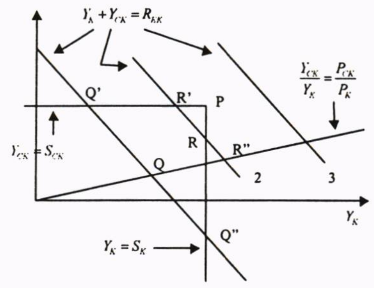


Figure 6. Diagram of feasible flows for a merge junction

The flows must satisfy following equations.

$$y_K(t) \leq S_K \;\; ; \;\; y_{CK}(t) \leq S_{CK} \quad \text{and} \quad y_K(t) + y_{CK}(t) \leq R_{EK} \tag{11}$$

As was done for ordinary cells and links, it will be assumed that cells K and CK send the maximum traffic as possible as cell EK can receive it.

$$y_K(t) = S_K \quad \text{and} \quad y_{CK}(t) = S_{CK}, \qquad \text{if} \quad R_{Ek} = S_K + S_{CK} \tag{12}$$

But, if the condition in equation (12) is not satisfied, it is necessary to define the priority ratio p_k, where $p_K + p_{CK} = 1$.

$$y_K(t) = mid\{S_K, R_{EK} - S_{CK}, p_K R_{EK}\}$$
$$y_{CK}(t) = mid\{S_{CK}, R_{EK} - S_{BK}, p_{CK} R_{EK}\} \qquad if \; R_{Ek} \langle \; S_K + S_{CK} \tag{13}$$

3. Diverging cell

(1) Dynamic splitting module

The dynamic splitting module assigns vehicles based on shortest paths heuristically. The cell traffic data is classified by a destination, a waiting time, kinds of vehicles. In order to apply FIFO rule, vehicles are assigned on shortest paths by destination in terms of decreasing a waiting time τ by 1 until a convergence criterion is satisfied. There is an assumption that drivers select only the shortest path.

[Algorithm]

<STEP 0> Initialization

τ = max (The maximum waiting time)

<STEP 1> Searching the shortest path by destination

<STEP 2> Transmission ratio decision

If $y_\tau^{ld} \le Acapa(fc) \rightarrow p=1$;

If $y_\tau^{ld} > Acapa(fc) \rightarrow p=\dfrac{ACapa(fc)}{y_\tau^{ld}}$;

Where, $ACapa(fc)$ is the capacity that can be transited on the forward cell of every destination.

y_τ^{ld} is the flow rate that will advance at the forward cell on shortest path

<STEP 3> Vehicles transmission

Transmit vehicles $y_\tau \times p$

<STEP 4> Update cost

<STEP 5> Update cell data

<STEP 6> Convergence test

If a convergence test satisfies only one of the following rules, terminate. Otherwise, set $\tau=\tau-1$ (if $p=1$) or $\tau=\tau$ (if $p<1$)

Rule 1> If the capacity that can be receive at the forward cell of every destination = 0
Rule 2> If the flow rate that will send at diverging cell = 0
Rule 3> If the waiting time $\tau = 0$

(2) Cost update module

If vehicles were transmitted every iteration in a dynamic splitting module, the forward cell cost should be updated in correspondence with a link performance function in order to search shortest paths of the next iteration. The relation between traffic flow and cost during a time slice is as following.

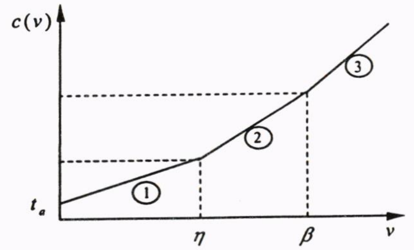


Figure 7. The relation between cost and traffic flow

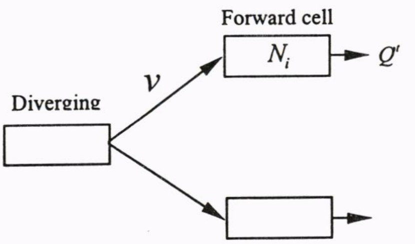


Figure 8. Diverging cell

The cost of vehicles advancing at the forward cell is estimated using above two figures.

$$c(v) = t_\eta v \qquad If\ \ v < \eta \tag{14}$$

$$c(v) = c(\eta) + (t_\eta + 1)(v - \eta) \qquad If\ \ v \ge \eta$$

The waiting cost t_a that the head vehicle passed through the forward cell should be estimated.

$$t_\alpha = INT\left(\frac{N_i}{Q'}\right) \tag{15}$$

$$\eta = Q' - MOD\left(\frac{N_i}{Q'}\right)$$

Where, v is the vehicles that are transmitted from the diverging cell.
t_α is the waiting time that the head vehicle passes through the forward cell.
η is the vehicles of v that can pass through at time t_α.

3-4. Ramp Splitting Procedure

The traffic flow splitting procedure between ramp and expressway cell should be treated unlikely with the splitting procedure between expressway cells which was explained the previous chapter. That must be connected with the toll gate system. The off-ramp splitting procedure is applied FIFO principle and queuing spill back condition according to the constraint of off-ramp capacity.

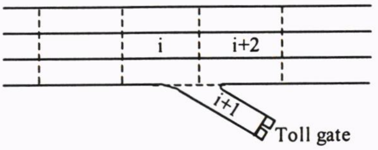


Figure 9. The presentation of off-ramp diverging

When queuing according to the inferior toll gate capacity in cell (i+1) affects traffic flow passing through on expressway, users must determine the range of lane(1, 1.5, 2...) influenced by ramp queue. This paper assumes that only one lane would be influenced by the off-ramp queue. By means of this principle, incident effect also can be analyzed.

3-5. Waiting Time Decision and Link Performance Function

1. Waiting time decision

The cell data set keeps track of vehicles by a waiting time τ, a destination d, a kind of vehicle l. If we define the maximum waiting time as max and the waiting time as τ in figure(10), the general function of cumulative vehicles can be defined as following.

$$Y_\tau = \sum_{\tau}^{\max} y_\tau - \left(\sum_{\tau}^{\max} y_\tau - \sum_{\tau+1}^{\max} y_\tau\right)(a_{BK} - \tau) \tag{16}$$

In order to calculate a_{BK}, the cell transmission traffic flow y_i must be calculated in the traffic flow procedure rule. If y_i has been calculated, we calculate the value of a_{BK} satisfying the following equation every τ.

$$a_{BK} = \frac{\sum_{\tau}^{\max} y_\tau - Y_k}{\sum_{\tau}^{\max} y_\tau - \sum_{\tau+1}^{\max} y_\tau} + \tau \tag{17}$$

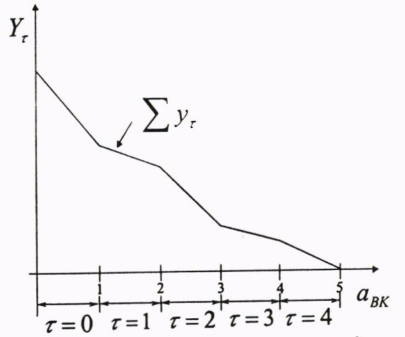


Figure 10. Graphical representation of $\angle y_k$

2. Link performance function

The cell travel time consists of free travel time and delay time in each cell. The free travel time is a time slice that is required to travel the cell with free speed. The delay time is calculated using waiting time τ of vehicles that stay in cell. And the cell travel time is calculated by the following equation for each kind of vehicles.

(1) The case that HOV lane doesn't exist

Average delay (for vehicles using HOV lane and vehicles using the regular lane)

$$= \sum_{\tau} (y_{\tau}^{ld} \times \tau) \;/\; \sum_{\tau} y_{\tau}^{ld} \qquad for\ \forall\ \tau \tag{18}$$

(2) The case that HOV lane exists

- Average delay time of vehicles using the HOV lane

$$= \sum_{\tau} (y_{\tau}^{ld} \times \tau) \;/\; \sum_{\tau} y_{\tau}^{ld} \qquad for\ \ l = HOV\ lane,\ \ \forall\ \tau \tag{19}$$

- Average delay time of vehicles using the regular lane

$$= \sum_{\tau} (y_{\tau}^{ld} \times \tau) \;/\; \sum_{\tau} y_{\tau}^{ld} \qquad for\ \ l = regular\ lane,\ \ \forall\ \tau \tag{20}$$

3-6. Shortest Path Searching Module

This module must search the forward cell that vehicles advance on shortest paths every destination at diverging cell. In order to do this, Modified Fixed Matrix Method (MFMM) is adequate to the shortest path algorithm. The MFMM is the modified algorithm that fixed matrix method (FMM), which finds the back-node matrix with minimum path, can estimate the fore-node matrix of the network as adopted by transposition of node matrix.

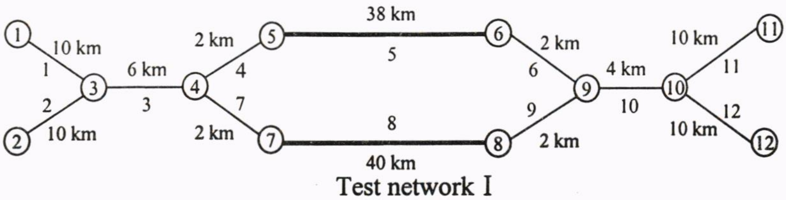
4. ANANLYSIS AND VERIFICATION OF MODEL

In this section, we illustrate the solution of dynamic traffic simulation model with the 12-node, 12-link test network I (Figure11) and with the 20-node, 20-link test network II (Figure 21). Analysis period (2 hr) is subdivided into 100 time slices (72 sec by a time slice). Not only verification of calculation procedure but also the result of simulation is analyzed.

4-1. Test network I

The toy network applied in this paper consists of two origins and two destinations as the following figure (11).

1. Input Data



Test network I

Figure 11.

(1) O-D data

Table. 1. O-D input data

Origin	Desti-nation	α_1	α_2	δ_1	δ_2	t_{p1}	t_{p2}	Auto demand (veh/day)	Bus demand (veh/day)
1	11	0.06	0.06	30	30	8	18	150000	7000
1	12	0.06	0.06	30	30	8	18	140000	5000
2	11	0.06	0.06	30	30	8	18	160000	6000
2	12	0.06	0.06	30	30	8	18	130000	6000

(2) Mode choice data

Table. 2. Mode choice input data

Origin	Desti-nation	Auto fare (won)	Bus fare (won)	Access time (hour)	Time value (won)	Auto average passenger (per/veh)	Bus average passenger (per/veh)
1	11	20000	10000	1	5000	2.2	20
1	12	22000	10000	1	5000	2.2	20
2	11	20000	10000	1	5000	2.2	20
2	12	22000	10000	1	5000	2.2	20

(3) Link data

Table. 3. Link input data

Link Number	Upstream Node	Downstream Node	Length	Free Speed	Lane	Capacity	Jam density	HOV lane
1	1	3	10	100	2	0.6	140	0
2	2	3	10	100	2	0.6	140	0
3	3	4	6	100	4	0.6	140	0
4	4	5	2	100	3	0.6	140	0
5	5	6	38	100	3	0.6	140	1
:	:	:	:	:	:	:	:	:
12	10	12	10	100	2	0.6	140	0

2. Verification of Calculation Procedure

(1) Cell numbering

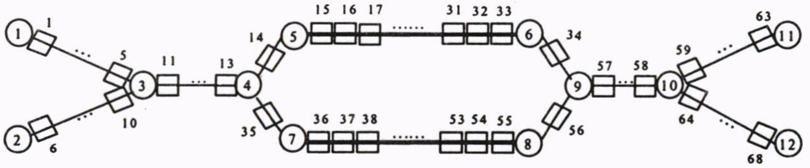


Figure 12. The result of cell numbering procedure

The cell numbering procedure plays a role in converting a link-base data to a cell-base data. The cell length is 2 km and the capacity is 0.6 $veh/\sec$. In order to analyze the bottleneck, the lane of link 10 decreases from 4 lane to 2 lane.

(2) Verification of traffic flow transmission between cells

In this section, we verify that transmission procedure of an ordinary, a diverging and a merging cell is advanced as previously stated.

Table 4. Transmission between cells which HOV lane exists

Time slice	Data of cell 54		Transm-issible Flow	Maximum Waiting time		Data of cell 55		Transmission flow	
	Auto	Bus		Auto	Bus	Auto	Bus	Auto	Bus
76	65	10	75	0.00	0.00	516	87	65	10
77	82	10	68	0.11	0.00	538	91	58	10
78	128	9	39	0.71	0.00	533	95	29	10
79	168	9	45	1.32	0.00	531	99	35	9
80	205	10	47	1.73	0.00	532	102	37	9
81	241	10	47	2.34	0.00	535	106	37	10

Table 5. Transmission between cell which HOV lane doesn't exist and cell which exits

Time slice	Data of cell 35		Trans-missible flow	Maximum Waiting time		Data of cell 36		Transmission flow	
	Auto	Bus		Auto	Bus	Auto	Bus	Auto	Bus
57	66	10	75	0.02	0.00	65	10	65	10
58	76	10	75	0.02	0.00	65	10	65	10
59	76	11	85	0.01	0.00	75	10	75	10
60	79	10	85	0.01	0.09	75	9	75	9
61	79	12	85	0.04	0.13	75	9	75	9
62	81	12	85	0.07	0.09	74	10	74	10

Table 6. Merging cell procedure

Time Slice	Data of cell 34				Data of cell 56				Inflow at cell 57
	Auto	Bus	Trans-mission flow	Maximum waiting time	Auto	Bus	Trans-mission flow	Maximum waiting time	
30	64	9	73	0.00	0	0	0	0.00	73
31	45	10	43	0.33	53	10	43	0.31	86
32	67	13	43	0.73	71	12	43	0.69	86
33	78	7	43	1.20	81	17	43	1.17	86
34	99	11	43	1.53	103	32	43	1.50	86
35	110	19	43	1.89	115	35	43	1.86	86
36	131	28	43	2.35	136	36	43	2.31	86

Table 7. Diverging cell procedure

Time slice	Data of cell 13		Cost of path 1	Inflow at cell 14		Cost of path 2	Inflow at cell 35	
	Auto	Bus		Auto	Bus		Auto	Bus
9	101	21	275	65	10	272	53	9
10	101	21	321	45	10	330	56	11
11	101	21	378	56	11	375	45	10
12	101	21	423	45	10	432	56	11
13	101	21	480	56	11	477	45	10
14	101	21	525	45	10	534	56	11
15	101	21	582	56	11	579	45	10

3. The Result of Analysis

(1) The result of dynamic assignment

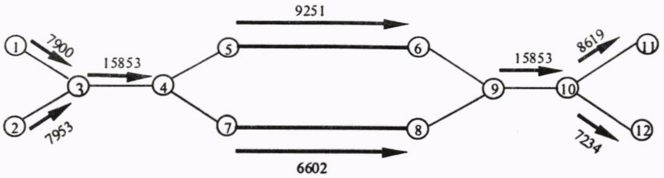


Figure 13. The result of dynamic assignment

(2) The analysis of the bottleneck

Figure (14) is the result of bottleneck effect analysis according to lane decrease of link 10. The auto experiences congestion from cell 56 to cell 53. But the bus experiences congestion only the cell 56 and the cell 55. It means that the bus goes through the congestion section faster than the auto.

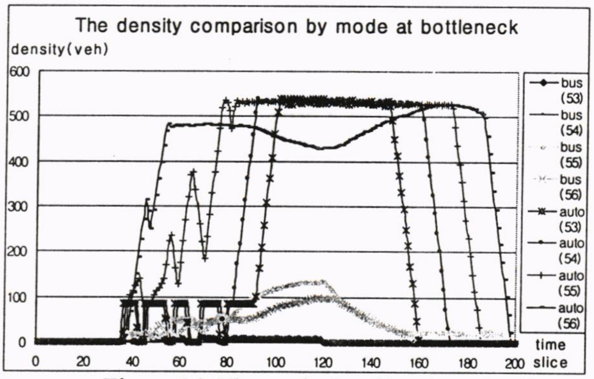


Figure 14. The analysis of bottleneck effect

(3) The comparison of average cost by path

Figure (15) shows the comparison of average cost between path 1(4→5→6→9) and path 2 (4→7→8→9). Since a heuristic technique has been used in the dynamic splitting

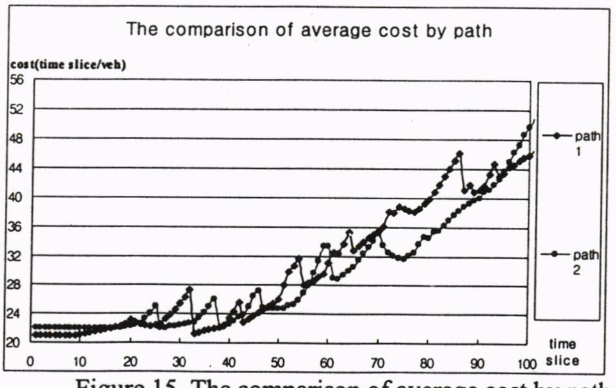


Figure 15. The comparison of average cost by path

module, the average cost by path is maintained similarly by every time slices.

Figure (16) is the result of the comparison of total cost between path 1(4→5→6→9) and path 2 (4→7→8→9). Since the average cost of path 1 is lower than path 2 initially, many vehicles select the path1. At time slice (85) the total cost of path2 exceed that of path1.

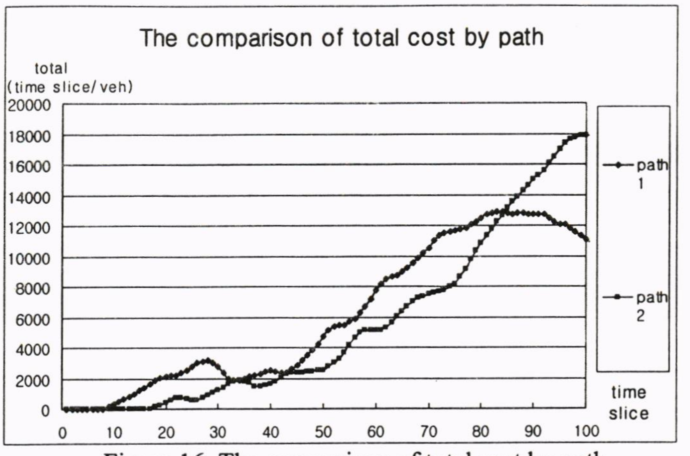


Figure 16. The comparison of total cost by path

(4) The comparison of average cost by mode

Figure (17) shows the comparison of average cost by mode between origin 1 and destination 11. According to growth of congestion, the cost of auto becomes higher than that of bus. It is analyzed as the result of the HOV lane effect.

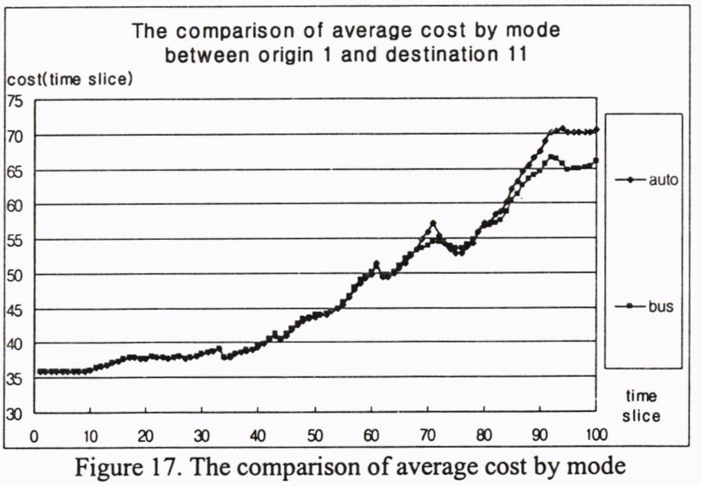


Figure 17. The comparison of average cost by mode

(6) The analysis of HOV lane effect

Figure (18) shows the comparison of total cost between the case which the HOV lane exits at lane 5 and lane 8 and the case which does not exist. As congestion is growing extremely, the gap of total cost is growing too. The effect of HOV lane can be analyzed as this.

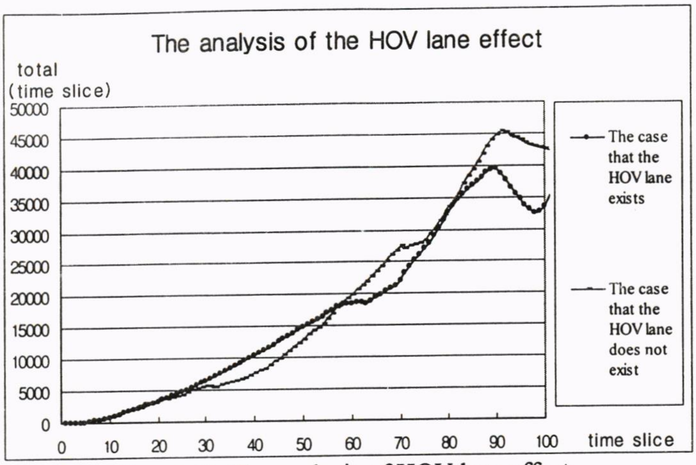


Figure 18. The analysis of HOV lane effect

4-2. Test network Ⅱ

The test network Ⅱ applied in this paper consists of two origins and four destinations as the following figure (19).

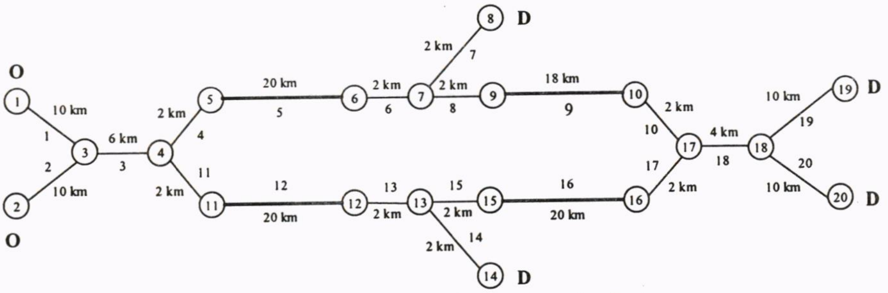


Figure 19. The analysis of mode choice

2. The Result of Analysis

(1) The result of dynamic assignment

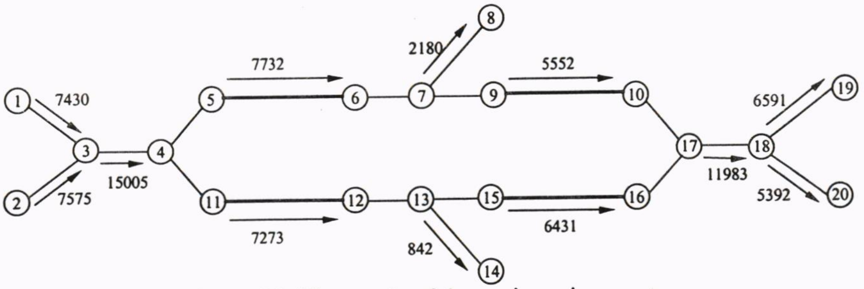


Figure 20. The result of dynamic assignment

(2) The comparison of average cost by path

Figure (21) shows the comparison of average cost between path 1(4→5→6→8→9→10) and path 2 (11→12→13→15→16→17). When it is compared with the network I , the assignment of network II shows more nice result. It means that the more complex network give the better results

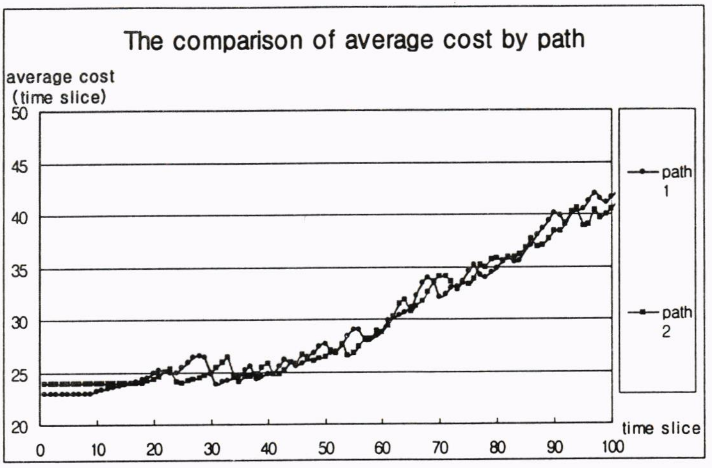


Figure 21. The comparison of average cost by path

5. CONCLUSION

In this paper, a dynamic traffic simulation model is constructed using *CELL TRANSMISSION THEORY* and *SPECIAL LANE THEORY*, which can be used an analysis of expressway congestion sections, dynamic assignment and HOV lane effect. We can see that this model describes traffic flow realistically according to outputs of section 4. But there are several limits that must be improved by future studies and it is important that we verify this model using real data of expressways. If it has been decided that this model describes real traffic flow very well by means of verification, this model can be used as an analysis tool of many purposes including ITS.

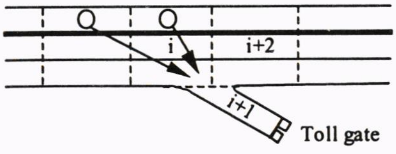
5-1. The required future studies

1. Methodological problem

(1) HOV lane theory :

The existing Danganzo's HOV lane theory has some requirement of development. When HOV vehicle at cell (i) and cell (i-1) wish to proceed to ramp cell (i+1), the adequate transmission theory is required. In real condition, we can see expressway structure easily as same as figure 26.

Figure 19. HOV lane and ramp diverging section



(2) Short-term prediction module :

The short-term prediction module is necessary at the dynamic traffic splitting module for equilibrium by path, since delay according to bottleneck or incident can not discover at diverging cell. Figure (16) which compares the average cost by path shows unstable equilibrium by path by means of this condition.

2. Application problem

In order to apply this dynamic traffic assignment to the expressway analysis, we should do some test. Firstly, the parameter value should be adjusted to describe the expressway characteristics accurately. Secondly, this dynamic traffic simulation model should be verified that it explains the expressway traffic flow as realistically.

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