

# TRAFFIC FLOW MODELS FOR ROAD NETWORKS

**Presented By**  
**Team 2**

## OUTLINE

- Motivation
- Introduction
- Problem statement
- Classification
- Related work
- Microscopic models
- Macroscopic models
- Mesoscopic models
- Comparison
- Future work
- Conclusion



## MOTIVATION

- Traffic congestion is a serious problem, that we have to deal with in order to achieve smooth traffic flow conditions in road networks.
- Also expanding infrastructure of road networks such as widening the roads was just not sufficient to handle the smooth traffic flow conditions in road networks due to increased traffic demands



# INTRODUCTION

- Traffic congestion is one of the major problems affecting the whole world
- Intelligent transportation systems like ATMS and ATIS face a big challenge in controlling traffic congestion and estimating the traffic flow in road networks.
- To model efficient Traffic flow in road networks, clear understanding on traffic flow operations like what causes congestion, how congestion propagation takes place in road networks etc are required
- Many traffic flow theories and models have been developed in this context



## CONTD...

- This made us to survey some traffic flow models for road networks
- In our presentation we are going to explain some traffic flow models, their classification and their applications in the road network.



## PROBLEM STATEMENT

- Intelligent transportation systems like ATMS and ATIS face a big challenge in controlling traffic congestion and estimating the traffic flow in road networks.
- A need for some traffic flow modelling methods to control the congestion in urban , free way as well as at the intersection areas.



# CLASSIFICATION

- Traffic flow models classified in many ways based on

## **1. Level of details**

- Macroscopic
- Mesoscopic and
- Microscopic traffic flow models

## **2. Operationalization criteria**

- Simulation
- Analytical

## **3. Representation of processes**

- Stochastic
- Deterministic

## **4. Time scale**

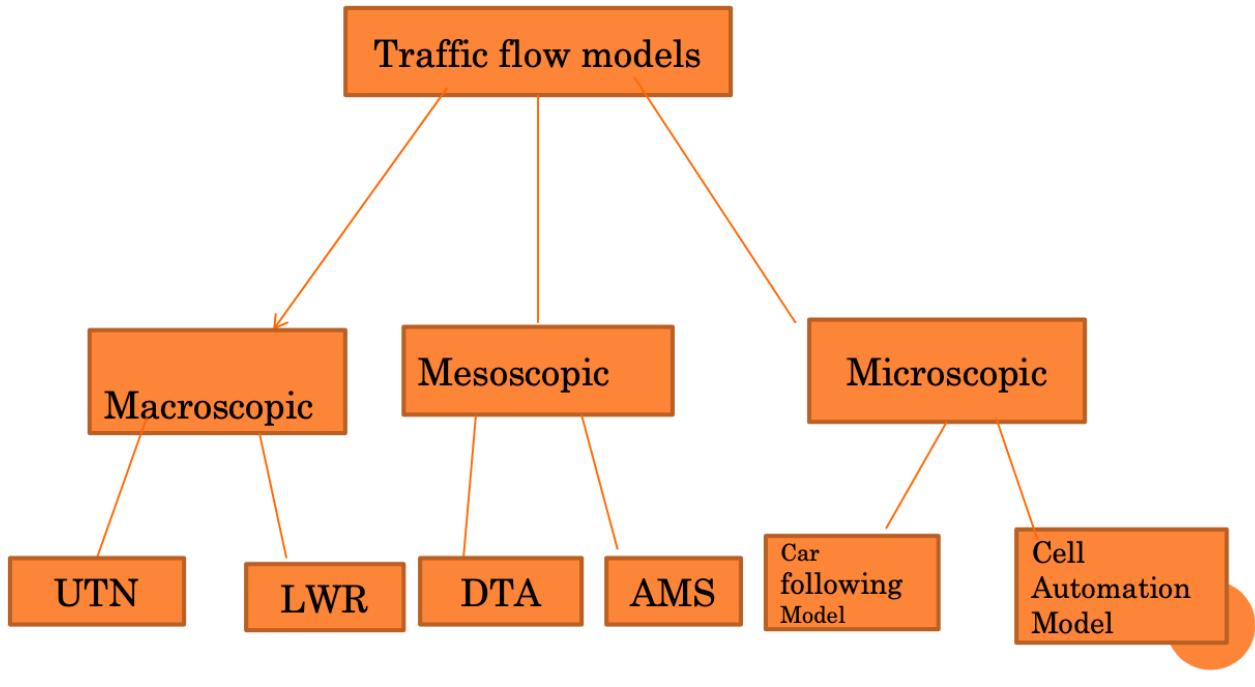
- Discrete
- Continuous

.

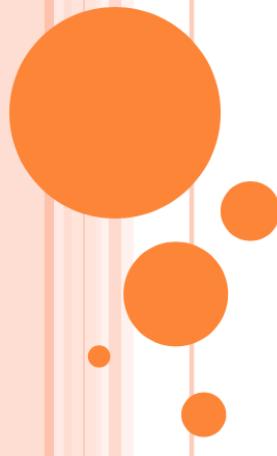


## CONTD...

**But our research just classifies the traffic flow models based on their level of detail as shown below**



# MICROSCOPIC MODELS



## MICROSCOPIC TRAFFIC FLOW MODEL

- A microscopic simulation model describes both the space time behaviour of the systems entities( vehicles and drivers) as well as their interactions at a high level of detail(individually).
- Two types of Microscopic traffic flow model
  - i)Car Following Model
  - ii)Cell Automation Model



## DEFINITON

- In the car-following theory, the relation between the preceding vehicle and the following vehicle is described that each individual vehicle always decelerates or accelerates as a response of its surrounding stimulus. Therefore, the  $n$ th vehicle's motion equation can be summarized as follows

$$[\text{Response}]^n \propto [\text{Stimulus}]^n$$

- The stimulus may include the velocity of the vehicle, the acceleration of the vehicle, the relative velocity and spacing between the  $n$ th and  $n+1$ th vehicle (the  $n$ th vehicle follows the  $n+1$ th vehicle).



## RELATED WORK

- Limitations of both the psycho-physical spacing model and of fuzzy models seem less than safe distance models and the stimulus-response mode.
- The Collision avoidance (CA) model is also called the safety distance model.
- According to the model, collision would be unavoidable if the distance is shorter than the safe distance and the behavior of the preceding vehicle is unpredictable.
- Simple models that have one or few functions, such as the safe distance and stimulus-response models, cannot describe certain traffic phenomena.



## PROPOSED CAR FOLLOWING MODEL

- First, the model should describe certain traffic flow phenomena.
- Second, the model should reflect differences among individual drivers.
- Third, it should avoid certain deficiencies mentioned above, such as drivers having to determine the deceleration capability of their lead vehicle.
- Finally, the model should minimize the number of rules employed, and thus it has the capability to provide real time traffic information and be a tool to analyze traffic properties.



## MODEL ASSUMPTIONS

- **Aggressiveness**

The model assumes that driver aggression increases with individual maximum speed.

- **Thrust**

Each vehicle has its own individual maximum speed, which is regarded as the thrust.

- **Repulsion**

Because the lead vehicle can prevent the following vehicle from running at its individual maximum speed, the lead vehicle is considered to be repelling the follower.



## CONTD..

- **Velocity decision**

The following vehicle decides its appropriate velocity based on existing thrust and repulsion, with the appropriate velocity equaling thrust minus repulsion.

- **Safety**

Since some drivers exhibit unsafe behaviors, the proposed model assumes that drivers do not consider safe distance. Drivers only consider the standstill spacing.

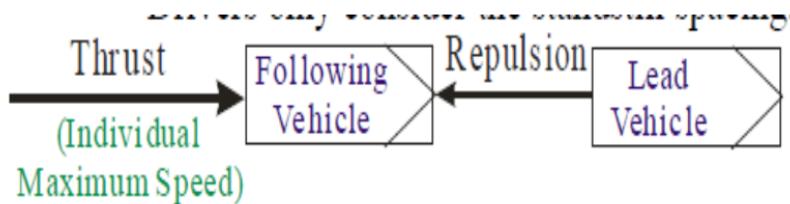


Fig. 1. Illustration of the car-following concept.

## MODELING

- If both the lead and following vehicles are running, the follower will choose an appropriate speed, which equals thrust minus repulsion.

$$\tilde{V}_{n,t+1} = V_{n,d} \left( 1 - \exp \left( -\lambda \frac{(V_{n-1,t})^\alpha}{(V_{n,t})^\beta} \left( \frac{H_{n,t} - S_n}{L} \right)^\gamma \right) \right),$$

*for  $V_{n-1,t} \neq 0$  &  $V_{n,t} \neq 0$*

(1)



## CONTD...

- If the speed of the lead vehicle is zero (as shown in (2)), the following vehicle decelerates its speed so that it can stop before a collision occurs.

$$\tilde{V}_{n,t+1} = V_{n,t} - \frac{(V_{n,t})^2}{2(H_{n,t} - S_n)} T,$$

*for  $V_{n-1,t} = 0$  &  $V_{n,t} \neq 0$*

(2)



## CONTD...

- Finally, if the following vehicle stops and the spacing is less than the start spacing, the follower remains stopped at the next time step.

$$\tilde{V}_{n,t+1} = 0, \quad \text{for } V_{n,t} = 0 \text{ & } H_{n,t} < Z_n \quad (4)$$

where  $\tilde{V}_{n,t+1}$  is the speed of the following vehicle at time step  $t + 1$ ,  $v_{n,d}$  is the individual maximum speed of the following vehicle,  $V_{n,t}$  is the speed of the following vehicle at time step  $t$ ,  $V_{n-1,t}$  is the speed of the lead vehicle at time step  $t$ ,  $H_{n,t}$  is the position of the following vehicle at time step  $t$ ,

## RESULTS

- An example involving the movements of four vehicles is simulated .
- The individual maximum speeds of the first, second, third and fourth vehicles are 30, 50, 60, and 70 km/hr, respectively.
- The initial speeds of these vehicles are their individual maximum speeds, and the initial spacings are 100 meters.



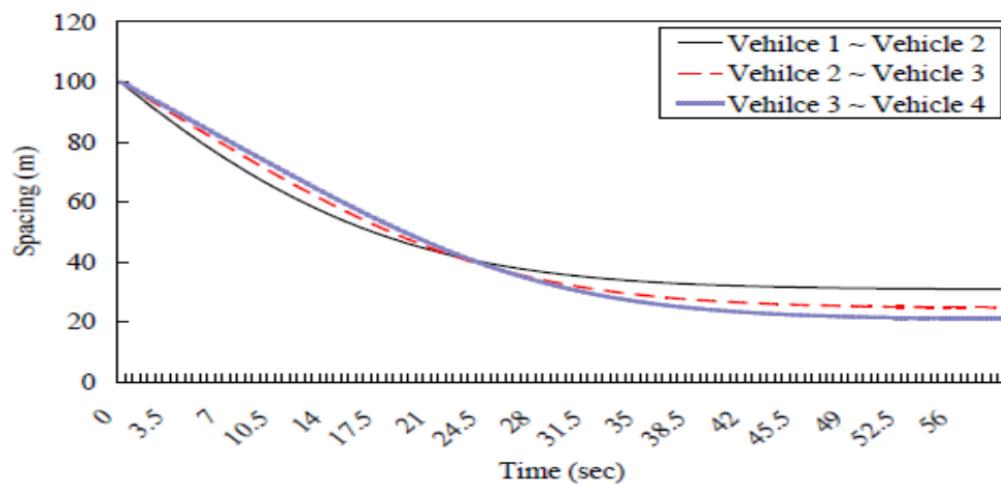


Fig. 3. Spacings between vehicles.

- It reflects the model assumption that drivers with higher individual maximum speed maintain a higher speed or a shorter spacing under identical condition.
- Finally, the simulation results indicate that equilibrium spacing depends only on the final speed and not on initial condition

## CONCLUSION

- The model applies individual maximum speed as a model variable, and thus reflects the difference between different drivers under the same condition.
- Numerical results confirm that the proposed model can describe the car-following process. The model successfully reflected certain microscopic traffic flow phenomena, such as: stable traffic, unstable traffic, closing-in, and shying-away.



# CELLULAR AUTOMATA APPROACH



- A cellular automaton (CA) is a discrete computing model which provides a simple yet flexible platform for simulating complicated systems and performing complex computation.
- The problem space of a CA is divided into cells; each cell can be in one of some finite states.
- The CA rules define transitions between the states of these cells.



## ONE DIMENSIONAL NAGEL SCHRECKENBERG MODEL

- For each time step, each vehicle computes its speed and position based on below steps,

```
v ← current vehicle speed

/* Acceleration step */
if v is less than maximum speed then
    increase v by one cell/step
end if

/* Deceleration step */
if a vehicle will collide with vehicle in front with v then
    decrease v by one cell/step so that the vehicle stops behind the vehicle in front
end if

/* Randomization step */
if v is greater than 0 then
    Decrease v with probability  $p_{slow}$ .
end if

/* Movement step */
Update the vehicle speed with v
Vehicle moves forward v cells
```

■ **Algorithm 1.** *Vehicle position update algorithm (NaSch model).*

## TWO DIMENSIONAL STREET MODEL

- Based on NaSch model, Choepard develops a traffic model for a network of two-dimensional streets.
- In this model the motion rules imposed on vehicles are similar to those used in the NaSch model with the exception of rules for vehicles near intersections.
- This model, however, does not capture the real traffic behavior as the model gives a higher priority to turning traffic than to through traffic.



# PROPOSED CA BASED MOBILITY MODEL FOR URBAN TRAFFIC

## ○ Motion Rules

```
if the vehicle goes straight at the next intersection then  
    go to Non-turning vehicle  
else  
    go to Turning vehicle  
end if
```

Non-turning vehicle  
 $v \leftarrow$  current vehicle speed

```
/* Acceleration step */  
if  $v$  is less than maximum speed then  
    increase  $v$  by one cell/step  
end if
```



*/\* Deceleration step \*/*

if Red or yellow light at the intersection then

  if a vehicle will collide with vehicle in front or pass the intersection with speed  $v$  then

    decrease  $v$  so that the vehicle stops behind the vehicle in front or at intersection (whichever comes first)

  end if

else

  if a vehicle will collide with vehicle in front with speed  $v$  then

    decrease  $v$  so that the vehicle stops behind the vehicle in front

  end if

end if

*/\* Randomization step \*/*

if  $v$  is greater than 0 then

  Decrease  $v$  by one cell/step with probability  $p_{slow}$ .

end if

*/\* Movement step \*/*

Update the vehicle speed with  $v$

Vehicle moves forward  $v$  cells

## Turning vehicle

```
if The vehicle is not yet at the intersection then
    go to Non-turning vehicle and assume red light at the intersection
else
    if Red light at the intersection or the destination street is congested then
        The vehicle does not move
    else
        if The vehicle wants to make a right turn, or (it makes a left turn and no upcoming traffic from the opposite direction)
            then
                The vehicle moves to the destination street
            else
                The vehicle does not move
        end if
    end if
end if
```

### ■ Algorithm 2. New vehicle position update algorithm (Tonguz-Viriyasitavat-Bai algorithm).

## INTERSECTION CONTROL MECHANISM

- Assuming pre timed signals. In order to realistically simulate the operation of pre-timed signals, the three necessary parameters are as follows,

- Cycle Duration**

The amount of time the signal turns green, changes to yellow, then red, and then green again.

- Green Split**

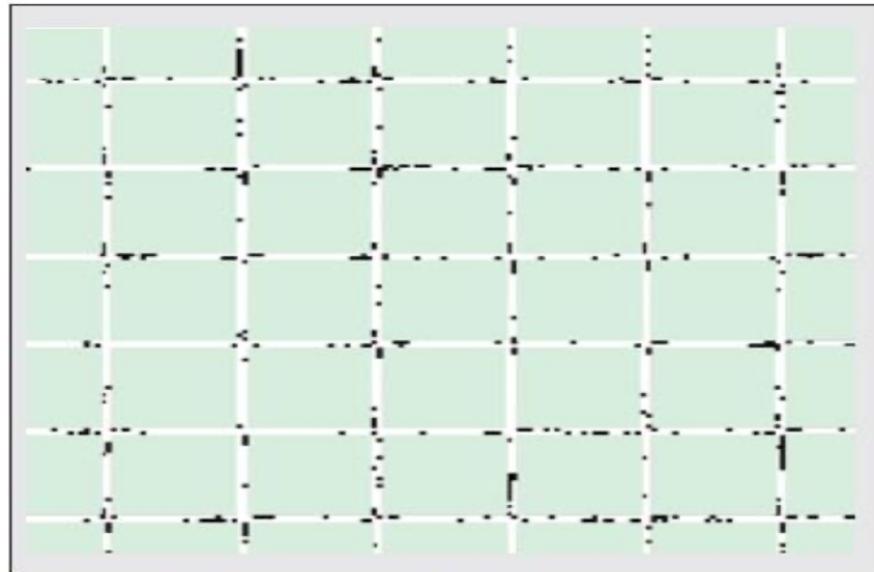
The fraction of time in a cycle duration in which specific movements have the right of way .

- Traffic Signal Coordination**

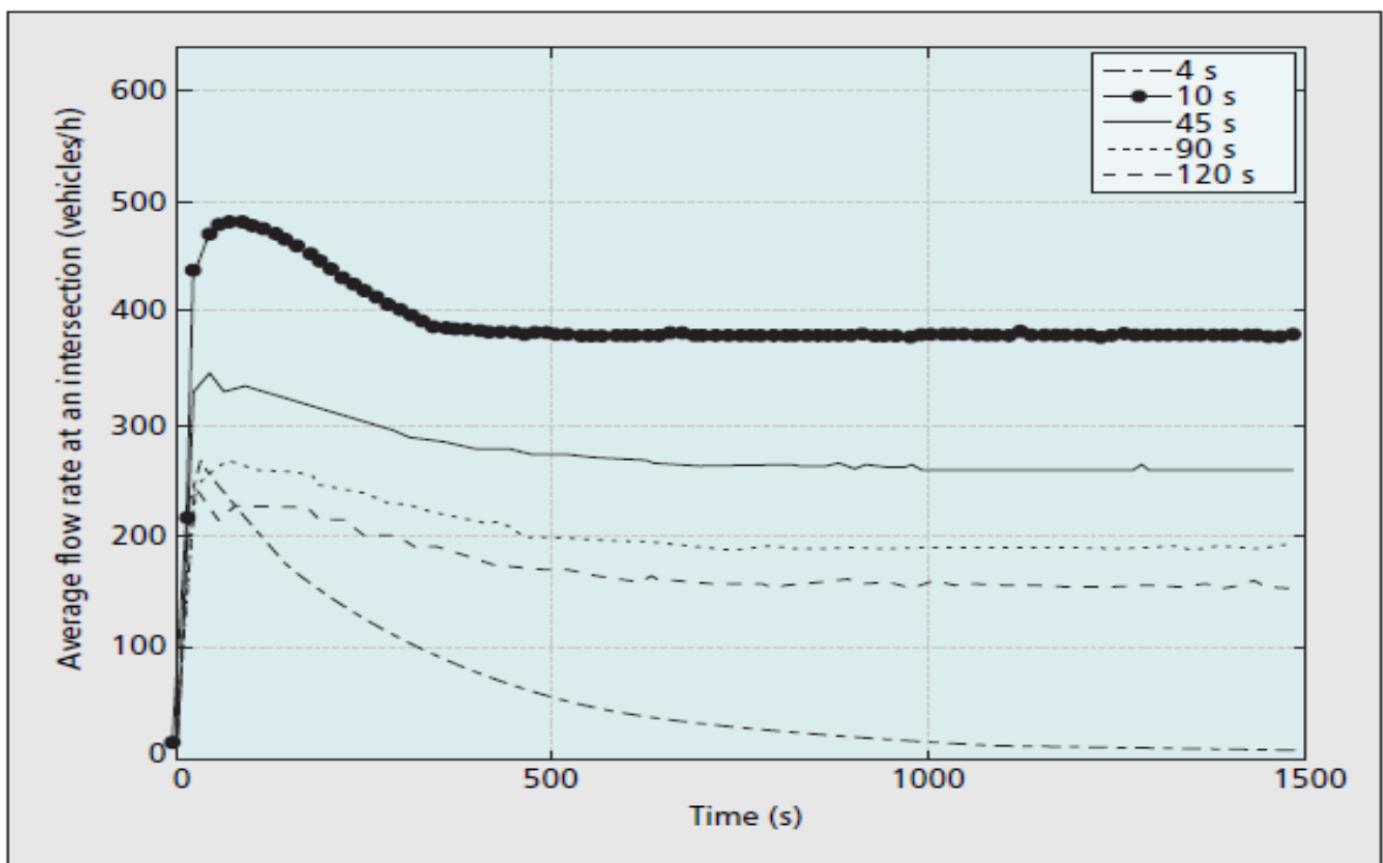
A method of establishing relationships between adjacent traffic control signals. This coordination is controlled by the value of signal offset.



## RESULTS



■ **Figure 1.** Snapshot of traffic pattern generated by the CA-based model.



■ **Figure 2.** The average flow rate over all intersections as a function of time for different cycle durations. Note that there is an optimal cycle duration that maximizes the flow rate.

## CONTD...

- It indicate that the average flow rate depends on the cycle duration.
- The average flow rate decreases as the cycle duration increases: as the signal cycle increases, the time an intersection is unused increases, thus resulting in more wasted time.
- Control mechanisms such as cycle duration, green split, and coordination of traffic lights have a significant bearing on traffic dynamics and inter vehicle spacing distribution.



## A CELLULAR AUTOMATION MODEL FOR FREEWAY TRAFFIC

- Computational model is defined on a one-dimensional array of L sites and with open or periodic boundary conditions.
- Each site may either be occupied by one vehicle, or it may be empty.
- Each vehicle has an integer velocity with values between zero and  $v_{max}$ .



## CONTD...

1) **Acceleration:** if the velocity  $v$  of a vehicle is lower than  $v_{max}$  and if the distance to the next car ahead is larger than  $v + i$ , the speed is advanced by one

$$[v \rightarrow v + 1].$$

2) **Slowing down** (due to other cars): if a vehicle at site  $I$  sees the next vehicle at site  $Ii+j$  (with  $j <= v$ ), it reduces its speed to

$$j - 1 [v \rightarrow j - 1].$$

3) **Randomization:** with probability  $p$ , the velocity of each vehicle (if greater than zero) is decreased by one

$$[v \rightarrow v - 1].$$

4) **Car motion:** each vehicle is advanced  $v$  sites.



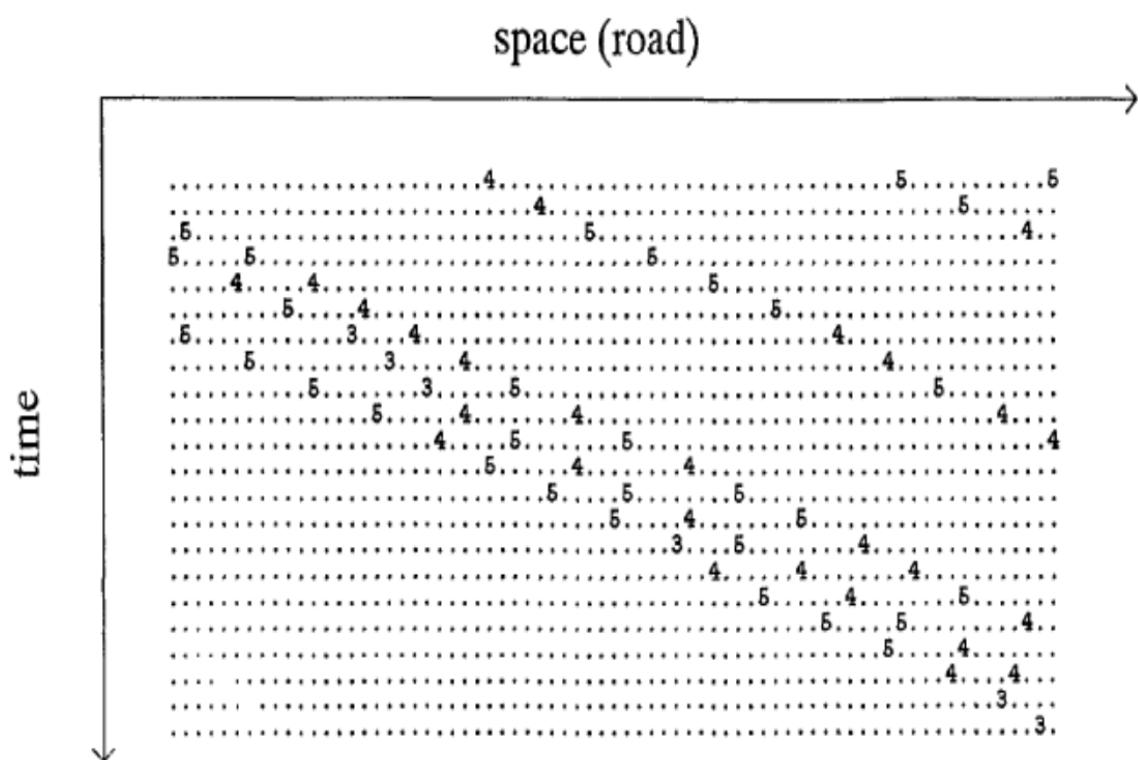


Fig.1. — Simulated traffic at a (low) density of 0.03 cars per site. Each new line shows the traffic lane after one further complete velocity-update and just before the car motion. Empty sites are represented by a dot, sites which are occupied by a car are represented by the integer number of its velocity. At low densities, we see undisturbed motion.

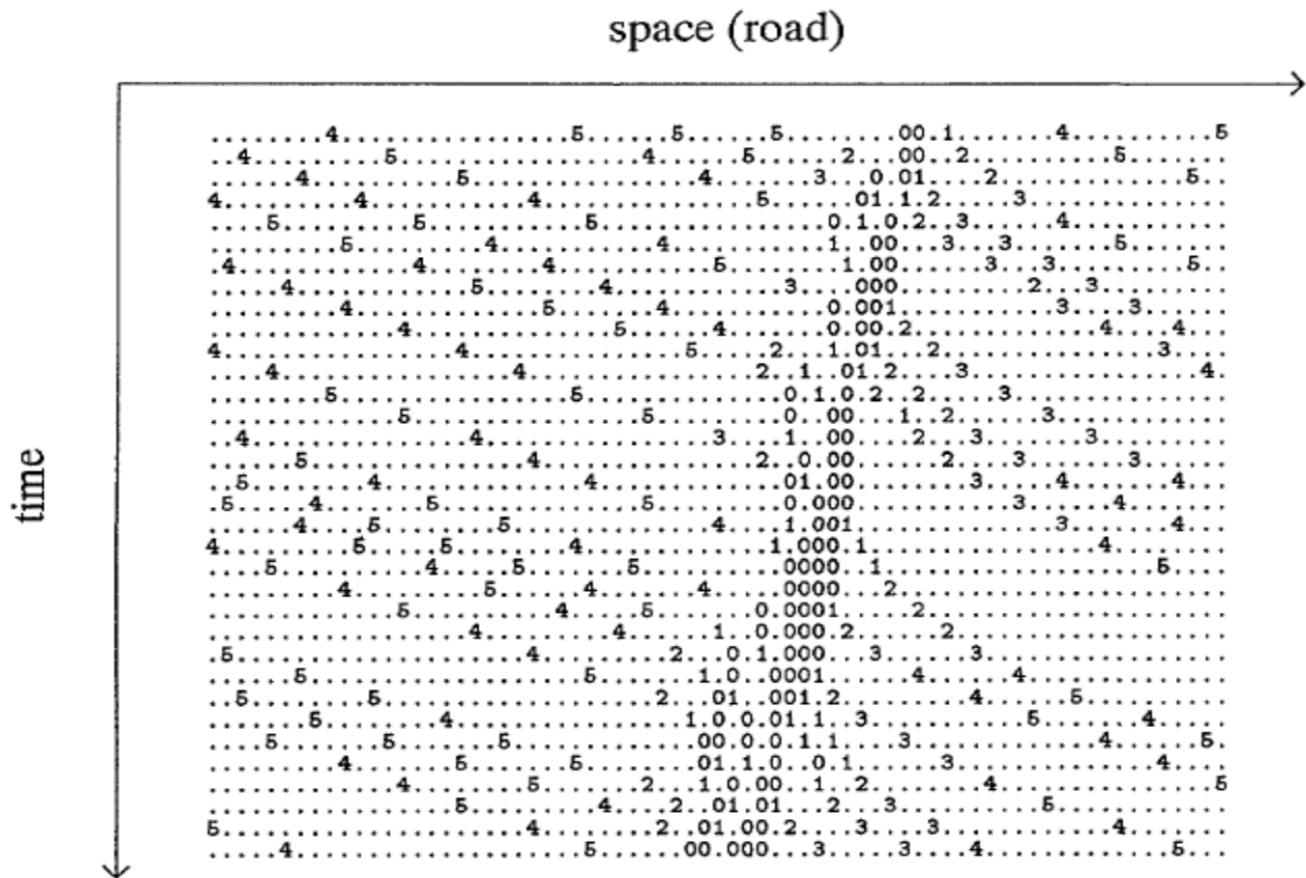


Fig.2. — Same picture as figure 1, but at a higher density of 0.1 cars per site. Note the backward motion of the traffic jam.

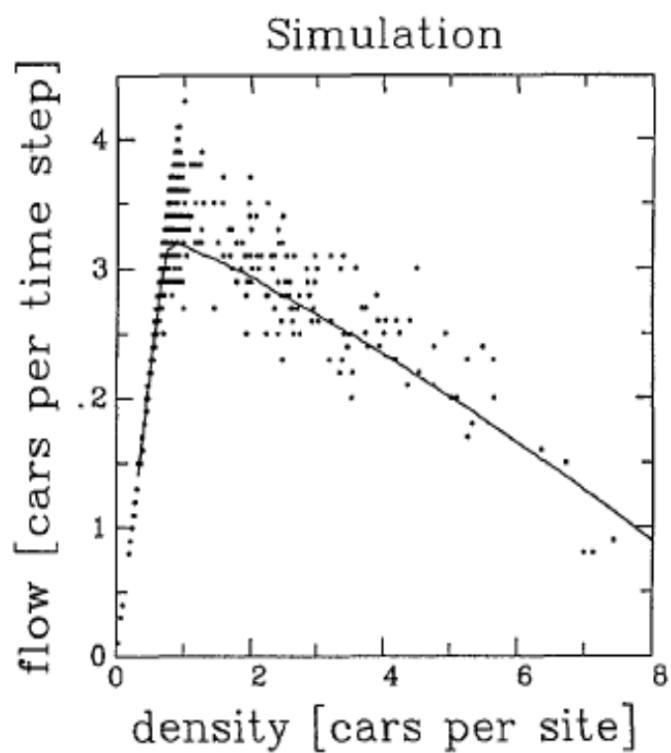


Fig.4. — Traffic flow  $q$  (in cars per time step) vs. density (in cars per site) from simulation results ( $L = 10^4$ ). Dots are averages over 100 time steps, the line represents averages over  $10^6$  time steps.

# CONCLUSION

- The discrete model approach which contains some of the important aspects of the fluid-dynamical approach to traffic flow such as the transition from laminar to start-stop-traffic in a natural way has been presented in this paper.
- This model retains more elements of individual (though statistical) behavior of the driver, which might lead to better usefulness for traffic simulations where individual behavior is concerned (e.g. dynamic routing).



## MICROSCOPIC BEHAVIOUR OF TRAFFIC AT A THREE-STAGED SIGNALIZED INTERSECTION

- Microscopic behavior and conflict of left turning and straight traffic under the control of three-staged signal lights.
  
- The primary influence factors at intersections are much more complicated, not only by the leading vehicle but also the crossing road conflicting traffic.



## THE CALCULATION OF CONFLICT POINTS ON AN AT-GRADE INTERSECTION

- Number of conflict points for the running of left-turning and straight vehicles

$$\sum P_{(left, straight)} = \frac{n^2(n-1)(n-2)}{6}$$

- n= Number of intersecting roads



## ENVIRONMENT SET UP

- The chosen survey site is the Hualian Edifice intersection in Fuchengmen of Beijing.
- In the collection, four digital video cameras were placed on two over-bridges; two Of them to record the motor vehicle movements and the other two to record the signal lights.
- Data was collected from **8:30am to 1000am**

East and West Directions

Lasting Time (second)	Signal Lights
55	G (straight + right)
2	Y
45	R (straight + right + left)
3	Y
23	G (Left)
2	Y

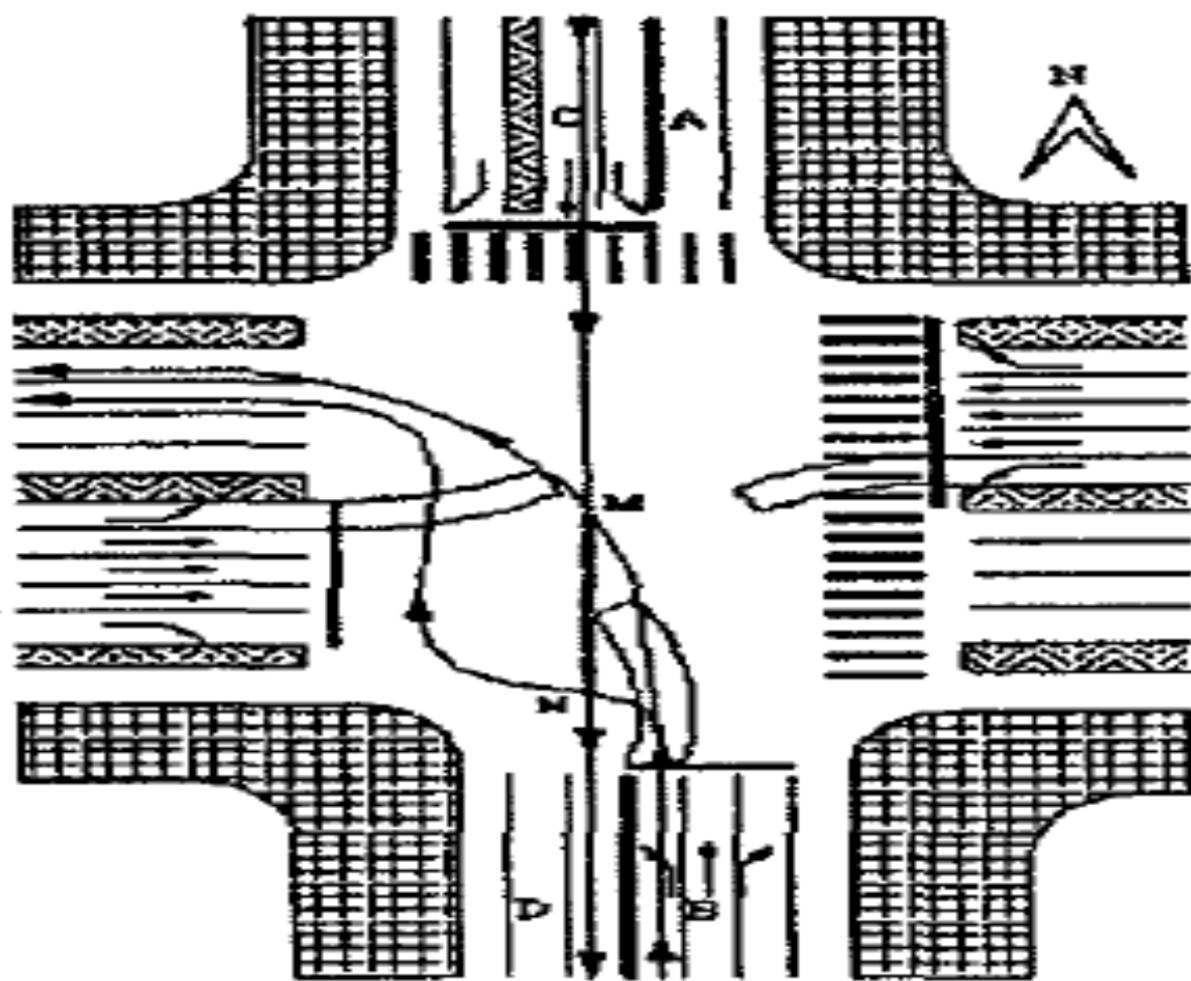
South and North Directions

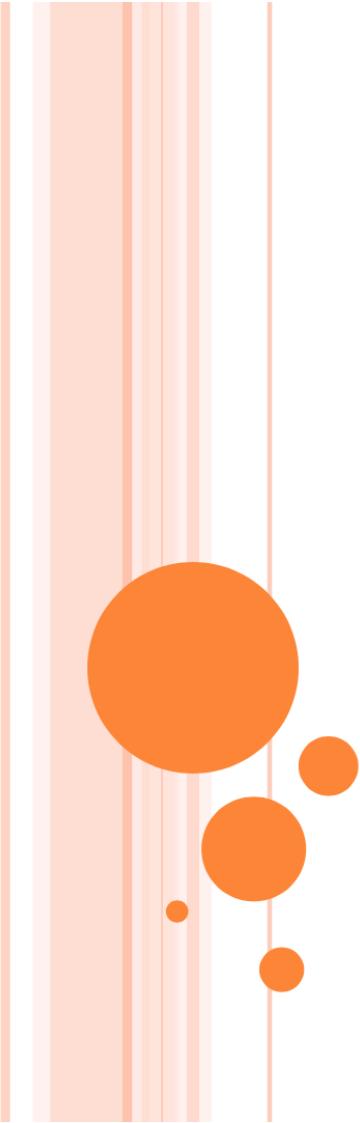
Lasting Time (second)	Signal Lights
85	R (Straight + right + left)
2	Y
40	G (Straight + right + left)
3	Y

## THE MOVING OF THE CONFLICT POINT FOR STRAIGHT-AHEAD AND LEFT-TURNING TRAFFIC

- Based on the data collected, accepted gaps for straight-ahead and left turning traffic have a mean of 5.8.
- In order to reduce delay and conflict with straight-ahead traffic from the opposite direction, left turning traffic often takes a left turn earlier and therefore results in a conflict point

Item	(Seconds)
Mean	5.83
Standard Deviation	1.87
Minimum	2.5
Maximum	10.5





## MACROSCOPIC MODELS

# A QUEUE-BASED MACROSCOPIC MODEL FOR PERFORMANCE EVALUATION OF CONGESTED URBAN TRAFFIC NETWORKS

- Presents a physical queue model instead of point queue model
- Represents the queue dynamics, ie, queue occupation at each time interval
- The traffic network is modelled by a directed graph and uses the equations from LWR model.
- This model uses a fixed route choice procedure.



## CONT...

- The current paper proposes a modified link/node model where the outgoing flow of a link explicitly depends on the downstream available room
- In this way vehicles which can flow through out a node can flow through the link , the remaining vehicles form a queue in the link resulting in running and queue sections
- Velocity of vehicles in running section is  $V_m$  and in queue section is  $V_{min.}$



# CONT...

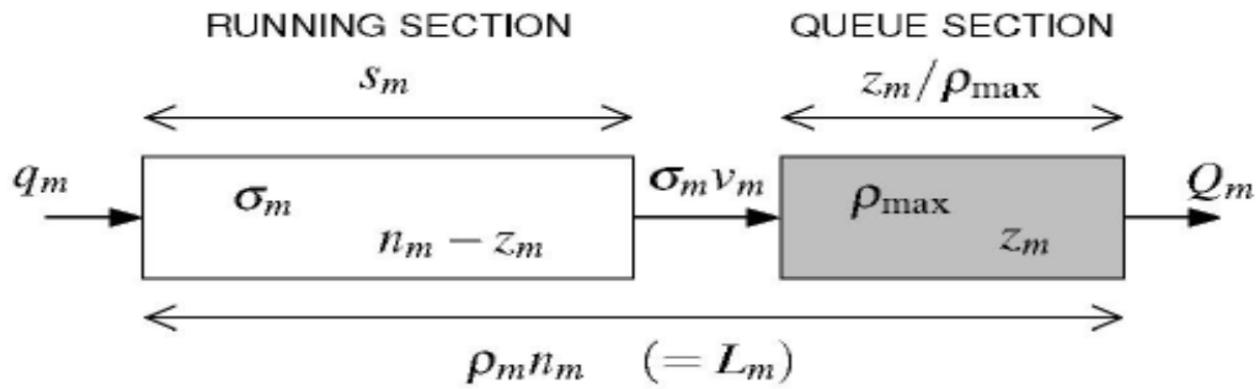


Fig. 3. Running and queue sections representation in the link model.

## CONTD...

- The total number of vehicles flowing through out the link(both running and link section)  $n_m(k+1) = n_m(k) + \frac{T}{\lambda_m} (q_m(k) - Q_m(k))$  on
- if  $Z_m(K)=0$ , , the queue section has zero length ( $Z_m(K)$  represents number of vehicles in the queue section)



## CONT...

- If  $Z_m(k) > 0$ , a queue section is already present at interval  $k$  and is given by equation

$$z_m(k+1) = \min \left\{ z_m(k) + \frac{T}{\lambda_m} [\sigma_m(k) v_m(k) \lambda_m - Q_m(k)], n_m(k+1) \right\}$$

- Thus this model helps in finding the congested areas in the urban traffic network by calculating the queue formation on the links as explained above.
- The model correctly represented the congestion and decongestion in the presence of bottlenecks when applied to the traffic network in the city of Bologna in north Italy

# TRAFFIC DENSITY ESTIMATION UNDER HETEROGENEOUS TRAFFIC CONDITIONS USING DATA FUSION

- The parameters of heterogeneous traffic are estimated using both location data and spatial data using data fusion.
- The current paper reports density estimation using flow and Space Mean Speed (SMS) .
- The most commonly available spatial data is travel time .
- Location based data for the present study were collected from a typical Indian urban roadway namely Rajiv Gandhi Salai (IT corridor), in Chennai, India, using video graphic technique



# DENSITY ESTIMATION USING TRAVEL TIME

- The estimation of density using travel time was based on the conservation equation and the fundamental traffic flow.
- Vehicle conservation equation for LWR model is given by

$$q = u k \quad \frac{\partial k}{\partial t} + \frac{\partial q}{\partial x} = 0,$$



## SMS CALUCLATION

- The travel time data needed in the correction stage is usually obtained from GPS.
- GPS data will constitute less than 1% of the total vehicle population. spatial data were collected using test vehicles equipped with GPS units.
- The test vehicles were travelling back and forth between entry and exit points continuously during the data collection period on both days.
- The Space Mean Speed (SMS) was then calculated as the Harmonic Mean (HM) of these spot speeds at the entry and exit points for each class of vehicles using the equation



$$SMS_i = \frac{n_i}{\sum_{j=1}^{n_i} \frac{1}{V_{ij}}},$$

$$SMS = \frac{\sum_{i=1}^3 N_i \times SMS_i}{\sum_{i=1}^3 N_i},$$

- where  $SMS_i$  is the space mean speed of class  $i$ ,  $n_i$  is the number of spot speed observations of vehicle class  $i$  in 1 minute interval and  $V_{ij}$  is the spot speed observation of vehicle class  $i$  namely two-wheeler, three-wheeler or four wheeler.
- The final SMS is calculated as the arithmetic mean of SMS at entry and exit
- Density Estimation is done using ***Travel Time and Space Mean Speed***. The performances of the methods were evaluated using the **Mean Absolute Percentage Error (MAPE)**.
- This study was able to reduce the error in density estimation in terms of MAPE by 10 to 40 %.

# COMPARISION

Method \ Data	30 <sup>th</sup> June 2009	23 <sup>rd</sup> Sep. 2010
Method 1	5.25 %	4.72 %
Method 2	8.59 %	8.93 %

- A comparison of the two methods shows a better performance when the data fusion between the location data (video) and spatial data (GPS) was carried out.
- The better performance with the fused data may be due to the fact that the GPS data were able to capture the spatial variability in the data better than an estimated SMS obtained from location based data

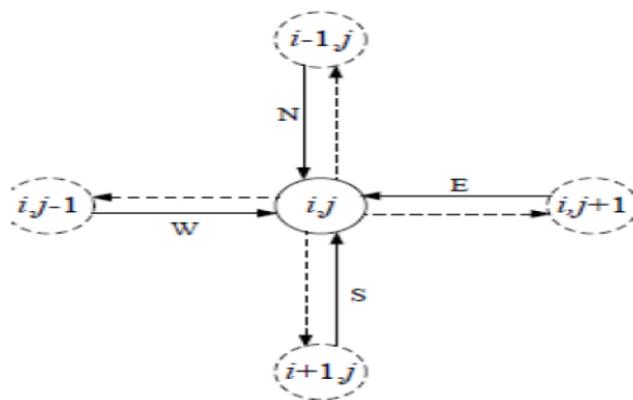
# **SHORT-TERM TRAFFIC FLOW FORECASTING USING MACROSCOPIC URBAN TRAFFIC NETWORK MODEL**

- Traffic flow forecasting provides important information for both traffic control and traffic guidance.
- Short-term traffic flow forecasting can principally be classified into three types: Traffic flux forecasting, Travel time forecasting and Mean-speed forecasting.
- CORSIM is used as the practical traffic system, and the proposed method is used to forecast the traffic flow.



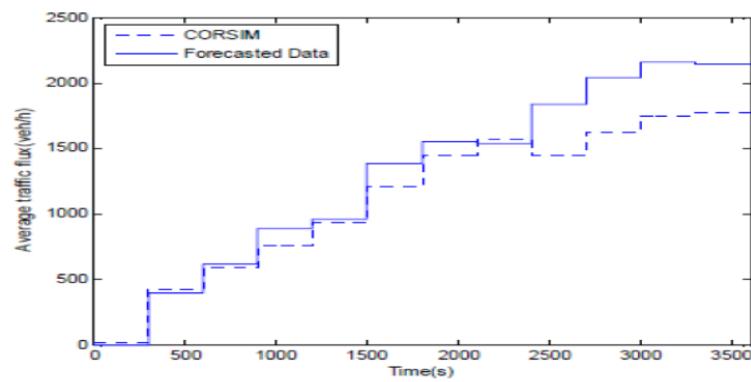
# URBAN TRAFFIC NETWORK TOPOLOGY

- The UTN is decomposed into a certain types of basic network elements including a node and all the links running into it.
- The “Cross” network element is defined as a junction with all four links running into it.
- The whole network element is marked as  $E(i, j)$ .



# SIMULATION

- CORSIM based model is employed to simulate the real traffic.
- The simulation time lasts for 1 hour. The sampling time interval is  $T=1\text{s}$ , both for CORSIM and the Macroscopic UTN model.
- It is observed that the suddenly increasing of the input traffic flow has little influence on the forecasting results.
- Simulation time of our model is much shorter than that of CORSIM, almost 57 times



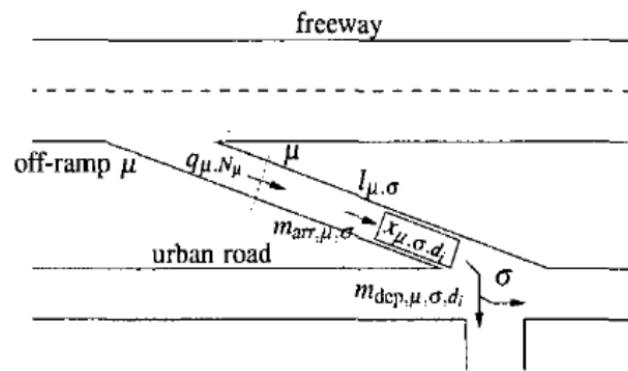
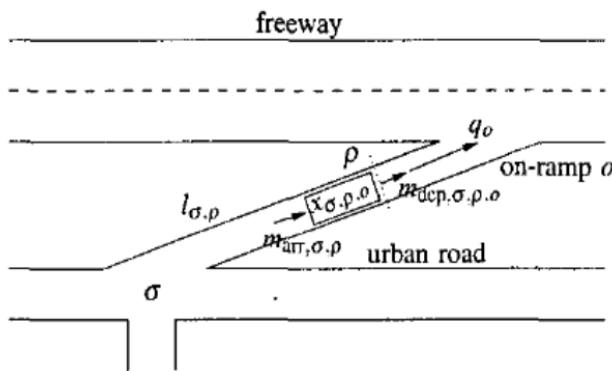
# A MACROSCOPIC TRAFFIC FLOW MODEL FOR INTEGRATED CONTROL OF FREEWAY AND URBAN TRAFFIC NETWORKS

- This paper proposes a macroscopic model for mixed urban and freeway traffic networks urban network is modeled based on the Kashani model.
- An extended version of the METANET traffic flow model is used to describe traffic flows in the freeway part of the network.
- The METANET model represents a freeway network as a directed graph with the links corresponding to freeway stretches
- The UTN model should satisfy the following requirements that offers an appropriate trade-off between accuracy and computational complexity.
  - Should be able model both light and heavy traffic,
  - Should contain horizontal queues,
  - Should describe blocking effects



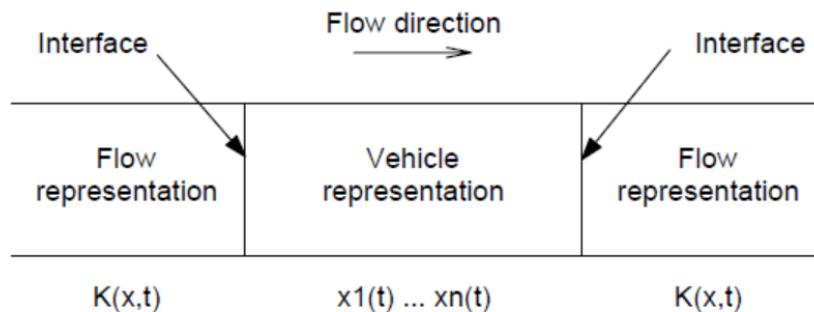
# INTERFACE BETWEEN FREEWAY AND URBAN MODEL

- The urban part and the freeway part of the network are coupled via on-ramps and off-ramps.
- The two main problems that have to be dealt with are the different simulation time steps for the urban and the freeway model, and the transformation of urban traffic flows into demands and boundary conditions for the freeway model



## MIXING MICRO AND MACRO REPRESENTATIONS OF TRAFFIC FLOW: A HYBRID MODEL BASED ON THE LWR THEORY

- Combines flow and vehicular representations of the same model, which is the classical Lighthill-Witham-Richards model
- It is shown to have good properties, particularly concerning congestion propagation and flow smoothing at the interfaces between the two models



## CONSTRAINTS

- Microscopic models are associated with stochastic aspects, and macroscopic models with deterministic ones.
- The two limits between flow and vehicle representations are called interfaces.
- Hybrid models must satisfy two constraints in order to be consistent:
  - The conservation of vehicles at interfaces must be ensured
  - Information must propagate correctly at interfaces both in the upstream and downstream directions under free flow and saturated conditions



## CONSERVATIVE EQUATION

- Translating boundary conditions at the interfaces remains as the main possible cause of errors, when moving from a continuous to a discrete representation of traffic and conversely.
- The objective is to minimize those errors in order to limit undesirable effects.
- The two models to be coupled are derived from the LWR model . It is based on three variables (density  $K$  , flow  $Q$  and average speed  $V$  ) and three equations:

$$\frac{\partial K}{\partial t} + \frac{\partial Q}{\partial x} = 0 \quad (\text{conservation equation})$$

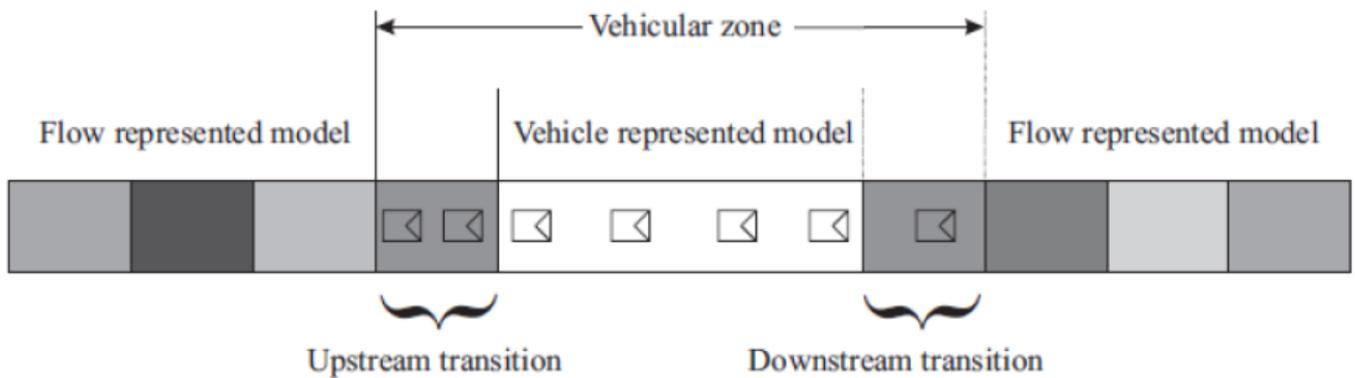
$$Q = KV \quad (\text{definition of the average speed})$$

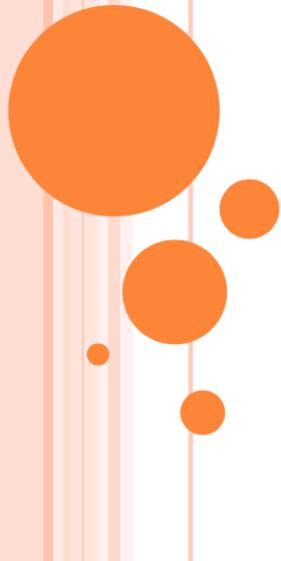
$$Q = Q_e(K) \quad (\text{equilibrium relation between flow and density})$$

## RESULTS

- A “transition cell” is introduced at each interface in order to split up the transition process.
- The upstream transition cell will ensure transition of traffic from the FR model to the VR one, and conversely for the downstream transition cell.
- The hybrid model is analyzed in three typical cases: **a stationary situation, a single state change and an incident or Multi state**.
- In stationary case hybridization does not change flow results in stationary situations
- Single stage creates perturbation that propagates downward going from 0.5 veh/s to 0.2 veh/s.
- In Multi state changes strong perturbation that propagates through the transition cells.







## Mesoscopic traffic flow models

## **ANISOTROPIC MESOSCOPIC TRAFFIC SIMULATION APPROACH TO SUPPORT LARGE-SCALE TRAFFIC AND LOGISTIC MODELING AND ANALYSIS**

- The AMS model is used for computational speed-ups
- Concentrates on balancing the computational burden and realism of macroscopic simulation properties by removing certain car-following behavior and adopting a coarser simulation temporal resolution.
- *Mesoscopic* can be generally defined in the field of quantum physics as intermediate between the microscopic and the macroscopic.



# ANISOTROPIC MESOSCOPIC SIMULATION (AMS) MODEL

**The two concepts that are foundation for this AMS model are:**

- The speed of the vehicle is influenced only by the vehicle in front of it(in the same lane or adjacent lane)
- The influence of traffic downstream upon a vehicle decreases with increased distance.

These two characteristics define the anisotropic property of the traffic flow and provide the guiding principle for AMS model design.

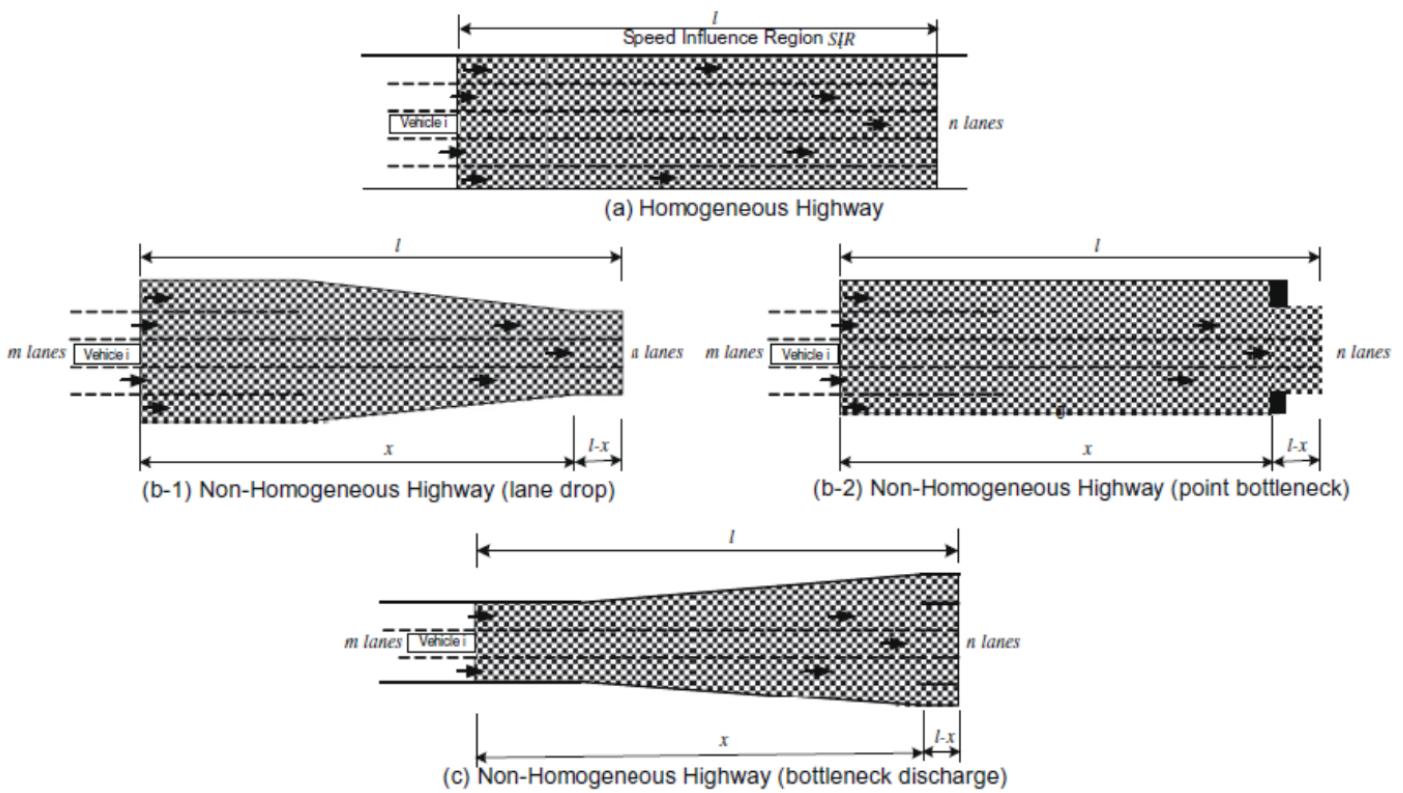


## CONTD..

- Speed Influencing region(SIR) influences the speed of the vehicle at each clock time(t).
- The traffic density in SIR(i), denoted as  $k(I) = \text{number of vehicles present in SIR}(i)/\text{the total lane-miles of the SIR}(i)$



# ANISOTROPIC MESOSCOPIC SIMULATION CONCEPT



## LANE-CHANGING MODEL FOR AMS

Lane changing is done when the following vehicle catches up with a slower moving lead vehicle and the adjacent lane permits acceptable gap.

The factors that should be considered when the lane-changing taking place are:

- a) The speed of the lead vehicle is slower than the desired speed of the following vehicle,
- b) There is a sufficient gap between the nearest lead vehicle in the neighboring lanes,
- c) The vehicle in the neighboring lane is moving faster than the lead vehicle, and
- d) The lane the following vehicle is going to merge into the neighbor lane and the vehicle has to change lane.
- e) Vehicle in the neighboring lane is sufficiently far away so that the vehicle can change lane freely without concerning possible crash.



## THE AMS LANE CHANGING ALGORITHM IS EXPRESSED AS FOLLOWS

### 1. Calculate three gaps:

gap $(i)$  Gap Forward in current lane

gap $o(i)$  Gap Forward in the neighboring lane

gap $b(i)$  Gap Backward in the neighboring lane

### 2. Calculate weight $^1$ to weight $^3$ based on the gap values

$$\text{Weight}^1 = \text{speed}(i) - \text{gap}(i)$$

$$\text{Weight}^2 = \text{gap}o(i) - \text{speed}(i)$$

$$\text{Weight}^3 = \text{gap}b(i) - \text{MaxSpeed}$$

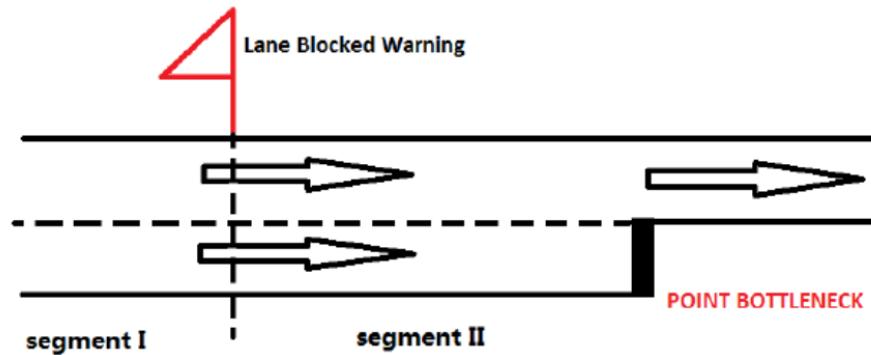
### 3. If the vehicle is in lane 1, then:

If  $\text{weight}^1 > a$ ,  $\text{weight}^2 > b$ , and  $\text{weight}^3$  is larger than 0, then mark the vehicle as "lane changing"

If the vehicle is in lane 2, then:

If  $\text{weight}^2$  and  $\text{weight}^3$  are both larger than 0, then mark the vehicle as "lane changing"

# LANE BLOCKAGE SCENARIO



Thus in this paper, the lane-changing enhanced Anisotropic Mesoscopic Simulation (AMS) model is presented and discussed to account for special scenarios involving stalled or particularly slow-moving vehicles.

# **A DISCRETE-EVENT MESOSCOPIC TRAFFIC SIMULATION MODEL FOR HYBRID TRAFFIC SIMULATION**

- Paper presents integrated meso-micro traffic simulation models to create hybrid traffic simulation.
- Mesoscopic models contains individual vehicle representation but with a more aggregate representation of traffic dynamics..



## MEZZO:

MEZZO, which combines the state-of-the-art mesoscopic modeling mechanisms with the ability to be integrated with microscopic models.

MEZZO is an event-based simulator and is defined by vehicles entering a link, exiting a link, making a new route choice, etc. MEZZO is a synthesis of a number of models and processes. They include:

*I. Network Representation*

*II. Vehicle Movement*

*III. Travel behaviour*

### A. Network representation:

The traffic network contains nodes and links. The nodes are the intersections. Links represent the path between such nodes, and are unidirectional. Nodes have usually multiple incoming and outgoing links.

## B. Vehicle movement:

The vehicle movement is captured by two models, the link model and the node model.

### **Link Model:**

A MEZZO link is divided into two parts, the running part and the queue part. The running part is the part of the link that contains vehicles that are on their way to the downstream node.

$$V(k) = \begin{cases} V_{free} & \text{if } k < k_{\min} \\ V_{\min} + (V_{free} - V_{\min}) \left( 1 - \left( \frac{k - k_{\min}}{k_{\max} - k_{\min}} \right)^a \right)^b & \text{if } k \in [k_{\min}, k_{\max}] \\ V_{\min} & \text{if } k > k_{\max} \end{cases}$$

where

$V(k)$  = speed assigned to the vehicle,     $k_{\min}$  = minimum density

$k$  = the current density on the running part of the link

$k_{\max}$  = maximum density

$V_{\min}$  = minimum speed

$b$  = model parameters

$V_{free}$  = free flow speed

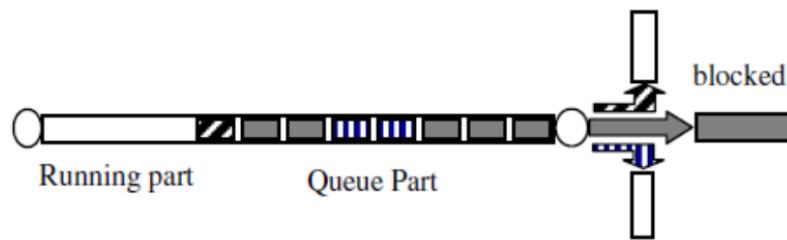
a,

## Node Model:

- Links are connected to downstream links through nodes. The capacity of turning movements is represented by queue-servers.
- The vehicles that are part of the queue segment are processed, one at a time, by such a server and transferred to the next link, if there is available space.
- The turning servers only process the vehicles whose route requires them to make that turning.



## QUEUE SERVERS AT TURNING MOVEMENTS SERVING VEHICLES.



- The server for the vehicles moving straight cannot process more vehicles until the destination link has become unblocked.
- Each turning movement has a *queue look-back limit*, which is the maximum number of vehicles from the front of the queue that a server can “look back”
- . The model explicitly represents the start-up shockwave of a dissipating queue.

$$\omega_{AB} = (q_A - q_B) / (k_A - k_B)$$

where,

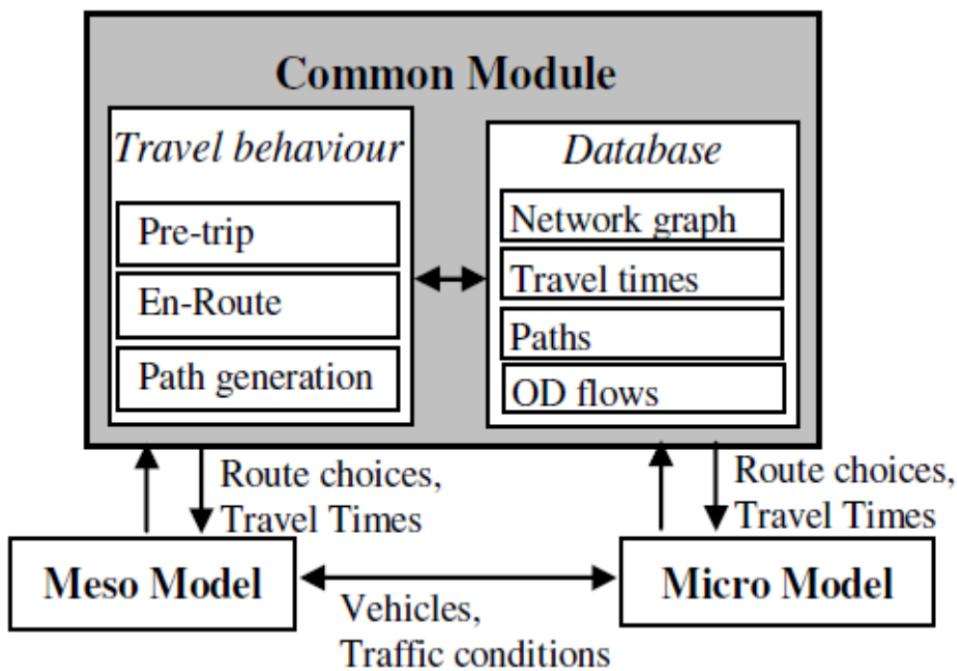
$\omega_{AB}$  = shockwave speed,

$q_A, q_B$  = flow upstream and downstream of the node,

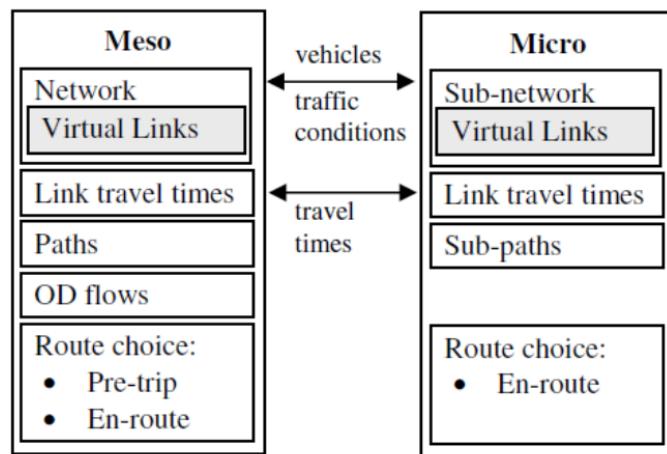
$k_A, k_B$  = densities upstream and downstream of the node.

- The earliest exit time of all vehicles in the queue-part is updated by calculating when the shockwave reaches them..

# MESO-MICROINTEGRATION FRAMEWORK HYBRID SIMULATION FRAME WORK

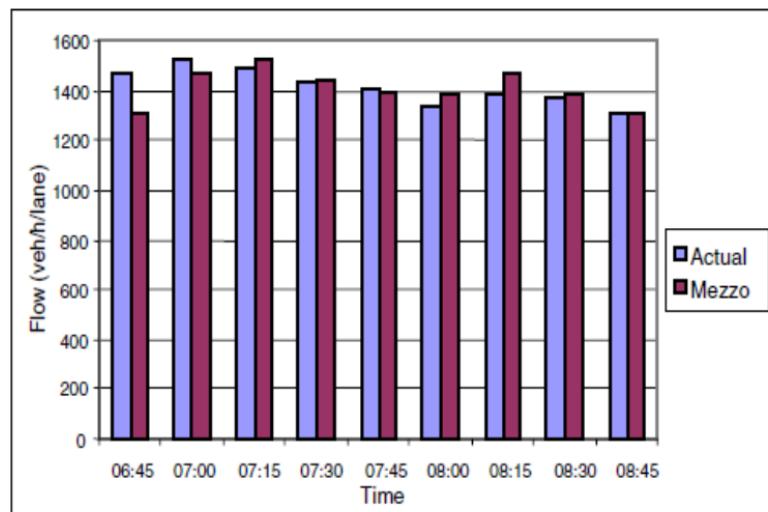


# SIMPLIFIED HYBRID SIMULATION FRAME WORK



- The meso model is solely responsible for all pre-trip decisions, while en-route decisions are the responsibility of the respective subnetwork.
- The initial architecture, in the case of a new meso-micro model, requires large amounts of communication overhead when combining two existing models.
- With the above modifications this overhead is avoided.

## SOUTH BOUND NETWORK USING MEZZO



Here it is observe that the performance of mezzo model is efficient when compared to actual model.



## A HYBRID OPTIMIZATION-MESOSCOPIC SIMULATION DYNAMIC TRAFFIC ASSIGNMENT MODEL

- A simulation model that attempts to capture the effects of the *car following, gap acceptance and lane changing* phenomena.
- The functional requirements of a dynamic traffic assignment model for ITS applications may be subdivided into two major modes of use: off-line use and on-line use.
- The off-line use of a dynamic traffic assignment model is for the testing and evaluation of a wide variety of ITS measures
- The online use of dynamic traffic assignment models is conceived to be a part of a real-time control system that monitors and governs the prevailing traffic.
- DTA handles networks of 2000-3000 links in reasonable execution times on the currently available computing platforms

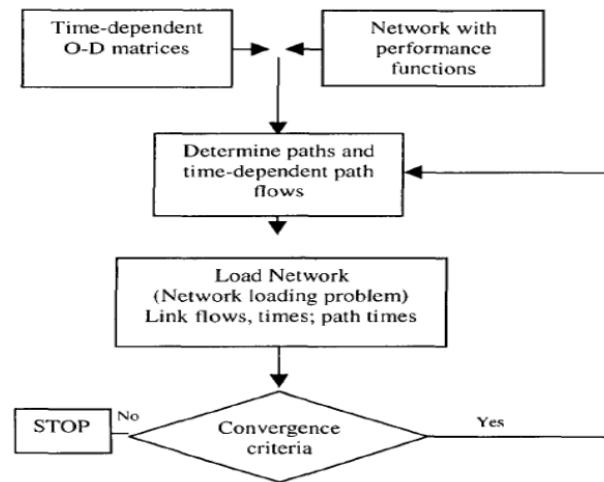


## THE NETWORK REPRESENTATION

- The network considered for the dynamic traffic assignment model presented here is similar to that used for static network models, with the addition of some information for links and nodes.
- The network is composed of the following domains: **node, arc, lane, turn**.
  - The vehicles are the entities that are moved on the network. Each vehicle is described by a set of attributes.
  - In the mesoscopic approach used here, the following mechanisms are considered: interaction between two successive vehicles, interaction between two vehicles whose paths cross as they traverse an arc, and interaction between two vehicles whose paths cross at a node.
  -



## APPROACH TO DTA MODEL



The two main approaches to emulate the path choice behavior of drivers, dynamic assignment *en route* and dynamic *equilibrium* assignment



## RESULTS

- North East part of Stockholm network was tested which consists of 220 zones, 2080 links and about 5000 turns.
- The origin-destination demand date is provided by four matrices for 20 minute time periods, starting at 7 am.
- The dynamic traffic assignment had run successfully by using 35 iterations that required between 2 and 3 minutes on the computing platforms.
- The execution time required by the code of this algorithm is reasonable.



## COMPARISION AND ANALYSIS

### **Microscopic models:**

- Microscopic models are vehicle based considering individual elements like driver speed, and vehicle speed.
- These are limited to limited area to control traffic.

### **○ Macroscopic models :**

### **Advantages:**

- These are based on traffic flow representations rather than individual elements like vehicle alone speeds.
- Hence these are used for larger areas like estimation of urban traffic.
- Short term traffic flow guarantees the forecasting effectiveness.
- UTN model provides an appropriate trade off between accuracy and computational complexity.



CONTD..

**Disadvantage:**

- Short term traffic flow relies too much on the precision of detectors and has too much parameters.

**Mesoscopic models:**

- This model omits micro scale details which needs lots of computation .
- Hence the computation speed is more than that of microscopic models.
- It supports large scale transportation and logistics modeling with realistic dynamic properties.
- Limited network coding and calibration effort
- The dynamic traffic assignment model which incorporates a route choice method has excellent potential for testing of ITS measures offline.
- Discrete event mesoscopic simulation presents new features such as start up shock wave for flexibility integration with microscopic models.

**Analysis:**

- From our survey work we observed that Hybrid models like mixing of micro and micro models would yield better performance than that of each individual model

## FUTURE WORK

- Future Research is to implement the simulation models using CTM model in its macroscopic engine.
- NEXTA for DTA Lite is another open source mesoscopic tool that uses Newell's N curve model in its mesoscopic engine.
- “Paramics” is one of the microscopic simulation tools.
- UTN model should be revised to improve its precision.



## CONCLUSION

- In this survey paper, we presented different efficient and well used traffic flow models that help us to model traffic flow, identify the traffic state and identify congestion in traffic networks.
- We classified 12 papers selected for by its level of detail into (Microscopic, Macroscopic ,Mesoscopic).
- Our survey paper explaines how the problems related to traffic flow such as congestion and bottleneck identification are easily handled by each method proposed in the research papers



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