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Abstract – Motion or Movement patterns of vehicles communicating wirelessly play a important role in the simulation based evaluation of Vehicular Ad Hoc Networks (VANETs). It is to know that recent research about mobility modeling has given direction for vehicular network study still to obtain realistic behavior of vehicles; developments in this area are required in detail level. In this paper, one of the main mobility modeling approach is discussed to the extent that it can help to understand models formulation and integr0ation strategies with network simulators. This approach is called as flow mobility modeling. It is put into the discussion and elaborated in such way it clarifies basics of flow modeling and its impact. It also finds a different ways of modeling and implementation into existing traffic simulators viz. SUMO, VISSIM etc. Flow of vehicle is a key aspect of flow modeling which is often used in VANET's simulation.

Keywords— *VANET, Flow modeling, Integration strategy.*

I. INTRODUCTION

Vehicular Adhoc network is a subset of mobile Adhoc network (MANET) having unique characteristic as road topology which separates both the networks. Vehicles move on roads and these road segments (maps) contains traffic lights, speed breaker, diversions, other obstacles etc. due to which movement of vehicle is not the constant from source to destination which changes due to above factors[1]. Thus while implementing mobility model into traffic simulator or into network simulator real motion constraints as well as motion pattern [1,2] with obstacles to be considered. This indicates that vehicles motion is major concern in VANET'S advancement. Additionally mobility modeling help to simulate motion of vehicles accurate rather than random or ambiguous. There are different approaches to model mobility as shown in fig.1. The movement of vehicle is modeled differently in all five approaches [3].

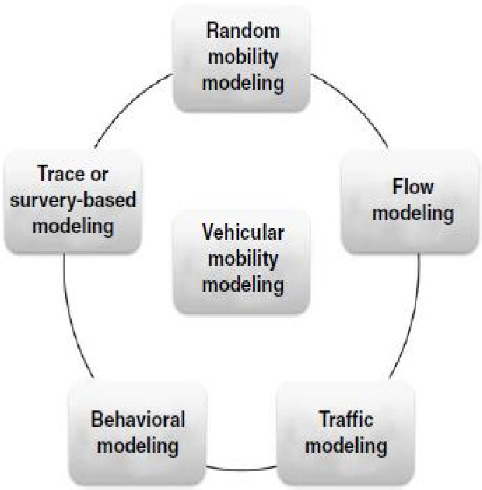

Fig. 1. Vehicular Modeling Approaches

From Fig.1 we can observe that vehicular mobility modeling can be achieved by five approaches viz random mobility modeling, flow modeling, traffic modeling, behavioral modeling and survey based modeling. In literature, it is found that from random modeling to survey based modeling is the improvement in mobility modeling approach which considers vehicle's own behavior and vehicle's interaction with other vehicles [4,5]. In this paper, flow mobility modeling is discussed in length since this is modeling used in latest many traffic simulators. This approach covers static and dynamic [6,5] behavior of car's in motion which can lead to simulate realistic behavior of vehicles. Instead of discussing other modeling approaches, flow modeling is emphasized and focused to understand clear idea behind consideration of smallest to largest details of car's behavior. This survey may give us required guidance when model is to be developed and clarifies basic of flow modeling to its classification as microscopic, macroscopic and mesoscopic[7,3]. Later it discusses in detail about how interaction between traffic simulator and network simulator can take place. This entire work of survey completes the discussion into five sections. Section I gives idea of flow modeling whereas next three sections discusses its types with existing models and last section explains different integration strategies.

II. FLOW MOBILITY MODELING

A. What is flow modeling?

Flow of vehicles is nothing but number of vehicles moving in one direction at one unit distance. Vehicles are moving on road (see fig.2) which a multi lane has traffic lights and diversions.

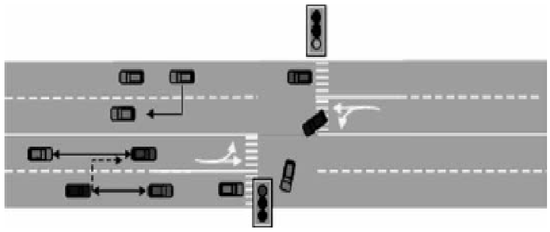

Fig. 2. Movement of vehicles in as directional flow

Vehicular flow modeling is a process in which mobility pattern which is described at local and global perspective as vehicle flows on road. Interaction of driver with external of cars is depends on its own parameters as well as on external conditions itself [8,3]. However it is the matter of perspective that both are important when realistic behavior is to be simulated. In this flow modeling flow of vehicle is important to have closer insights to develop a model. As surveyed flow modeling is useful because it can cover critical aspect of vehicular motion. Vehicular flow can also be explained with the help of car following theories [9, 7] which describes how one vehicle follows another vehicle in an uninterrupted flow. Various models were formulated to represent how a driver reacts to the changes in the relative positions of the vehicle ahead [9, 5]. The basic assumption of these models is the “A good rule for following another vehicle at a safe distance is to allow yourself at least the length of a car between your vehicle and the vehicle ahead for every ten miles per hour of speed at which you are traveling[10]”.

While designing flow model [11], it mainly emphasize on flow of vehicle but it is also influenced by street layout, block size (Road in grid form), traffic control mechanism and average speed [11,4,2]. Fig.3 depicts these influencing factors.

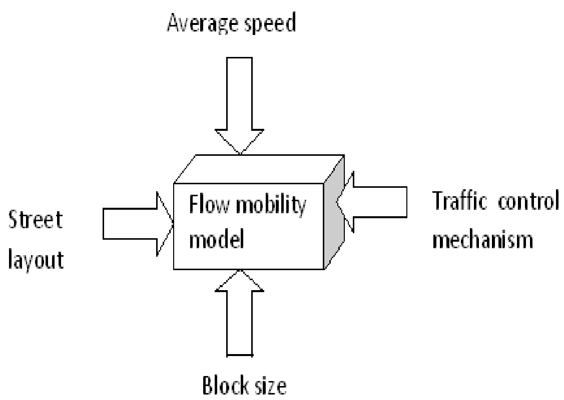

Fig. 3. Factors affecting flow mobility model

Generally mobility model is capable of including various dimensions of vehicular mobility which we can be encountered in formal design framework [3] for mobility generator.

There are three kinds of flow modeling approaches and recognized as development occurred in this area. These are viz 1) microscopic 2) macroscopic 3) mesoscopic etc following Sections III to V discusses these three ways of modeling.

B. Impact of flow modeling on routing

Routing protocols are used for communication among vehicles on road. These routing protocols popularly are based on distance vector or link state algorithms [11]. They are used when scenario such as moving vehicles on road and message communication is to be simulated and one of the routing protocol is used for communication then the impact of traffic generator on routing is observed and understood by analyzing its performance using some metrics [6,11] . Suppose we are using different traffic simulators to generate same scenario and those traffic simulators are implemented with different mobility models. Then we can obtain different results although the same protocol is used for communication. This is because flow models in traffic simulators are different and therefore we can say that performance of routing protocol may get influenced due to the use of different simulators. Hence impact of flow modeling [3,6,11] can be reported.

III. MICROSCOPIC FLOW MODELING

Microscopic mobility modeling is way of flow modeling in which flow of vehicle is considered in detailed level i.e. local characteristic of vehicle [5,8] is attributed. In other words, Car’s properties such as car’s acceleration / deceleration, driver’s behavior, car’s length, car’s speed etc [3] are to be modeled. Following are the examples of microscopic flow models.

A. Car Following Model (CFM)

This model represents microscopic details such as time, speed and position of cars on road segment. Mobility pattern is formulized as rules which are set to avoid any contact with leading vehicle that are called as distance headway and distance gap. Pipe rule is applied in this model which has equation as

$$\Delta x^{safe}(v_i) = L + T\,v_i + \mu . v_i^2$$

Where L is Length of vehicle, T is the safe time headway, Vi is the velocity of vehicle, *μ is the adjusting* parameter for deceleration.

B. Intelligent Driver’s Model (IDM)

This is the extension of CFM. This model includes instantaneous acceleration of car which is based on stimulus response approach. Rather than finding safe distance it is able to calculate free acceleration which has equation as follows.

$$a^{free} = a\left[1 - \left(v_i / v_i^{des}\right)^4\right]$$

To reach desired speed, Interaction deceleration to contact leading vehicle i+1 is

$$a^{int} = -a\left(\delta / \Delta x_i\,(t)\right)^2$$

Where δ is the desired gap between follower and leader vehicle.

This model is implemented in well know traffic simulator VanetMobiSim (2009).

C. Krauss Mobility Model

This model is also based on stimulus – response approach but differs from IDM in the term that it models acceleration which is discrete in time. IDM is ideal that it finds maximum acceleration and maximum speed whereas this model uses µ. stochastic parameter to adjust maximum speed and acceleration. It is nothing but variation to current speed for unit step time Δt. This provides speed increment and driver's conformance to model.

This model is implemented in traffic simulator SUMO (2009)

D. Wiedemann Mobility Model

It is a psycho- physical model. Reason to introduce such model is that same behavior cannot be induced from different drivers since stimulus and various external conditions changes rapidly. This model is identified with four driving states that are free driving, approached, following and breaking in which driver's driving influenced differently by other vehicles as following equation is true.

Driver's response = stimulus * sensitivity

It is model which implemented in VISSIM (2008) traffic simulator.

E. Cellular Automata Model (CAM)

Representation of this model includes not only time which is discrete but also discrete space to reduce computational complexity. It is also capable to mimic driver's reaction precisely. This model describes traffic lane as lattice of cell of equal size as well as like the widemann model, it also incorporates four driving states. Additionally other rules of acceleration to control movement of vehicle cell to cell are used. Cell size is chosen such that it can host a single vehicle that can move at least to next cell in unit step time Δt. Rules for accelerating, breaking, randomization are used in terms of distance and velocity.

It is implemented in traffic simulator TRANSIMS (2009).

IV. MACROSCOPIC FLOW MODELING

This is a approach of flow modeling which considers flow of vehicle at global perspective. Macroscopic properties are global in nature that is when large number of vehicles is in motion; global parameters can be represented as flow, mass and density respectively. If x is road segment, then flow *m(x,t)* is the expected number of vehicles passing by x for more interval (x, Δt) and density $\rho(x,t)$ reflects expected number of vehicles located in x at unit time t. The velocity $v(x,t)$ is the expected speed of vehicles in x and it is represented by below equation which is nothing but relationship among speed, density, flow etc.

$$v(x,t) = m(x,t) / \rho(x,t)$$

Another equation describes that the vehicular density in varies according to incoming and outgoing flows in x.

$$\frac{\partial \rho(x,t)}{\partial t} + \frac{\partial m(x,t)}{\partial x} = 0$$

V. MESOSCOPIC FLOW MODELING

Mesoscopic modeling represents an intermediate modeling level of traffic flow. It is a way of modeling in which microscopic and macroscopic modeling is merged. It may lead to efficient trade-off between modeling of individual vehicles and the modeling of large quantities of vehicles. This type of model's may take different forms such as the modeling headway distance[3,8] as a average of large number of vehicles sometimes size or density of cluster of vehicles. One of mesoscopic model called as queue model [3].This model includes dynamic behavior of vehicle and macroscopic properties such as density and velocity for large number of vehicles. Queue is nothing but waiting place where vehicles have to follow first in first out policy to maintain flow. Queue capacity is another crucial aspect of this model since this quality is macroscopic in nature which affects flow of vehicles [3].

VI. INTEGRATION STRATEGIES FOR TRAFFIC SIMULATORS

Interaction between traffic generator and network simulator is needed to established properly to achieve smooth communication between simulators and application [1,3]. Below mentioned Interaction strategies may give us idea about existence of architectural techniques for traffic generator that historically generates random, microscopic, real world (survey based) traces [1,4] etc. Presently in literature there are three major methods to accomplish this interaction between traffic and network simulators and they are follows.

A. Isolated simulation

In this class of integration, vehicular, mobility traces are generated as static and parsed to network simulator. These traces can be real world traces or randomly generated traces. No specific interface is defined for communication (see Fig. 4). This may include external random modeling and main network simulator is coupled as two separate entities [2,3].

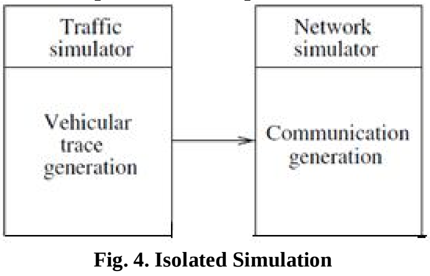

Fig. 4. Isolated Simulation

Modifications to the mobility scenario are not possible and therefore no interaction exist between these two simulators[2,7].Unfortunately, all historical models and most of the recent mobility models available to the research community fall into this category [3].

B. Embedded simulation

A vehicular traffic simulator is into network simulator or conversely a network simulator is embedded into a vehicular traffic simulator allowing bidirectional interaction between both the simulators (see in Fig.5). This method includes microscopic traces and also traffic simulator is coupled as microscopic model inside the network simulator [2,7].

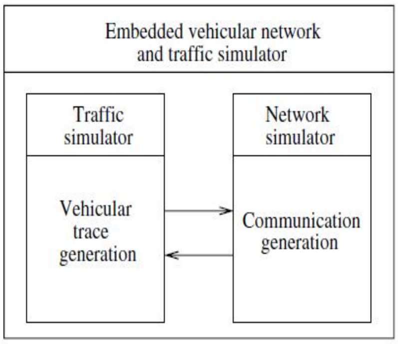

Fig. 5. Embedded Simulation

This coupling exists in The NCTUns simulator (Wang and Chou 2008) also falls into the category of embedded models [3]. Although being initially a network simulator, it has later been embedded with a vehicular traffic simulator providing a sufficient level of detail in the vehicular motion pattern.

C . Federated simulation

Coupling between traffic simulator and network simulator communication occurs via external interface which controls as well as permits smooth communication to pass between two. In this type of method, interface will be bidirectional for two separate entities [3].This is depicted in Fig.6.

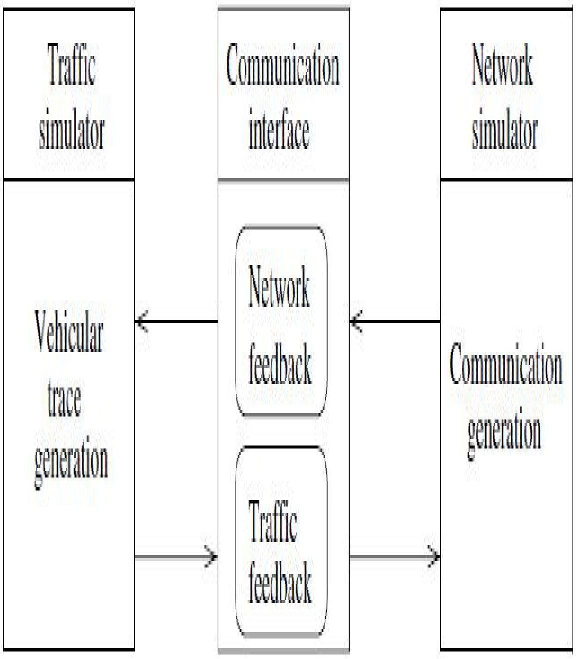

Fig .6. Federated Simulation

This approach exist in traffic simulator SUMO which federates with network simulator NS-2 or OMNeT++ Using an interface called TraCI interface[3].

VII. CONCLUSION

VANET is a advanced technology composed of modules which helps in simulation of vehicular network for last many years. But recent development in network simulator requires another or more advance modules which can simulate more realistic behavior of highway and urban scenarios. This paper surveys flow mobility modeling approach in which flow model is developed in fact it gives clear idea about what is flow model and its various ways to develop it. Flow of vehicles is focused in these models. Flow can be seen as local or global parameter in order to incorporate it into the mobility generator. It may lead to implementation of traffic simulator which can generate realistic traffic. However, most often microscopic mobility modeling is used in many traffic simulators and Krauss model which found useful in traffic simulators since it cover necessary formulation when urban and city scenarios are to be simulated. This work also covers the details of integration strategies exist for communication between traffic simulator and network simulator.

VIII.FUTURE WORK

When considering large number of vehicles to be simulated in vehicular applications, road with single lane cannot be fixed factor. In real world, road can be of multilane and movement of vehicles on this topology is different than single lane road. Therefore research in future should be conducted to have road map which is multilane structure and flow of vehicles is not in one direction or in one lane only in other words lane changing models can also be analyzed and developed in detailed. Other than this, intersection management and real world traces can be used in formulation of models when bridge scenarios [9,11] to be simulated. It can give large impact on generation of traffic since city scenarios such as bridge (flyover) is common in road layout. Finally, to make modeling more easier apart from having traditional design framework [3,6] various different templates can be developed to achieve more flexibility in their modeling.

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