Framework of Real VANET Simulation Research[1]

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***Abstract*-Vehicular Ad hoc Networks (VANETs) has a high node mobility speed, frequently changed network topology and limited node movement directions. Simulation is the main method that obtained in the VENET's research. The simulation of VANET includes two main parts: the built of vehicular mobility model and the simulation of self-organizing wireless mobile network. The authenticity of network simulation result is largely determined by the authenticity of the vehicular mobility model. This paper analyzes the category of vehicular mobility models, concludes the basic method to build vehicular mobility models, introduces SUMO as a vehicular mobility model building software and outlooks the future development of VANET simulation technology.**

Keywords-Vehicular Ad hoc Networks (VANETs); simulation; mobility model

I. INTRODUCTION

In today's field of MANET research, VANET is one of the hot areas. The main objective of the research is vehicular communication system and its main applications are traffic safety, traffic guidance and coordination, traffic status inquiry and management, etc. As a special case of MANET, VANET not only has MANET's common problems but also be characterized as its high node mobility speed, fast changing network topology and complex using environment.

It is very important for the research and analyse of VANET to test and evaluate VANET under real environment. However, VANET research under real environment is subject to human, material and financial resources. Therefore, simulation technology is firstly considered when developing communication protocols suitable for VANET.

At present a variety of simulation tools have been successfully applied to network communication protocols testing and evaluation, for example ns2[1], OPNET[2] and Qualnet[3]. However, these tools can only provide general MANET communication simulation environment instead of a simulation scene suitable for traffic environment communication. On the other hand, a variety of simulation tools used to analyse transportation program on both micro-level and macro-level have appeared. For example PARAMICS[4], CORSIM[5] and VISSIM[6]. It is necessary to combine network communication simulation with traffic simulation in the study of VANET.

The mobility of node is an important parameter in simulation study of Ad hoc. It is important to use more realistic mobility model for VANET simulation so that simulation results can reflect the real-world performance of VANET. VANET is a special Ad hoc and shares the similarity of instability of topology. While the difference is that in VANET nodes have a large range of speed variation which is limited to the condition of traffic roads.

II. VEHICULAR MOBILITY MODEL

Simulation research of VANET is divided to two parts, one part is network communication model (mainly including routing protocols, etc.) which has been studied by domestic and foreign scholars. And many achievements have been obtained especially in the research of performances of routing protocols such as AODV, DSR, ZRP[7][8]. The other part is vehicular mobility model (changes of topology). As described in the first part of the paper, the majority of the scholars today study them separately. Thus combination study of network simulation

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and vehicular mobility model is a hot area in the VANET study as well as in the Ad hoc real-world simulation study.

Early researches on VANET adopted random, mobility-restricted simple mobility models of Ad hoc study. The results of those researches could hardly reflect the real performance of VANET because those models ignored the special nature of vehicular traffic[9].

In fact, it is really complicated to construct a vehicular mobility model which can fully reflect the real vehicular traffic in VANET. The construction should consider factors from both macro-level and micro-level. In the macro-level the restriction on vehicular mobility should be taken into consideration, for example the driving route (map), location of traffic lights, peak of vehicle stream, aggregation of vehicles, etc. In the micro-level factors including driving habits of drivers, driving status (driving speed, distance between vehicles, style of vehicles, etc.), driving environment (pedestrians, bicycles, temporary traffic control, speed limitation , etc.). Simultaneously, there are other communication relationships like vehicle-to-vehicle (V2V), vehicle-to-roadside (V2R) and vehicle-to-Internet (V2I) which should be taken into consideration.

According to the level of detail of the simulation, vehicular mobility models can be classified as Macroscopic models, Microscopic models and Sub-microscopic models. The Macroscopic models are the fundamental vehicular mobility models which mainly consider about the traffic flow, density of vehicles and the vehicular mobility speed. The Mesoscopic models mainly using the queue approaches, thus to study the vehicular mobility models through the study of the relationship between vehicles' speed and density. The Microscopic models focus on the mobility of a single vehicle and mainly consider about vehicle's physical mobile ability and the habit of the driver. The Sub-Microscopic models focus more on the detail of the vehicle such as the relationship between rotation speed of the engine and the mobile speed of the vehicle or the relationship between the habit of driver and the speed of the vehicle. Sub-microscopic models will take a long calculation time so that the scope of the vehicular mobility model is restricted. Figure 1 shows us the different models, from left to right are Macroscopic model, Mesoscopic model (in the oval), Microscopic model and Sub-microscopic model[10].

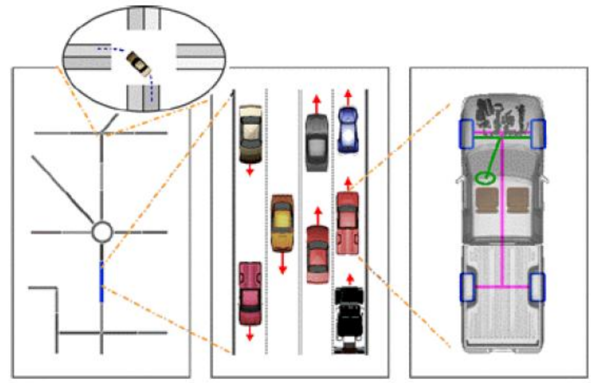

Figure 1.Different vehicular mobility models

When it comes into the research of vehicular mobility model, Harri[11] classified the vehicular mobility models as four classes, they are the synthetic models, the traffic simulators-based models, the survey-based models and the trace-based models. FDORE classified the synthetic models into four classes, they are the stochastic models, the traffic stream models, the car following models and the flows interaction models. At the same time, FDORE found through simulation study that the car following models can relatively authentically reflect the real traffic condition.

III. VEHICULAR MOBILITY MODEL CONSTRUCTION

It can be seen from the analyses before that constructing a vehicular mobility model is a complicated work. On the macro-level one should consider about the traffic map (highways, streets, traffic lights and crossroads) as well as traffic stream (origins, destinations, departure time, etc.). On the micro-level one should also consider about a single vehicle's physical features and drivers behaviours.

VANET researchers usually use open source softwares to construct vehicular mobility model needed for study. Two open source softwares are commonly used in the construction of vehicular mobility model. They are VanetMobiSim[12] and SUMO[13]. The two softwares usually have two kinds of functions, one is map edit function and the other one is vehicular mobility edit function. The map edit function is used to generate the road topology and the vehicular mobility edit function is used to generate the vehicular mobility model.

A. *Road Topology Construction*

There are three ways to construct road topology, one is to construct manually, one is to construct through software and the last one is to import a real map. In the process of generating map manually the related information about "node" and "side" should be also provided manually. A "node" is a special dot on the map and can refer to a intersection or the end of a road (e.g. A blind alley in the city center). It can also refer to a communication signal. While a "side" is a line between two nodes which usually includes features like speed limitation, number of driveways, priorities and length. The road topology can also been generated by software automatically without any information given by users. The three random road topologies that can be automatically generated today are grid topology, spider web topology and random network topology. The most realistic application is to directly import real maps, for example to use Tiger (Topologically Integrated GEographic Encoding and Referencing) map, etc.

B. *Construction of Vehicular Mobility Model*

When constructing vehicular mobility model a more realistic vehicle mobility condition can be obtained by setting parameters like mobility routes, number of vehicles, departure time, origins, destinations, distance of travel, mobile speed (acceleration, deceleration, highest speed), vehicular mobile duration and probabilities of every turning direction in every intersection.

C. *SUMO*

SUMO (Simulation of Urban Mobility) is an open source, space-continuous and time-discrete multi-mode traffic simulation software. It can simulate a given circumstance like a single vehicle travelling through a given road topology, and it can also simulate to solve large-scale traffic management problems. SUMO uses microscopic vehicular mobility model. That is to regard a single vehicle as an accurate model and have its own mobile route and move independently in the traffic network.

SUMO uses standard C++ and supports multi-driveway with turnings, microscopic routes (each vehicle has its own routes) and dynamic routes. It is featured as high reliability, high interoperability and can control more than 10,000 roads with different vehicle types, different road permissions, traffic regulation and traffic lights supported. The software can also support different types of network inputs (VISUM, Vissim, Shapefiles, OSM, RoboCup, and XML-Descriptions). SUMO includes a group of kit and provides both command and graphic simulation interface models with a relatively high processing speed. However, SUMO cannot generate vehicular track profiles necessary for the simulator. Yet SUMO can still be used to do secondary development to work out the vehicular mobility model with MOVE as an example[14].

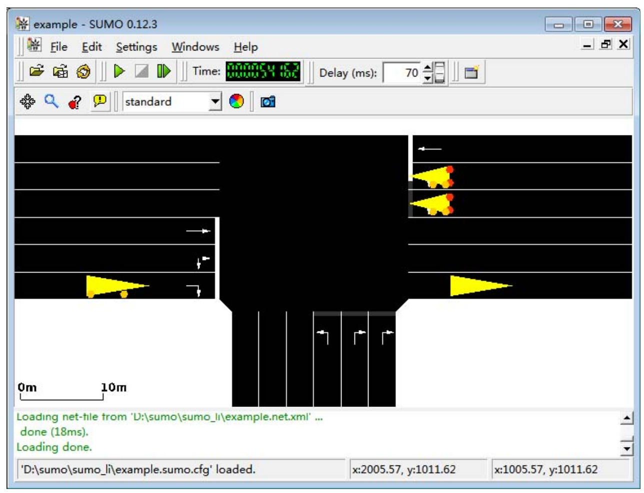

Figure 2. Graphic Interface of Simulation Software

IV. VANET SIMULATION

Conclusions from the analysis of I, II and III shows that two aspects of research are demanded to realize VANET simulation. The first one is the wireless vehicular network communication research, which is similar to Ad hoc network research. The second one is to build vehicular mobility model. Different from Ad hoc, the mobile speed of nodes in VANET is faster and the changing of network topology structure is more rapid. What's more, the moving direction is bounded to traffic network. Therefore, the combination of vehicular mobility model and the Ad hoc network simulation is one of the best projects to study VANET.

One of VANET's simulation approaches is to use open loop mode, thus by using SUMO to build up a vehicular mobility model which can reflect real quantity of vehicular mobility flow. And then generate results supported by network simulation softwares like NS2 and QualNet so that network simulation can be done and the performance of the vehicular mobility model can be studied. However, in this way the simulation work of vehicular mobility model is been done separately on two different softwares both on the time and space level. As soon as the vehicular mobility model is produced it cannot be modified in the network simulation environment. This brings a certain degree of inconvenience to simulation research on VANET.

The other VANET's simulation approaches is to use close loop mode. A close loop model means using softwares like NCTUns[15] and ASH[16] that can combine the construction of vehicular mobility model with the network simulation together to study VANET.

A. NCTUns

NCTUns is an open source software running in Linux environment and can directly use Linux kernel TCP/IP protocol. The reallife of NCTUns can generate real network flow and thus can work out more realistic simulation results. NCTUns uses methods that combines Intelligent Transportation Systems (ITS) with network simulation and supports basic driving behaviour and basic road network construction in vehicular mobility model aspect. In the aspect of network simulation it can simulate the roadside wireless unit and the vehicular wireless access unit. Besides, it supports IEEE 802.11(b) infrastructure mode, IEEE 802.11(b) ad-hoc mode, GPRS RF mode and DVBRCST satellite RF mode. In the newer edition (NCTUns5.0) the control of effective nodes' mobility in large-scale vehicular network is added and the map profiles in the popular SHAPE format is applied to automatically generate road network topological gragh. Simultaneously, it fully supports the IEEE 802.11(p)/1609 Wireless Vehicular Networks (WVN). NCTUns's disadvantage is that it can only support TCP/IP protocol based on Linux kernel version.

B. ASH

ASH (Application-aware SWANS with Highway mobility) is extended by SWANS and is characterized by the following features:

a. Two-way communication.

Two-way communication is realized by two original language set defined on the application layer. The first original language set supports the application layer to retrieval messages stored by network simulation in the network stack. The application layer sends the message to a specified port through its message management program. When the message reaches the specified port the network stack sends the message to related message management program. The application layer on the vehicle can influence the vehicular mobility by bilateral communication. Figure 3 shows an application of the bilateral communication. Vehicle C receives a brake warning message from Vehicle A. While IDM (Itelligent Driver Model) won't slow down Vehicle C because Vehicle B and Vehicle C are beyond the dangerous distance. However, the drivers can choose to brake earlier. ASH provides the bilateral communication mode in order to let the application layer make available simulation decisions that divers will make.

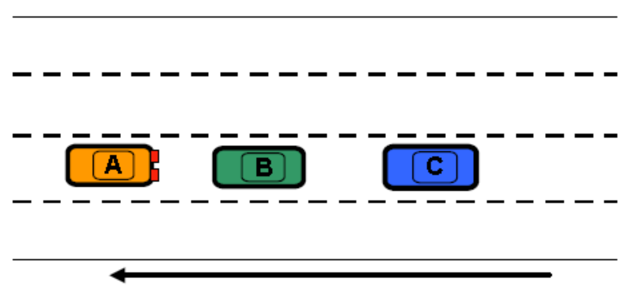

Figure 3. The Collisions prevention Cooperation System

b. Customizable highway topology

By configuration file ASH can set simple road segment. Parameters like length of road, number of directions, number of lanes of each direction, number of entrances and exits and locations of entrances and exits can be assigned in the configuration file.

c. Enhanced node model

In SWANS all nodes have the same mobility (all stop or all move) and all nodes participate in communication. In ASH each node can define its own mobile status and can choose not to participate in communication. So in ASH there may be four kinds of nodes which can be seen in Figure 4.

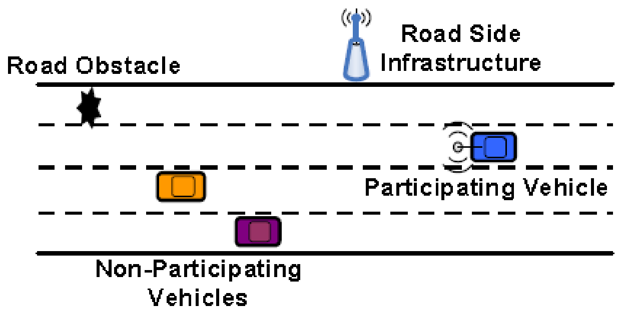

Figure 4. Four Kinds of Nodes in ASH

Mobile Communicating Node as Participating Vehicle in Figure 4;

Mobile Silent Node as Non-Participating Vehicles in Figure 4;

Static Communicating Node as Road Side Infrastructure in Figure 4;

Static Silent Node as Road Obstacle in Figure 4.

d. Realizing Inter-Vehicle Geocast (IVG) and probabilistic IVG (p-IVG)

When a vehicle receives a broadcast message it will start a timer. When the timer becomes invalid the vehicle will broadcast the message if no other repeated messages from other nodes is received.

V. CONCLUSION

As a special Ad hoc network, the research result of VANET is has significant meaning for urban construction, traffic management, military command, mobile officing and automotive manufacturing, etc. Since that the research of VANET involves many aspects of factors such as vehicle movement, wireless network, information security, the research of VANET becomes more complex. And because its experiments costs high, it makes simulation research on VANET one of the preferred means The difficulty of simulation study, however, is the method to make the simulation research more authentic. Therefore, it is particularly important to build a model that can authentically reflect the vehicular mobility model and wireless communication model. This paper gives a basic frame for the simulation research of VANET, introduce several common VANET simulation softwares and there features. As the development of the Internet of Things and the in-depth study of wireless sensor network, VANET research areas will be updated.

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