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A Review on The Realistic Mobility Models for Vehicular AD-Hoc Networks

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Abstract

There has been an imperative rise in interest in Vehicular Ad-hoc Networks (VANETs) in both the academic and commercial arenas. In the research of VANETs, one of the problems is to define a model of vehicle mobility that provides an accurate and realistic description of vehicle movement at macro and micro levels. The ability to dynamically adjust vehicle mobility as a result of vehicular communication protocols is another problem. The community has come up with a variety of solutions to these two problems. For this reason, as well as the fact that there are so many models on the market claiming to be suitable for vehicle traffic, it is difficult to discern their genuine qualities, level of realism in relation to vehicular mobility, and actual capabilities.

Keywords: VANETs; Mobility models; VANETs' Mobility

1. INTRODUCTION

In latest years, vehicular ad-hoc network (VANET) communication become a hot research issue in both the wireless networking and automotive sectors. To improve passenger safety and convenience, VANET researchers are working to create a vehicle-to-vehicle communication network.

VANETs (Vehicular Ad Hoc Networks) are a fast growing and challenging subset of Mobile Ad Hoc Networks (MANETs) (MANETs). VANETs are self-organizing, dispersed communication networks made out of moving vehicles; as a result, their nodes move at very high speeds and with a restricted amount of flexibility. In VANETs, these qualities may render ordinary networking protocols ineffective

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or impossible to use. Vehicle-to-vehicle communication (V2V) protocols are now focused on using the messages sent between vehicles to improve traffic flow in order to prevent congestion. There is a close connection between network protocol and vehicle mobility in both circumstances. Mobility affects data traffic in a conventional way. Mobility can be affected by data traffic in VANETs. As a result, in VANETs, mobility and wireless communication are intimately linked. This increased focus on developing vehicle-specific communication protocols and mobility models makes sense when considering the enormous effect VANET technology implementation may have on the automotive business.

The mobility of nodes is a critical consideration when modelling ad hoc networks. In order to accurately represent the real-world performance of a VANET in simulation, it is critical to adopt a realistic mobility model. For a realistic mobility model, you'll need a topological map that shows varied densities of roads and different types of streets, each with a separate speed limit. The impediments are yet another crucial element that should be modelled. Vehicle nodes in the actual world are often limited to roads that are divided by buildings, trees, or other things. Compared to an open field, impediments like these might increase the average distance among the nodes. In addition, each vehicle must choose its own path at crossing (e.g. turn left, turn right or go straight). Using a turning model like this might have an impact on traffic congestion and vehicle clustering. For this reason, a model that accounts for gradual deceleration and acceleration should be considered. For reliable network simulation results, several past research have proven that a realistic mobility model with adequate detail is required.

2. LITERATURE REVIEW

(John Justin Thangaraj et al., 2021) The topological structure of vehicular ad hoc networks (VANET) is constantly changing since the cars are continually on the go. Security is a critical problem for network resources in vehicular ad hoc networks because of this. The Vehicular ad hoc networks protocol architecture has the purpose of detecting traffic jams and determining the safest routes around them. An effective data communication model for mobile ad hoc networks using cloud computing is the goal of this article. Vehicle Processing Units are equipped with a configurable Cloud server interface mechanism for inter-vehicle communication. This paradigm guarantees low-cost, rapid computation, and expanded storage for the nodes without the need for extra network infrastructure. ' Data aggrega- tion, resource management, and privacy are all included in the service offerings. The results of the simulation are compiled and compared to the current model of mobility. Reduced packet loss is readily seen in this graph when compared to the previous method. As a result, the model for Cloud-based Ad-hoc Vehicular Networks outperforms the Mobility model in terms of performance.

(Ye et al., 2021) It has evolved as a critical element of the sophisticated Intelligent Transportation System (ITS) for information transfer and vehicular communication in the form of vehicle-to-everything (V2X) communication. The development and application of innovative network routing protocols that provide V2X communication with reliable end-to-end connection and effectual packet transfer is a critical research topic in VANET. VANET's packet delivery accuracy and reliability are threatened by the dynamic nature of road traffic vehicles. Position-based routing protocols are the most used in VANETs because they are able to handle fast vehicle movement changes. There are various drawbacks to current routing protocols such as inaccuracy in high dynamic network topology, faulty link-state estimation, and poor movement prediction in diverse road layouts that need to be overcome. Therefore, in this research, a novel target-driven and mobility prediction (TDMP) oriented routing protocol is presented for high-speed mobility and dynamic topology of automobiles, fluctuant traffic flow, and diverse road layouts in VANETs. TDMP relies heavily on a driver's destination goal for mobility prediction and the Received Signal Strength Indicator (RSSI) for inter-vehicle link-status assessment to construct an effective routing protocol. As opposed to existing geographic routing protocols, the proposed TDMP is able to improve packet transmission by taking into account the assessment of inter-vehicular connection status and the forecast of vehicle locations dynamically in fluctuating mobility and global road layouts. Experimental findings demonstrate higher performance in terms of enhancing packet delivery ratio by 21-57 percent ; lowering end-to end latency by 13-47 percent ; and average hops count by 17 to 48 percent when compared to many standard position-based routing protocols such as GPSR, GyTAR, and PGRP.

(Sethi et al., 2020)Models for optimising HANETS based on quality of service are examined, observed and evaluated in this research. An intelligent communication heuristic may be used in smart cities to alleviate emergency services, traffic congestion, and safety concerns, among other things. In real-time deployment, self-organization and optimization in ICN make it difficult and expensive to achieve congestion, dynamic topology, high mobility, scalability, and optimization. Various routing algorithms and network performance characteristics have been observed in literature by various authors using different simulation tools in different settings and circumstances. Routing protocols are affected by a variety of factors, including vehicle speed, road conditions, driver behaviour, and barriers. Longevity of a network is greatly impacted by the volume and mobility of data. Speed impacts VANET performance measures including throughput and packet delivery ratio at various BSMs in different conditions were studied in this work.. The simulated vehicle ad hoc network's throughput, goodput, and packet delivery ratio all improved with increased mobility and link awareness.

(Duarte et al., 2019) MobiVNDN, a distributed framework that is used for Vehicular Named-Data Networking (VNDN) communications, is proposed in this study. ' In VNDN, mobility and wireless communications degrade communication performance. MobiVNDN attempts to mitigate this deterioration. Multiple issues, including broadcast storms, redundant messages, network partitions, and content source mobility are all addressed concurrently by MobiVNDN. When it comes to scalability and performance, MobiVNDN is a clear winner, according to simulation data. MobiVNDN also functions effectively when numerous apps are using the same wireless communication channel.

(Sun et al., 2018) With the advent of 5G, vehicular networks will play an increasingly important role in the development of intelligent transportation systems (ITS) and smart cities (SC). The assessment of routing policies and the control of traffic flow rely heavily on mobility models. With the rapid advancement of big data technologies, academics are more interested in vehicle mobility analysis and design. As a result of the vehicular network's inherent dynamism and complicated network theory, these properties are also shown. This section introduces a large GPS dataset in Beijing and its difficult feature verification. On the basis of the GPS dataset, new vehicle and location-based cooperative mobility solutions are developed. Complex parameters including duration distribution, interval time distribution, and temporal and geographical characteristics are used to assess their performance. This study discusses the design and analysis of automotive networks in terms of mobility.

(Abdelgadir et al., 2017)VANETs (Vehicular Ad-hoc Networks) are one of the most current and hard study fields for automobile businesses and ITS designers. As a result of these networks, a broad variety of uses for transportation systems may be realised, including safety applications, mobility, and connection for both drivers and passengers alike. The most appropriate routing protocol must be chosen for use in safety-critical applications. DSR, AODV, and DSDV are the three most prevalent routing protocols in VANET. A VANET simulation programme may be used to conduct testing and evaluation of various routing protocols before implementing them in the real world. Based on this study, three routing protocols for the VANET system in Khartoum have been compared and evaluated. PDR, average throughput, latency, and total energy are all metrics used to assess and compare the system's performance. It is our goal to evaluate the performance of a city routing model. In Khartoum, Sudan, the primary purpose is to establish the best routing protocol for a dense traffic location. DSR, AODV, and DSDV are the three routing protocols we've examined. The findings show that the DSDV protocol, a sort of proactive routing system, is of low quality. At its utmost, the AODV protocol can provide throughput of 330.07 kilobits per second on average. The DSR technique resulted in a maximum delay of 15.81 ms.

(Campolo et al., 2015) When large-scale solutions are implemented, the expense and complexity of the experimental evaluation of vehicular ad hoc networks (VANETs) rises. Prior to implementing VANETs, performance assessment is required, and simulation is the de facto norm for network protocols and topologies to be analysed. For network simulation, automotive settings are especially hard because they need accurate modelling of not just the network stack, but also traffic dynamics and radio-frequency signal propagation in highly mobile surroundings. In this chapter, we'll go over how VANET simulations reflect mobility, the first of these two aspects. To be more specific, we'll go through the criteria for a reliable simulation and introduce models for road infrastructure, driver behaviour, and traffic dynamics in general. In addition, we'll talk about the progress of the simulation tools that implement these models and provide a practical example of trustworthy VANET simulation vehicular mobility modelling.

(Silva et al., 2015) To evaluate large-scale vehicle networks, researchers encounter a significant hurdle. Because large-scale testbeds aren't possible, simulation is the most often utilised assessment approach, which necessitates a realistic mobility model in order to deliver correct outcomes. But constructing large-scale realistic vehicle mobility models is a tough endeavour and many crucial aspects, especially macroscopic ones, have been overlooked. As part of this study, we describe a real-world vehicle motion trace and infer macroscopic properties. In this study, we propose and test a more realistic model of the vehicular network assessment process based on this characterisation. By presenting a more realistic macroscopic model that complements a number of vehicle mobility generators in the literature, the acquired findings add to the research community.

(Rahman & Nasiruddin, 2014) VSAs are specifically designed for VANETs. Inter-vehicle communication may be used to separate them. It is essential for a vehicle to be able to drive at high speeds while maintaining its reliability and safety. IDM-IM and IDM-LC mobility models were explored in this study to see how they affected AODV, AOMDV, DSDV, and OLSR routing protocols in a specific urban situation in Dhaka city. In the event of an emergency or collision avoidance, messages are sent between cars using the periodic broadcast (PBC) agent. Prior to designing a strong safety application for VANETs, the simulation findings propose that various issues, including reduced packet loss rate, latency, jitter, route cost, and mean-hop, be taken into consideration.

(Ros et al., 2014) Smart transportation systems that use communication-capable cars to deliver important safety, traffic management, and informational services may be designed and evaluated using simulation. When real-world models are included in the simulation toolchain, simulation results become meaningful. It's true that many studies in this area are based on too simplified models that don't account for the particularities of vehicular communication networks. For simulation findings to be accurate, it is important to understand the assumptions made by the models used in the simulation. Wireless signal propagation, short-range communication technologies, and vehicle mobility models are all examined in depth in this article. A variety of simulation tools and techniques are described, also procedures which must be done to fine-tune model parameters for getting the realistic results. In addition, we provide helpful tips and resources to assist you choose best tools and models. It is our aim that this paper will serve as a guide for future ITS researchers and encourage the use of best practises in simulation in order to get accurate findings.

(Kumar and Dave,2014) There has been a steady flow of research on vehicular networks coming from academic institutions as well as commercial research firms. For the vehicular network, defining a general mobility model that describes mobility accurately and realistically is a major issue. But since there are so many mobility models, it's difficult to actualize incomparable characteristics, genuine capabilities, and the true level of realism with regard to vehicle mobility. In vehicular networks, all the cars share a limited network capacity, therefore data aggregation and dissemination (distributing the data to other vehicles or roadside devices) conserve the network bandwidth and, thus, enable more vehicular applications to co-exist on the same network. Numerous studies in the literature deal with mobility models and data aggregation or offer new models for aggregating and disseminating the information they contain. As mobility models evolve, so does the performance of data gathering and dissemination systems. As a result, examining the impact of mobility models on data aggregation and dissemination is critical in studies of vehicular network performance. In this study, we begin by describing the various degrees of mobility and numerous elements that influence mobility. On to the performance measures for evaluating different vehicular network algorithms. Following that, we describe the various types of mobility models in detail. Finally, we provide an overview and taxonomy of several vehicular network mobility models that may be simulated. Mobility models have a significant influence on data collection and distribution, and this guideline will help readers make an informed decision about which model is ideal for a certain application.

(Kumar Singh & Lego, 2011) Many initiatives and research groups are working on the implementation of VANET (Vehicular AdhocNETwork), which has sparked attention throughout the globe. The primary goal of these initiatives and studies is to create protocols and technologies which will allow automobiles to communicate wirelessly. In order to create new VANET protocols and algorithms, actual cars cannot be used in a large-scale scenario since it is impractical. VANET simulators need a representation of the wireless channel's unsteadiness and lossiness. It is crucial to consider radio propagation and mobility models for VANETs in order to choose a viable protocol for vehicle-to-vehicle (V2V) communication.

(Lan & Chou, 2008) Using automobiles as movable nodes in a network, the Vehicular Ad-Hoc Network (VANET) is becoming more popular. Most VANET research depends on simulations for assessment since real-world deployment and implementation of such a system would be too expensive. VANET simulations need a realistic vehicle mobility model to guarantee that the insights derived from simulation tests are applicable to real-world deployments. First, we offer a tool called MOVE that can be used to quickly construct realistic mobility models for VANET simulations. SUMO, an open source micro-traffic simulator, serves as the foundation for MOVE. As a result of MOVE, network simulators such as ns-2 and qualnet may instantly employ a realistic mobility model. It is crucial to pick suitable levels of simulation details for VANET protocol design when evaluating the implications of mobility model parameters in three case studies of VANET simulations (particularly the presence of traffic signals, driver route choice, and overtaking behaviour).

(Karnadi et al., 2007) There is a new ad-hoc network called the Vehicular Ad-hoc Network (VANET), which is made up of automobiles. Research in VANET is heavily dependent on simulations because of the prohibitive costs of building and operating a system in the real world. A realistic vehicle mobility model is essential for VANET simulations because it assures that the findings derived from simulation trials are applicable to real-world deployments. For VANET simulations, we've developed a new tool called MOVE, which makes it easy for anybody to quickly create realistic mobility models. SUMO, an open source micro-traffic simulator, serves as the foundation for MOVE. As a result of MOVE, network simulators such as ns-2 and qualnet may instantly employ a realistic mobility model. MOVE's ad-hoc routing performance is evaluated and compared to that of the random waypoint model for vehicular nodes. A realistic mobility model produces dramatically different simulation outcomes than the typically used random waypoint model, as we demonstrate.

(Filali & Bonnet, 2006) We begin by introducing a framework for developing vehicle mobility models that might serve as a guide. There are a variety of ways in which vehicle mobility models and network simulators are developed by the community. For automotive ad hoc networks, we provide an overview and taxonomy of the several mobility models accessible. The goal is to help readers comprehend and objectively evaluate the various models, so that they may finally pick the one that best meets their requirements.

3. A FRAMEWORK FOR REALISTIC VEHICULAR MOBILITY MODELS

The following components should be included in mobility models in order to produce realistic patterns of vehicle motion:

- **Accurate and realistic topological maps:**

There must be a variety of junction densities, numerous lanes, and various types of streets and their related speed limits in streettopolo- gies to handle.

- **Obstacles:**

When used broadly, the term "obstacles" includes both physical restrictions on vehicle movement and technological challenges in wireless communication.

- **Attraction/repulsion points:**

We don't choose our starting and ending points at random when we go on a road trip. Many cars go to or from the same ultimate destinations, known as "attraction points," or "repulsion points," which may lead to bottlenecks and jams on the roadways.

- **Vehicles characteristics:**

a collection of traffic parameters is affected by the characteristics of each vehicle type. Macroscopically speaking, trucks are prohibited from using certain metropolitan streets and roads during certain times of the day. Cars and trucks have varied acceleration, deceleration, and speed capabilities when seen from a microscopical perspective. When simulating genuine vehicle movements, traffic generation engines must take into account certain features.

- **Trip motion:**

When seen from a macro perspective, a journey consists of a collection of urban origin and destination places. It's possible that different drivers have different preferences when it comes to where they want to go.

- **Path motion:**

Macro-scopically, a route is defined as the collection of road segments an automobile uses to go from one location to another. In reality, vehicles don't just randomly select the next lane at a crossroads, as is the case in most vehicular networking traffic simulations. There are several factors to consider, such as time of day, traffic congestion, distance, and the habits of the drivers themselves.

- **Smooth deceleration and acceleration:**

There is no sudden acceleration or deceleration in the driving of a car. Consequently, slow down and speeding up models should be investigated.

- **Human driving patterns:**

Static and dynamic impediments, such as other automobiles and pedestrians, are all factors that drivers consider while interacting with their surroundings. Overtaking and traffic jams are examples of reciprocal interactions between vehicles that should be controlled by a model of mobility.

- **Intersection Management:**

Static obstacles (stop signs), conditional obstacles (yield signs), or time-dependent obstacles (traffic lights) are all examples of this procedure (traffic lights). But the Traffic Generator block does not notice the modification between stop sign and a huge quantity of traffic. These are seen as the restriction on movement.

- **Time patterns:**

During the day, the volume of traffic is not the same. At top periods, such as rush hour or during special events, there is always a wide range of traffic density. Motion Constraints and Traffic Generator blocks can be affected through this block's trip or path calculation and attraction/repulsion points.

- **External Influence:**

Vehicle mobility models can't control various types of movement since they're impacted by factors beyond their control. This category represents the effect on the mobility restrictions and the traffic generating blocks of accidents, temporary road works, or real-time traffic status information. Communication systems are major source of information on external influences.

4. CLASSIFICATION OF VEHICULAR MOBILITY MODELS

There are four broad categories in which the advancement of automobile mobility models may be placed on a global scale: Survey-based Models, Trace-based Models and Traffic Simulators-based Models are all examples of synthetic models that include all models based on a mathematical model and are used to generate mobility patterns using actual mobility traces. Figure 1 depicts a possible categorization system.

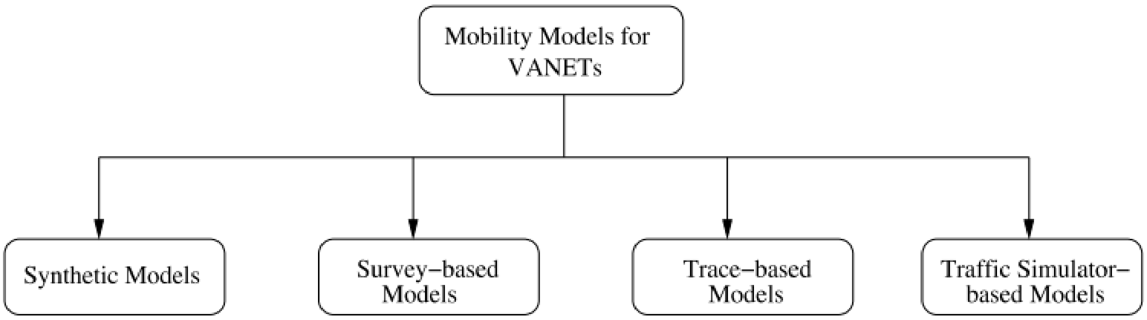

Figure 27 Classification of Vehicular Mobility Models

- **Synthetic Models**

Synthetic models make up the first and most well-known category. In order to build mathematical models that accurately represent the physical impact, much research has been conducted. Fiore [4] compiled a comprehensive list of all the models that fit this description. The categorization he came up with may be summarised in a few sentences. We recommend [4] for those seeking a more in-depth explanation. Stochastic models, traffic stream models, Car Following Models, QueueModels, and Behavioral Models are the five classes of synthetic models according to Fiore's classification, and each model is classified into one of these five categories. Fiore's categorisation is seen in Fig. 3. Mathematical models must be validated before they can be used to predict real-world traffic patterns. Large-scale measurement campaigns may be used to obtain mobility traces, which can then be used to compare these patterns to those generated by a synthetic model.

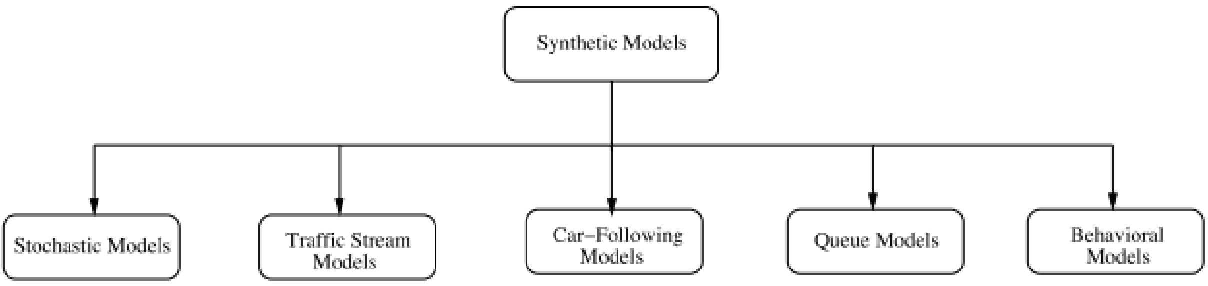

Figure 28 Classification of Synthetic Mobility Models (Fiore)

The difficulty of modelling complicated human behaviour is a fundamental drawback of most synthetic models. Drivers aren't robots, and they can't be made to do what we want them to do all of the time. A local disturbance or stimulus may have an impact on traffic modelling at the global level. Behavior theory should be taken into account while creating a realistic mobility model, so.

Synthetic mobility models have a three-pronged approach: first, they attempt to analyse a movement, then they construct a mathematical model, and lastly, they attempt to duplicate it. It's conceivable that certain motions are so intricate or intertwined that a mathematical model is hard to build. Based on these observations or surveys, the following methodologies seek to recreate an approximation of the movement.

- **Survey-based Models**

Macroscopic mobility data may be gleaned via surveys, which are common in the business world. It is the US Department of Labor that conducts the most comprehensive large-scale surveys, compiling considerable data on the habits of US employees in areas such as commute times, lunch breaks, travel distances, and lunch preferences. One may construct a generic mobility model capable of reproducing the pseudo-random or deterministic behaviour seen in actual urban traffic by integrating such data in a mobility model.

- **Trace-based Models**

Complex synthetic models can only get close to genuine motion patterns because of the difficulty of portraying vehicle movement. It's possible that we'll choose a different route. Directly extracting general mobility patterns from movement traces might save important time instead of constructing sophisticated models and then calibrating them using mobility traces or surveys. In recent years, such an approach has been more common as numerous measurement initiatives established by projects such as CrawDaD, UMASS Diesel-Net, MIT Reality Mining, USC MobiLib, or Cabspotting have begun to collect mobility traces. Using this method, the most challenging component is extrapolating patterns that can't be seen in the traces themselves. It is feasible to anticipate some of the movement patterns that are not recorded in the traces using complicated mathematical models. The measuring campaign's class is also a common source of the constraint. Using an extrapolated model for personal car traffic is not possible if motion traces have been collected for bus networks.

Trace-based vehicular mobility models are hindered by a lack of available vehicle traces. However, the results may not be known to the general public for some time, if they are indeed made available at all.

To better represent actual pedestrian movement patterns, researchers have been able to derive mobility models that include traces. As a result of trace-based mobility modelling, the speed and pause time distributions are not uniform but rather follow a log-normal distribution, and inter-contact time should be modelled by an exponentialdistribution rather than a power law. This contradicts the hypothesis used by synthetic models. In order to be as realistic as possible, synthetic models should be further developed to include more details that reflect their real-world counterparts. Real-world data may help us understand the distribution of speed, halt durations, and inter-contact periods in vehicle motion, and we can then utilise this information to design the synthetic models appropriately.

- **Traffic Simulator-based Models**

Some firms or research groups have developed realistic traffic simulators by enhancing synthetic models and through an extensive validation procedure which is based on actual traces or behaviour surveys. It is possible to replicate microscopic traffic in urban areas using fine grain simulators like PARAMICS, SUMO and CORSIM for urban traffic engineering purposes. However, since no interface has been built and the traces are mutually incompatible, these simulators cann’t immediately be utilised for network simulators. There may also be a licencing fee associated with the use of these traffic simulators. In light of these problems, we decided to create new, commercially available vehicle mobility models, which we will discuss in this article. However, by establishing a parser between traffic and network simulators' input files, end-user might acquire access to verified traffic patterns and so receive a degree of detail which is not attained by any genuine vehicular mobility model. This method's primary flaw is its high level of setup complexity, since calibrating these traffic simulators often requires adjusting a significant number of parameters. Another consideration is that compared to traffic analysis, simulating global patterns of vehicle mobility rather than identifying specific vehicle behaviours may not need the same degree of granularity. Some university programmes may even eliminate the need to obtain commercial licences for the usage of commercial traffic simulators (VISSIM, for example), allowing students to use them for free.

5. CONCLUSION

In this part, we discussed the various methods for creating mobility models. Developing a mathematical model and then simulating it with great accuracy may be an option if the motion patterns aren't too complicated. Observed movement patterns may be used to estimate the motions if that is not possible. This method relies on global mobility patterns rather than exact motions, which has its drawbacks. In addition, the created model is unable to duplicate a pattern that was not detected in traces or surveys. Another benefit is that it can show intricate motion that is impossible to describe mathematically.

However, the decision between the two ways is heavily dependent on the needs of the application, therefore they are not mutually exclusive. The mobility model, for example, must be developed by a synthetic model if the application is a vehicle safety protocol that requires a high degree of accuracy in representing actual motion. The gross motion patterns are adequate for evaluating a data distribution technique in comparison, and thus a trace or survey-based model may be imagined. As we'll see in the next section, the traffic simulator technique is also becoming more popular since it provides a degree of accuracy that can't yet be achieved by any synthetic model.

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