

Vehicular Ad-Hoc Network for Smart Cities

Bhawna Chaudhary¹, Sheetal Singh²

¹School of Computer Systems & Sciences, Jawaharlal Nehru University, India

²Ramanujan College, University of Delhi, India

¹bhawna.0101@gmail.com, ²sheetal.2109@yahoo.co.in

Abstract—The rapid increase in urban population is alleviating various kinds of problems such as long hours traffic-jams, pollution which is making cities life insecure and non-livable. The notion of a smart city is proposed to improve the quality of life. Smart cities are emerging to fulfill the desire for the safety of its users' and secure journeys over in the urban scenario by developing the smart mobility concept. At the same time, Vehicular Ad-hoc networks are widely accepted to attain such idea, by providing safety and non-safety applications. However, VANET has its own challenges from node mobility to location privacy. This paper discusses the application areas, security threats and their consequences of VANET into the smart city.

Keyword—Ad-Hoc Networks, VANET, Smart city, Security, Privacy

I. INTRODUCTION

THE growing need for vehicular ad-hoc networks (VANET), in which vehicles can communicate with each other, with or without the help of infrastructure on a temporary basis. The purpose of creating such network is to reduce the traffic delays and to make safe traveling for its users. In a typical VANET environment, vehicles directly communicate with other is known as V2V communication and with RSU is known as V2I communication. Each vehicle is equipped with a hardware OBU that has computational and communication capabilities.[1]. Apart from OBU, these smart vehicles are integrated with micro sensors, embedded systems, and GPS. As per dedicated short range communication (DSRC) standard, a vehicle needs to periodically broadcast the traffic and safety-related messages known as beacons. These beacons contain four-tuple information, i.e., the speed of the vehicle, location, direction and traffic events briefing accident or road scenarios. This beacon travels in the network carrying data loaded by the sender vehicle to others moving in the same region. For example, A vehicle can carry aware future traffic about the real-time traffic situations that would help other drivers to take early action in response to an unexpected situation. Due to these attractive features, this technology is considered as a mandate pillar in developing the smart city project.

VANET applications can be categorized into four main classes: Safety (time-critical and life-critical applications), Traffic Management (provide traffic information, prevent

traffic jams), Enhanced Driver Comfort and Maintenance and is described below:

- **Safety Applications:** Proactive measures for violation of traffic signals, stop sign and intersection collision; warning for the emergency vehicle coming, breakdown and wrong way driver; and can track a stolen vehicle, etc. are included in this category.
- **Traffic Management Applications:** These applications comprise of area access control, traffic flow control, electronic toll payment and rental car processing, etc. for the complete movement of the traffic on the roads.
- **Enhanced Driver Comfort Applications:** The applications under this category involve updated route guidance and navigation, parking spot locator, point-of-interest notification and map download/update/GPS correction, etc. for the driver's assistance while moving on the road.
- **Maintenance Applications:** This category includes wireless diagnostics, safety recall notice, and information about software update/flashing, etc.

Vehicular Ad-Hoc Networks (VANETs) permits Dedicated Short Range Communications (DSRC) of vehicles in the 5.9 GHz band, defined in the IEEE 802.11p standard. They support ITS with both Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications for applications in both near and far environment. In such a way, VANETs are a technology that enables a unified framework for integrating traditional ITS applications, Advanced Driver Assistance Systems (ADAS), Advanced Traveller Information Systems (ATIS), and Advanced Traffic Management Systems (ATMS).

A smart city has no universally accepted definition, but the motive behind developing such cities in every country is to enhance physical, social and economic infrastructure. In simple words, a city becomes smart when it start adopting the smart use of public resources provisions yield by the government, increase the quality of the services profound to its citizens and decrease the operational cost of public administration[2].The solutions implemented till date are installations of sensors and cameras in the public domain to encapsulate the data and use them to utilize in new services,

such as management of traffic lights, assistance in searching parking slots in crowded areas or help in flow management of public transportation. All such applications, not only improve the quality of life of citizen's but also diminish operational cost and lead to financial gains for the economy. Nowadays, specific focus in developing smart city demands smart mobility on the road, which includes enhancing traffic conditions, travel efficiency, vehicle safety and drivers/ passengers comfort while traveling. Readily availability of internet gives liberty to subscribe a bundle of services and helps to access real-time information about road conditions and facilities. For example, nearest petrol pumps/ Gas station, hospital, restaurant, etc. Such information can be easily accessed by VANET, but require perpetual network, i.e., still a big concern. The main contribution of this paper can thus be summarized as follows:

(a) A study, which emphasizes for enabling VANET applications in the smart city project.

(b) Also, discuss the benefits of implementing VANET applications and their possible consequences.

This article is structured as follows: Section 2 presents the contribution of VANET into Smart cities. Section 3, describes why smart cities need to introduce VANET like infrastructure?. Section 4, gives the overview of security and privacy challenges after implementing VANET. Finally, section 4, concludes the work.

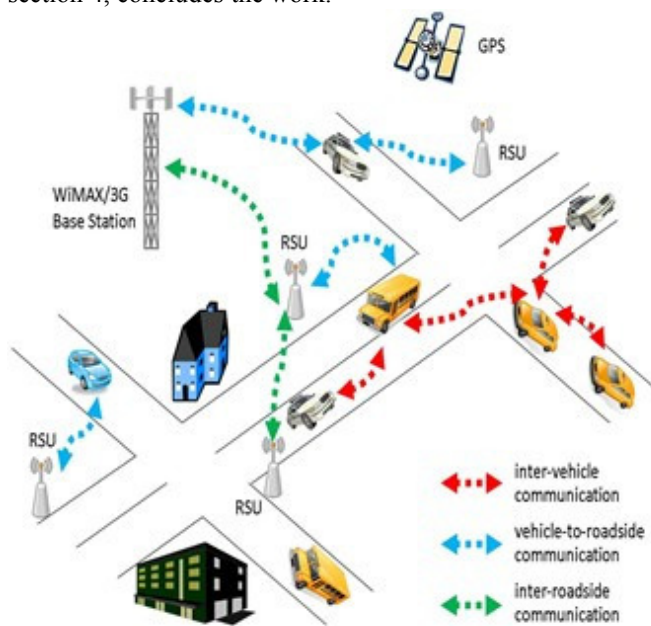


Figure 1. VANET Communication

II. RELATED WORK ON VEHICULAR AD-HOC NETWORKS IN SMART CITY

Traditionally cities (TC) were very simple in structure and developed for a thin population though the continuously increasing movement of rural population into urban triggers

the idea of developing smart-cities (SC). Current scenario of the city is very complicated as it has mix-cultured population, various categories of modes of transport, various communication technologies and utilities. Thus, to improve the shape of the current situation of metro cities the idea of a smart city has been gaining lots of attention from researchers and government. Though, debates are still not over its attribute set and standard needs. It is inevitable that these requirements cannot be satisfied without using Information and Communication Technology (ICT), which is already helping most of the city in proper utilization of resources. The extensive use of ICT in the smart city plays a vital role in collecting and delivering information and knowledge, by affecting the quality of life for its citizens by providing facilities such as e_services, a more in-depth involvement of citizens in the city governance and proactive step thanks to e_democracy and e_participation[3].

ICT acts as a digital nervous system that obtains data from heterogeneous sources such as parking spaces, traffic signals, security cameras and school thermostat, etc. The role played by ICT helps in decision-making planning and controlling activities within the automatic routine process. A perfect blending of right data and right policies can help peak hours traffic run smoothly in cities [4].

In [5], the importance of ICT in healthcare sector has been discussed i.e. using ICT; diagnosis of diseases and prevention can be made remotely by healthcare department. Apart from that observation of patients from hospitals can be done on demand. This movement from TC to SC can make learning system much forward, and it can help in improving the capitalizing system education policies. Also, it can create more opportunities for students and teachers using ICT tools. By using these tools, learning can become interactive and more research can be done[6]. The cities that are proposed to develop as SC have different sizes regarding the area, for this reason we cannot have a standard approach to apply the technologies. Another significant contribution was mentioned in [7] where the authors monitor the traffic with a novel approach for urban scenarios in which they implement collision detection and smart traffic management applications with a centralized and strongly infrastructure approach. In [7] this paper, it is suggested that initially, we should do the pilot study on smaller area sized cities which is not only cost-effective but also helps in calculating the outcomes fairly. Environment sustainability of a city is always an essential dimension as it may help to figure out the available green spaces which reflect the quality of life of citizens. Therefore, it is drawn that implementation of SC idea in such cities will help to lower the marginal cost if further improvements are required [8].

In [6], a survey explain the multifunctional data-driven intelligent transportation system, which collects a significant amount of data from various resources: Vision-Driven ITS (data gather from video sensors and used recollection include vehicle and pedestrian identification); Multisource-

Driven ITS (e.g. inductive-loop detectors, laser radar and GPS); Learning-Driven ITS (adequate assumption of the happening of accidents to enhance the safety of pedestrians by reducing the impact of vehicle collision); and Visualization-Driven ITS (helps in decision makers quickly for identifying unusual traffic patterns and then take necessary measures).

But, it requires a vast amount of memory to store the videos. Also in some complicated situations, as shown in figure 2, there are some problems regarding object reorganization.

In such a situation it becomes gruesome to identify each vehicle and perhaps to figure out the centroid of every vehicle. Hence it enhances problems in traffic density calculation. Another problem is while doing object extraction, if the color of the vehicle and the color of background become same then it becomes difficult to identify the object uniquely. Again we have to keep video data which is very large.



Figure 2. Complex scenario of traffic

III. REQUIREMENT OF VANET INFRASTRUCTURE IN SMART CITY

Smart cities are meant to enhance the performance of urban services through tight coupling of several sectors using Internet and Communication Technologies. The purpose of developing smart city is to satisfy requirements that can change in real-time, depending on the events appearing in the city. This section presents the requirement of VANET application into the smart city.

(1) *Traffic Management*: The expected number of people living in India is 1.34 billion, and 32.8 percent of this total population lives in urban areas. Today, cities are responsible for more than 75% of waste production, 80% of emissions and 75% of energy utilization. The road transport produces more than 50% of its total CO₂ emissions. This statistics profoundly point out the demand of implementing a technology that can make city transportation system more sustainable [7]. The first and foremost challenge to which developing a smart city is to resolve its traffic related problems. In

metro cities, the road is the only transport medium which creates adverse effects on overall traffic situation and environment safety level. In such complex environment, VANET can play a crucial role in improving traffic sustainability by controlling the system more efficiently and reduce energy consumption. It can be applied to the smart city infrastructure to help citizens, companies, and city government in the decision-making process, by providing real-time information about road conditions. VANET can resolve traffic situation in many different ways. For example, the GPS enabled vehicle can gather data from the network and able to predict the expected delays in a defined route and also suggest alternative less time taking routes to its users. Prior mentioned, both type of V2v and V2I network add-on their benefits into the network. V2V solution mainly focuses on safety, thanks to applications such as emergency braking system. Whereas V2I applications improve traffic flows by setting the most appropriate speed based on the future status communicated by smart traffic lights (i.e., red, yellow, green)[9].

(2) *Parking Management*: Parking problem becomes one of the major issues in the city transportation management since the spatial resource availability in the cities are limited and parking cost is increasing rapidly. In cities, people spend unnecessary time on searching for free parking spaces which not only consumes energy also cause chronic stress in life. According to the recent research significantly dealing with the parking problem states that the traffic flow peak produced by searching parking facilities can elevate 25-40% and on an average create delays of approximately 7.8 minutes[10]. It has been observed that 30% of the vehicles in the cities are struggling for the parking spot, with a consequent proportion of CO₂ emissions.

(3) *Collision Avoidance*: The VANET safety application set gathers information from other vehicles or sensors or both, for the safety management decisions. These decisions could involve a wide range of safety messages such as emergency braking, collision avoidance, intersection avoidance, alternate routes, etc. In highly populated areas, improving intersection collision systems help in reducing rate of roads accidents; that frequently occurs on the T-intersections or blind intersections. This type of communication involves V2I infrastructure of VANET which is primarily designed for cities scenario [11]. The sensors collect information from the vehicles moving towards the intersection and from the RSU's installed in that location; if sensors detect any possibility of a collision or any hazardous situation, an alert message is sent to all the vehicles driving towards that intersection.

(4) *Smart Policing*: The applications designed for road safety can be significantly proven useful in smart cities to perform the smart-policing such as the surveillance sensors installed at traffic signal can send a warning message to the drivers about a dangerous situation. On the contrary, if any vehicle breaks the rule the captured images can help the traffic police to trace out the vehicle's plate. In another situation, A warning message can be used to inform the

oncoming vehicle for the stop sign by recalculating its distance from the signal concerning its speed [12]. After receiving the message, the driver can control the speed and does not violate the sign which in turn avoid accidents. Hence, VANET not only assists the police with its applications but also makes them secure and livable by watching the roads round the clock.

(5) *Management Requirement*: In our traditional cities government is entirely responsible for every action. Limited transparency, fragmented accountability, different city division and leakage of resources are some fundamental characteristics of regular government. But in case of SC, we need e-governance which can monitor the whole city remotely. To cover the entire city's traffic and vehicles problems, we have technological solutions provided by VANET like SOS services that help in emergency cases to send a signal to the nearest infrastructure point directly. Alternatively, it depends upon the vehicles in range repeating the signal and delivering it to the most adjacent infrastructure.

To resolve the stated problems, VANET can apply to the smart city project by using the sensors, wireless communication technologies and efficient applications can be developed to assist the drivers with the information of free parking spots. Which reduces driver's frustration and negative impact on the city's traffic. In some countries, this application is already adopted and proven very convenient. More recent papers investigated the opportunities enabled by VANET technologies for car parking systems [13]. The car parking system was object area in the previous frame. Tracking by contour tracking method can be performed using two different approaches. (i) The state space models to model the contour shape and its motion. (ii) Minimizing the contour energy using direct minimization techniques like gradient descent. Made up of three layers: sensors to detect the occupancy of individual parking spots, communication technologies to collect the information from sensors, and an application layer to give (near) real-time information to the drivers. The application layer is crucial to assure a good user experience. After implementation, drivers can avail the benefits by using their smartphones or internet to make the slot reservation in a particular area parking space. Then, different technologies can be used to recognize each car at entry points (e.g., RFID, Bluetooth) and to trigger automatic reservation checking and parking payment [14].

IV. SECURITY AND PRIVACY CHALLENGES:

The awareness that smart cities are exposed to various security and privacy challenges is rapidly increasing, and lots of research focus to find feasible solutions to make our cities guarded is conducted. Security is of foremost priority in smart cities as business opportunities strongly rely on rules and regulation designed by the government to maintain privacy and trust in the technology. Before the market introduction of VANETs attractive applications and to increase

demand, citizens should be confident that these data exchanges will remain secure and confidential. Also, their personal information is kept private and not revealed to unwanted entities. In this section, we enlighten the security and privacy threats of VANETs that could be vulnerable in smart cities.

Though it has been suggested by some researchers to introduce VANET like applications into the smart city and there is no uncertainty that these features can make lives better. But on the other hand, their use makes people's life vulnerable and expose them to additional threats. For example, Smart parking is susceptible to many risks and precisely hardware attacks, which can compromise the physical devices or their communication interfaces by using jammers. To regulate and govern in such environment, a central controlling body is required. Another issue concerns the loss of privacy and confidentiality of citizens. For making a reservation in a parking slot, driver's information needs to be shared with controlling authority or central authority which will save the given credentials into a vast database. If a malicious user compromises the information available in database, confidential credential of a driver may expose or by finding out the source and destination of a person, a malicious user can figure out the possible route of the driver.

In the V2R environment, vehicles rely on the information provided by RSU's to run the network efficiently. These RSU's are responsible for sending safety messages to the vehicles and placed on the road-side with minimal security restrictions. The second type of possible attack is RSU spoofing; a malicious user can spoof the safety messages and mislead the drivers to the wrong direction. In the case of emergency situations, if a node injects malign flows into the VANET that will eventually degrade the ability of a vehicle to forward the packets containing information to neighbor nodes since RSU's are considered reliable, can create havoc in the city. Consequently, safety messages will not be relayed to traffic authorities, possibly leading to fatal accidents [15].

Another prospect is that an adversary may get access to GPS system and spoof the device, failing which can lead to faking positioning and unexpected outcomes may occur. These types of attacks like jamming attack or replay attack whenever happen in the SC not only affect a single entity but raise the question to the authorities regarding safety and security of its citizens[16]. Such things point the need for proactive measures that must be taken care of before initiating the project. As [14] says "technology gives comfort at the big cost."

Privacy is an essential factor for the public's acceptance and successful deployment of VANETs in SC as people are increasingly concerned about Big Brother enabling technologies and demanding their rights to privacy. In vehicle context, it can be attained when two related goals are satisfied (untraceability and unlinkability). This service ensures the user can preserve control of personal data and his/her lo-

cation. This service also secures other information related to the vehicle such as the identity of the driver, the driving behavior, Electronic License Plate (ELP), the speed of the vehicle, internal car sensor data, the past and present location of the vehicle from unauthorized parties. Therefore privacy can be of categorizing into various types such as (a) User Data Privacy (b) Location Privacy (c) Route Privacy.

Finally, by examining these possibilities from a different perspective, it can be concluded as it would be favorable to implement such novel security mechanisms, which can be successful where other conventional solutions have failed. By using various available technologies like LTE, GPRS, Zigbee, UMTS and Bluetooth, users remain connected in smart cities [6]. Every technology has an independent and specific security policy which clashes with the other technology policy. These raise a situation where policy conflicts may occur, so we need a standard privacy policy for a single category of technologies. For example, LTE networks use IPSec for its backhaul protection, on the other hand, Public Key Infrastructure (PKI) is used to prevent VANET from malicious users. Hence, maintaining and controlling these diverse set of security applications is not a simple task. To resolve this problem, we need a central controller, who poses powers to deploy an extensive collection of security policies by eliminating the overlap occurs between the technologies, and also helps to optimize the available network resources [14]. The central controller knows that he can efficiently manage the entanglement of globally available security policies and thus leads to enhance the overall network performance by designing compatible platform

V. CONCLUSION:

Establishing connectivity of vehicles in a smart city is required to provide support to the drivers in alarming situations. Precisely, VANETs are globally accepted as a foundation for safety, minimizing traffic related issues and exciting infotainment applications available for drivers, passengers, and walkers in the smart city. The expected contribution of VANETs are to provide information to the drivers about upcoming potential threats present in their surroundings, also gives alternate route information. The Wireless communication nature of VANETs applications makes its users vulnerable to the city, as we have discussed. Another issue that needs to be concerned is that a user should be well aware of the handling methods of such technologies. Mostly, this paper provides the understanding of how the VANET can be

useful and susceptible to the smart cities at the same moment. To resolve vulnerabilities, we need government contribution to regulate and apply the standards designed by standardization bodies and research institutions along with car manufacturers, to built secure and safe smart cities.

REFERENCES

- [1] S. A.-Sultan, M. M. Al-Doori, A. H. Al-Bayatti, H. Zedan, "A comprehensive survey on the Vehicular Ad Hoc Network", *Journal of Network and Computer Application*, Vol.37, pp.380-392, Jan 2014.
- [2] R. Mangaracina, A. Perego, G. Salvadori, A. Tumino, "A comprehensive view of ITS for urban smart mobility", *International Journal of Logistics*, Vol. 20, No.1, pp 39-52, 2017.
- [3] R. P. Dameri, "Using ICT in Smart City", Springer international publishing, pp 45-63, 2017.
- [4] H. Chourabi et al, "Understanding smart cities: An integrated framework", In system sciences(HICSS), International conference held in Hawaii, pp 2289-2297, 2012.
- [5] T. V. Ramachandra, Shwetmala, "Emission from India's transport sector: Statewide Synthesis", *Atmospheric Environment*, Vol.43, Issue 34, pp 5510-5517, Nov 2009.
- [6] A. D. Maio, M. R. Palatella, R. Sona, L. Lamorte, X. V. Lajosana et al., "Enabling SDN in Vanets : What is the impact on security?," *Sensors* 2016.
- [7] A. F.Santamaria, C. Sottile, A.Lupia, P. Rimando, "An efficient traffic management protocol based in IEEE 802.11p standard", *International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS 2014)*, pp 634-645, IEEE.
- [8] P. Neirotti, A. D. Marco, A. C. Caigliano, G. Mangano, F. Scorrano, "Current trends in smart city initiative: Some stylised facts", *Cities* 38, pp 25-36, Jun 2014.
- [9] E. L.Glasear, J. D.Gottlieb, "Urban resurgence and the consumer city.", *Urban Studies*, Vol.43, Issue 8, pp 1275-1299, 2006.
- [10] Z. Ji, I. Ganchev, M. O'Droma, L. Zhao, X. Zhang, "A Cloud-Based Parking Middleware for IoT Based Smart Cities", *Sensor*, Vol.14, Issue 12, pp 22372-22393, Nov 2014.
- [11] T. B. Hodel and S. Cong, "Parking space optimisation services, uniformed web application architecture", *ITS world congress proceedings*, 2003.
- [12] Z. Y. Rawashdeh and S. M. Mahmud, "Intersection collision avoidance system architecture." In *consumer communications and networking conference, CCNC 2008*, pp 493-497.
- [13] G. Yan, S. Olariu and M.C. Weigle, "Providing VANET security through active position detection.", *Computer communications*, Vol.31, Issue 12, pp 2883-2897, 2008.
- [14] B. Mokhtar, M. Azab, "Survey on Security Issues in Vehicular Ad Hoc Networks", *Alexandria Engineering Journal*, Vol.54, Issue 4, pp 1115-1126, Dec 2015.
- [15] J.-H. Shin, H. -B. Jun, "A study on smart parking guidance algorithm", *Transport research part C : Emerging technologies*, Vol.44, pp 291-317, July 2014.
- [16] P. C. Chishere, S. Magrini, "population growth in european cities: weather matters but only nationally", *Regional studies*, Vol.40, Issue1, pp 23-27, 2006.
- [17] A. M. Malla, R. K. Sahu, "Security attacks with an effective solution for dos attacks", *International Journal of Computer Applications*, Vol. 66, Issue 22, Jan 2013.
- [18] Y. C. Hu, H. J. Wang, "Location privacy in wireless networks," *Proceeding of ACM SIGCOMM Asia Workshop*, 2005.