Adaptive of Software Defined Network (SDN) technique to improve the connectivity between Two Vehicles in Vehicular AD HOC Network (VANET)

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Abstract. The automotive business has changed as a result of connected vehicles, which have improved urban adaptability and livability. The influence of Vehicle Ad-hoc Networks (VANETs) and their development into Intelligent Transportation Systems (ITS) is examined in this paper. The Internet of Vehicles (IoV), which facilitates vehicle-to-vehicle (V2V) communication, is built on top of VANET. Even though VANETs have advantages like increased entertainment and road safety, managing a variety of services with different Quality of Service (QoS) needs can be difficult. Software-Defined Networking (SDN), which facilitates effective control of mobile nodes, inter-operations, and resource allocation, is essential in addressing these issues. The paper is reviewed that how VANET technologies have developed over time, showing how they are now used for more than just safety services. Examples of these uses include IoT-based advertising, surveillance, and vehicle cloud computing. However, the inherent difficulties of VANETs, including changing node densities and high mobility, need programmable networking designs like SDN .Splitting architecture of network to control plane with data planes. Strategically, and SDN-enabled Vehicular Networks (SDVN) offer a centralized view for efficient management.

1 Introduction

Connected automobiles improve both the safety and convenience of travel, while also providing valuable data for the multibillion-dollar manufacturing business. The predicted figure for the year 2020 indicates that the quantity of interconnected automobiles will reach a total of 250 million. An Internet of Vehicles (IoV) is a development within the Internet Of Things (IOT) The Internet of Vehicles (IoV) has emerged as an advancement of the Vehicle

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Ad Hoc Network (VANET), the contemporary technology employed to managing vehicle-to-vehicle communication (V2V) Due to ongoing improvements in VANET technology, they are now acknowledged as networks capable of providing many services, including vehicle cloud computing, surveillance, IoT-based advertising, and safety traffic control. Nevertheless, the coordination of VANETs to deliver efficient services with diverse quality of service (QoS) demands remains hard, primarily due to the varying node density and significant mobility of the networks. Hence, VANETs require programmable networking architectures in order to facilitate inter-operation across different networks, efficiently manage a significant number of mobile nodes or users equipped with intelligent devices, and effectively distribute resources [9]. A novel clustering method, utilizing Software-Defined Networking (SDN) and social-awareness, was introduced for 5G-VANET. Its purpose is to enhance the adaptability and efficiency of clustering in facilitating information and communication exchange among Base Stations. The fundamental principle is to construct a cluster of nodes that exhibit comparable social affinities, perhaps leading to shared future trajectories. A refined evolutionary algorithm has also been suggested to improve the efficiency of dynamic network adjustments in VANETs. It encompasses a resolution to adapting to the frequent dynamic changes in the network and ensures the presence of a diverse range of solutions. The primary concept is to achieve equilibrium between V2V and V2I traffic in order to decrease delay. The issue of vertical handover in heterogeneous wireless networks, which is based on software-defined networking (SDN), can be resolved by employing the fuzzy analytic hierarchy method and the multi-path transmission control protocol. The authors proposed the deployment of a 5G-VANET system that leverages software-defined networking (SDN) to facilitate dynamic vehicle grouping and focused transmission using beamforming technology.

This system is specifically developed to manage the collective traffic generated by the cluster head. Software-Defined Networking (SDN) enables the division of the data plane and control plane, hence facilitating the administration of 5G-VANET and enabling centralized control over HetNets. This is accomplished by providing a comprehensive perspective of the worldwide network and a consolidated configuration interface, irrespective of the underlying HetNets involved. SDN offers a flexible and adaptable interface that allows for the implementation of smart and uniform policies in 5G-VANET HetNets. The proposed 5G-VANET will utilize SDN to predict incoming road traffic and accomplish adaptive vehicle clustering.

Inside every group of vehicles, a cluster head (CH) is chosen to gather data from other vehicles and connect with the cellular base station (BS) to minimize the amount of communication required. Subsequently, a dual channel (CH) design is suggested to ensure both the resilience and uninterrupted transmission of data across the trunk link [8].

2 BACKGROUND AND OVERVIEW

2.1 Vehicular Ad Hoc Network (VANET) Technology Ad Hoc networks:

It is accomplished using mobile broadband, such as 4G/LTE, by utilizing (Vehicle to Infrastructure V2I) within a Roadside Unit (RSU) and Vehicle-to-Vehicle (V2V) communication with an improvised design. Typical VANET services encompass activities such as enhancing traffic safety, managing car and road security, and optimizing traffic flow to enhance community welfare. Infotainment services provide a combination of entertainment and information. These devices are utilized in ad hoc communication, where the use of wires is unnecessary and each connected node has the ability to move unrestrictedly. The vehicles utilize dedicated short-range communication (DSRC) technology, which functions inside the 5.9 GHz frequency spectrum. This frequency allocation provides a bandwidth range of 75% and covers a distance of around 1000 meters. RSUs, or Roadside Units, are referred to as routers due to their similar functionality in V2V communication and their ability to communicate with other network devices. While both public and private data communications require network support, public communications are given priority over private data communications [3].

Automobile ad hoc the development and convergence of intelligent transport systems, wireless communication technologies, and automobile construction technologies result in networks. They are regarded same as the particular parting ad Hoc of mobile networks, or MANETs, with requirements with features unique to automotive nodes. A VANET is a collection of fixed (roadside units) and mobile (cars) entities that collaborate to share vital information about other vehicles and the state of the roads. In V2I, the vehicular network takes into account the apps that utilize RSUs to enhance the services offered by online portals. The two prior techniques are blended in hybrid mode [13]. The **Fig. 1.** illustrates various VANET connection domains [12].

Communication in VANET Include:

- (v2v) vehicle-To-vehicle communication.
- (v2i) vehicle-To-infrastructure communication.
- (i2i) intra-T-infrastructure communication.
- (v2s) vehicle- To-sensor communication.
- (v2pd) vehicle-To-personal device communication.

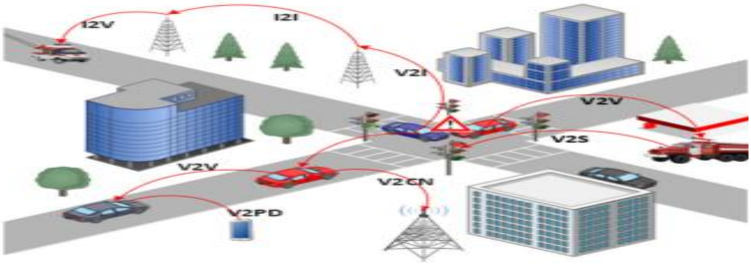

Fig 1. Communication in VANET can occur through various modes

2.2 Software Defined Networking

SDN can be characterized as the split between the system (control plane) and the transmitting capacities (data plane). Before data is sent to a network device, the controller creates the rules, and the controllers regulate the logic that dictates how the network behaves. SDN is described like a more modern network that has the potential to overcome the drawbacks of more traditional, in before the older networks were in use for decades. From Fig. 2. There is the Logical representation of SDN [3].

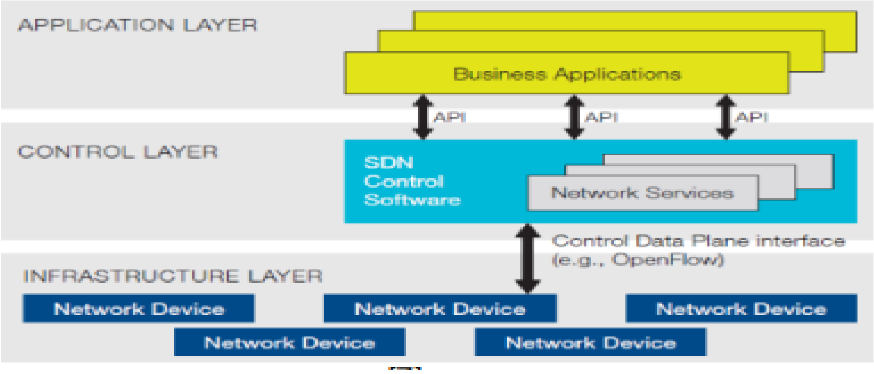

Fig 2. Basic SDN architecture

A. **Data Plane:** Every forwarding device linked via wireless radio channels is part of the data plane. As SDN switches, all of a data plane component are were worked switches as SDN, base stations, RSUs, and vehicle forward packets by the directives provided according to a SDN controller.

B. **Control Plane**: Control plane might be seen as the "network brain". Creating rules, data pre-processing, resource allocation, and other duties fall under the purview of the SDN controller. The controller creates flow rules for packet forwarding and sends them to the switches using southbound APIs. The control plane receives the status information from the switch, which includes the vehicle's location and velocity. In addition to keeping these statuses up to date, the control plane helps the vehicles by making effective routing decisions.

C. **Application Plane:** includes every application, QoS, traffic management, routing, and more. The policies were described then sent into a northbound APIs which that control a Control Plane using these applications. Finally, the forwarding devices' habits are managed from the application plane [10].

2.3 SDVN (Software-Defined Vehicular Networks):

Some of the researchers are optimistic about SDN's ability to revamp the network infrastructure for automobiles. SDN has become recognized as a solid approach to network management in recent years. Software-defined networking, or SDN, uses OpenFlow for communication between the control and data planes. In VANET applications, SDN's adaptability works well. Current ad hoc wireless networks are unprogrammable, inflexible, and centralized. One way to reduce the constraints on VANETs is to apply SDN ideas to them. Constructed on SDN, VANET networks offer novel V2V and V2I services, improved network structure, and simpler network administration. Because of the SDNVN design, overall connectivity is improved and dis-connectivity caused by vehicle movement is decreased. In the following sections, the authors presented three essential parts of an SDN-integrated VANET, as illustrated in Fig. 3**.**

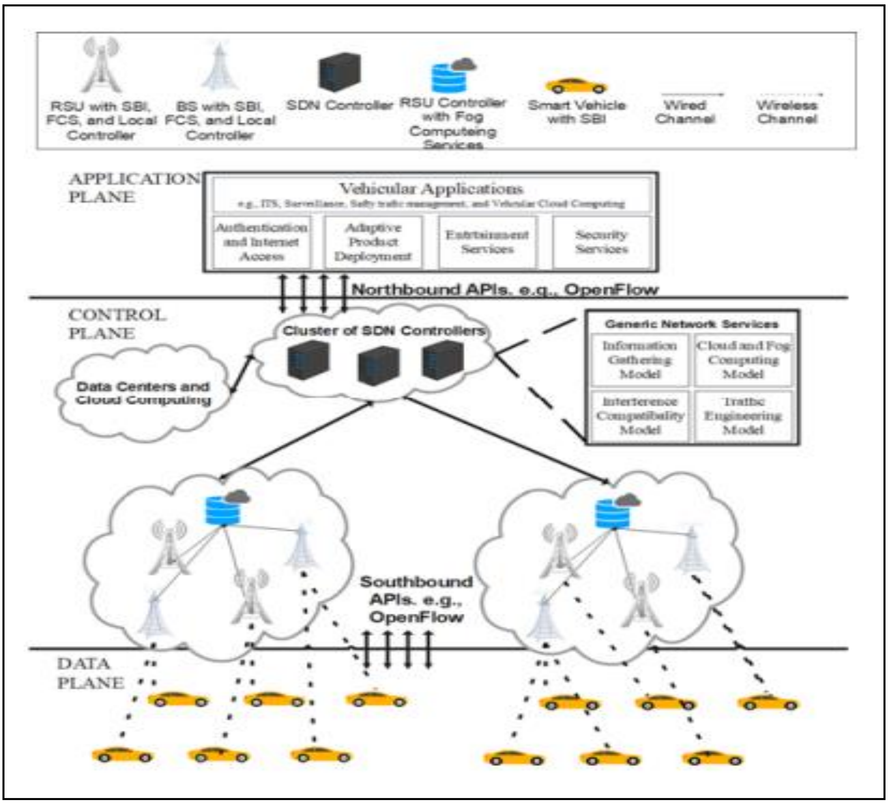

Fig 3. Methodological approach of the present study

3 SDN TECNIQUES ON VANET:

3.1 Dynamic Routing Algorithm:

When it comes to directing and sending, many questions arise regarding the transfer of SDN servers and their services from the source to the destination, in accordance with the movement of the vehicle. Software-Defined Networking (SDN) Server Switching Vehicles typically make decisions about their optimal course of action within a short period of time, as they are constantly moving at a high speed. It is difficult to predict which vehicles will receive services from BS or SDN servers based on traffic and public transportation data that analyze the movement patterns of vehicles to anticipate their location in the future. Despite the implementation of various approaches to address the problem, it remains an ongoing research issue that requires further investigation). SCSR and ICH provided by SDN during the present and a final intersection. Those potential route consists of a chain of intersections, as illustrated in Fig. 4. The range of every routing is determined by calculating the average outcome (using equation 1) to all segments. In the lack of vehicles in the area where several intersections meet, the present 7 ICH follows forward principle and the store. So that it keeps the present packet and continues moving forward till reaches a different CH inside its range of transmission and close to the last intersection comparing of itself.

$$Weight(j) = S_1 \times \prod_{i=1} \left(\frac{T_{avg}}{T_{avg} + HOT}\right)^i \qquad (1)$$

Where: *Weigh(j):* The weight of segment j - $S1$: The transmission rates for cluster 1 of segment j - HOT: Handover Time ($TAvg$) refers to the average duration it takes to send data. Algorithm 2 elucidates our proposed protocol using pseudo code. In the IDVR system, every forwarder node (also known as the source node) acquires and stores all available routes to the intended destination in a designated buffer called the route set.

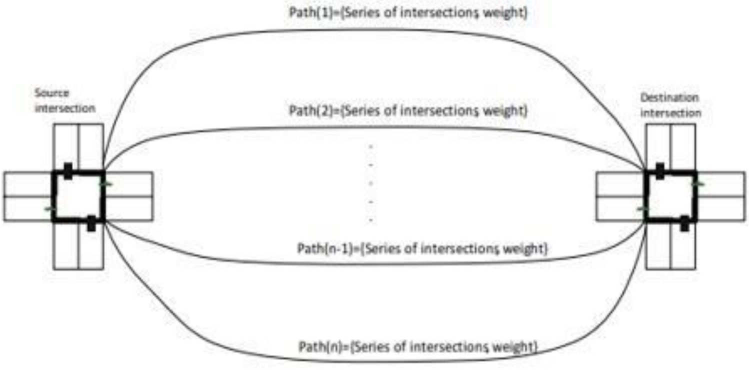

Fig. 4. Routing candidate

3.2 Resource Allocation

Within vehicular networks, autonomous cars must engage in V2V communication with other vehicles, as well as connect with the roadside infrastructure. This communication is crucial for collecting real-time information, including speed, direction, and location, and requires a high level of reliability. Furthermore, the autonomous vehicular network faces tough objectives due to the growing need for data services and high bandwidth in the presence of increasing vehicular density, changing traffic conditions, and distributed RSUs across the infrastructure. Conventionally, DSRC is employed for vehicle-to-vehicle (V2V) communications and Remote Access Technologies (RAT). Nevertheless, these technologies are not without their constraints. For instance, LTE's radio access relies on orthogonal frequency multiple access, which is hindered by spectrum limitations and inherent delays in vehicle communications. In safety applications, the delay in reaction might lead to catastrophic consequences. Furthermore, the limited spectrum poses a constraint on achieving the projected level of extensive connection in 5G networks. Fig. 5. illustrate the architecture of 5G IoV of Resource allocation .They have developed a model for the Internet of Vehicles (IoV) that considers four key factors: service delay, work computation stability, power utilization, and balancing of. Every vehicles should submit a service asking in a random manner when passing by an RSU. Upon receiving the service asking achieved obtained with a RSU, the RSUC employs a dynamic dividing scheme suggested from [reference] to separate the service ask through n distinct subtasks (S R = {ST1, ST2, ..., STn−1, STn}). Assume that there are l fog nodes (F N = F N1, F N2,..., F Nl−1, F Nl) in the fog cluster and m cloud nodes (C N = C N1, C N2,..., C Nm−1, F Nm) in the cloud that are capable of handling this service asking .A RSUC assigns every subtask for these nodes by executing a algorithm of resource allocation. Based on a Load-input Data Ratio (LDR),, the sophisticatedly for every subtask that could be explained like bellows:

$$LDR_k = \frac{STC_k}{STS_k}. \qquad (2)$$

The RSUC going back to the service requesting vehicles after integrating each node's processing results once each subtask is finished [6].

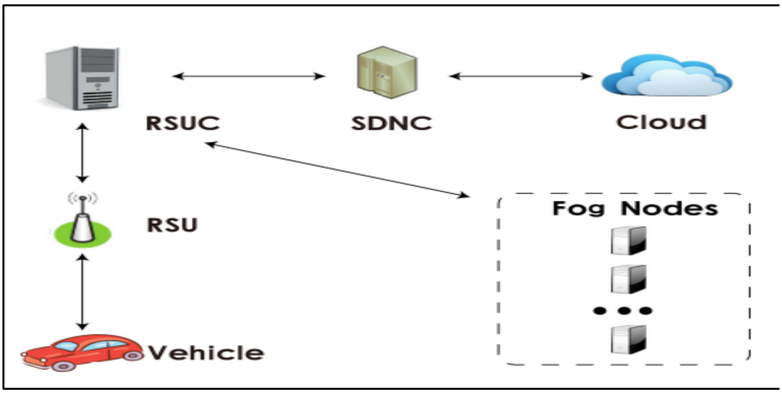

Fig 5. 5G IoV architecture of Resource allocation

3.3 SDN-QoS in VANET:

The IEEE 802.11e standard's traffic prioritisation strategy is insufficient for quality of service (QoS) because it does not allow for the prioritisation of traffic belonging to the same access category (AC) and instead assigns a static, predetermined class-specific priority. Conversely, one intriguing feature of SDN is that it provides flexible and fine-grained flow-based QoS control. The authors used this feature to our advantage to construct the QoS mechanism and dynamically accomplish QoS in VANETs [5]. Assumed to be fitted with a Global Positioning System (GPS), every vehicle updates its position, speed, and direction data to the controller every time interval Δt. Assumed to be fitted with a Global Positioning System (GPS), every vehicle updates its position, speed, and direction data to the controller every time interval ΔtWhen a source in reactive mode has data to send, it notifies the controller by sending a request. The controller determines the destination's location and counts the number of hops needed to get there from the source. Next, it forecasts the positions and configurations of the cars for a few time intervals in the future, or times t1, t2, t\tp. [11]. The beacon messages are used by the position-based routing (PBR) protocol to periodically get the position of a specific neighbouring vehicle. However, the authors compute the average control packet overhead taking into account the beacon message, RREQ, and RREP messages. Fig. 6. Displays the quantity of control data packets that were created during the exchange of information between multiple vehicles to determine the destination vehicle's most recent position. The authors refer to this as overhead in Fig. 7. The average E2E Delay for the quantity of cars is displayed. It is evident that as the number of cars rises, the average E2E delay decreases for all protocols. Our scenario has the lowest E2E delay once more. For 300 automobiles, our suggested approach takes roughly 1.411 seconds, whereas the same value for GPCR takes roughly 4.511 seconds. Consequently the recommended approach is almost four times quicker than GPCR for the 300 vehicles on the network. In comparison to the GPCR technique, the newly suggested method is roughly 3.20 times faster when there are 300 automobiles [7].

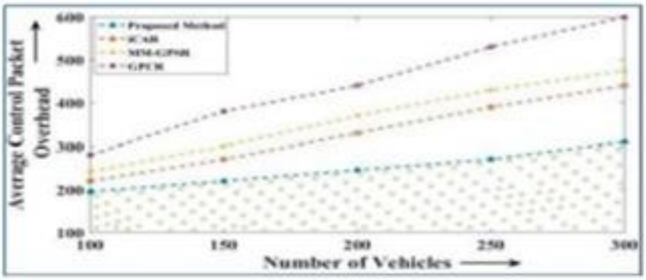

Fig 6. Average Control Packet

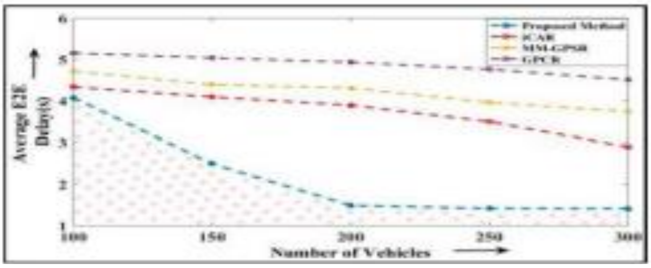

Fig 7. Average E2E Delay vs Number of Vehicles

3.4 Traffic Engineering and Balancing:

Traffic control, road monitoring, and road control: SDN controllers continuously keep an eye on and manage the enormous amount of traffic in cities. In order to accomplish this, the controller watches the data from moving automobiles while concurrently interacting with multi-hop routing. Traffic conditions, such as accidents and bottlenecks, are tracked by sensors and reported to the SDN controller. Consequently, the controller dynamically adjusts routing and forwarding decisions by exchanging monitored data and flow rules with the vehicle over the data plane. Methods for identifying traffic accidents can also be applied based on tracked data, including acceleration, speed, and vehicle coordinates. With this strategy, machine learning techniques like support vector machines, random forests, and artificial neural networks are utilised to assess the behaviour of the cars using the data set that has been obtained [14]. Traffic congestion is one of the main reasons for changes in traffic. As a result, it is critical to recognise traffic bottlenecks and take prompt, suitable action. Many efforts have been made recently to identify traffic congestion using machine learning techniques. Through their research, they were able to locate the congestion's cause and achieve an 89.51% forecast accuracy for random forests.

In order to discover accidents, they conducted research using SUMO simulations and the Random Forest Classifier technique. With an accuracy of 91.56% as opposed to 88.71% for SVM (Support Vector Machine), the Random Forest method performed better than SVM. K-means clustering is an unsupervised learning technique used when unlabeled data is available (i.e., data without predetermined categories or groupings).
The SDN controller provides the road traffic topology, which allows the BSs to anticipate incoming traffic and make the necessary adjustments. The automobiles are grouped inferometrically according to similar AoA and RSS when the cell is stressed and the classifying requirements are met. The member information for each group within that group is subsequently made available to the mobile gateway candidates.
Considering that the BS side, received car signals are grouped into N evenly divided transfer angles of 360/N degrees and road speeds around VMAX. Different transmission angles combined with RSS allow us to distinguish.

$$\theta_x - \theta_y \leq \frac{360}{N} \text{ and } RSS_x - RSS_y \leq 1 - e^{-\frac{\Delta V}{a}} \qquad (3)$$

where an is a constant that indicates the speed of change of the 5G signal power when the speed of mobility increases or drops by a one, x and y stand for two vehicles, and /V is the variation in the speed between the two vehicles [8].

3.5 SDN-based VANETs Security Challenges

Security is still a major concern since real accidents can be caused by the dissemination of misinformation from prohibited sources. The following section discusses the main goals of caution from a security perspective. First and foremost, the SDN controller continues to be the primary point of leadership and needs to be strongly guaranteed top-to-bottom barrier methodology is advised, as is the verification of standard SDN frameworks. Second, securely coupled SDN layers promote the propagation of threats among layers. In this way, APIs between layers ought to be established and formalised. Third, SDN threats to the control and application layers are increased by the adaptability and responsiveness of vehicles in the lower information plane. Therefore, it is necessary to verify the two layers of the information plane, and further verification is necessary. A few dangers to the application, control, and transmitting layers. Man in-the-middle Attacks occur when there is no transport-layer security between a switch and the controller. It is possible to mitigate these threats by strengthening physical system security Attacks that refuse to be administered could saturate cushions and stream tables. The incorporation of receptive principles instead of adopting a proactive methodology result in such attacks. They can be averted by utilising alternative controllers. Various threats might arise from apps, distributed multi-controllers, unauthorised access, or conflicts with security policies or procedures. Despite current setups, high portability necessitates security components with ongoing validation capabilities. Dormancy can also result in traffic bottlenecks that impede SDN-based VANET acknowledgment this persistent factor makes strengthening security difficult. Potential security risks for SDN-based VANETs are listed in Fig. 8. [4].

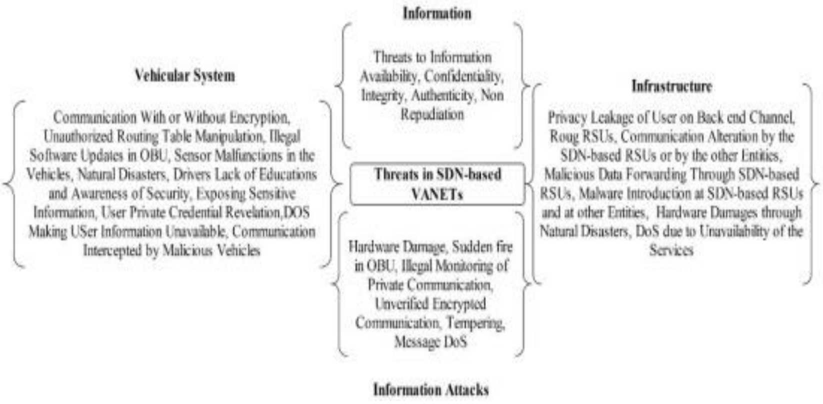

Fig 8. The categorization of threats in SDN-based vehicular ad-hoc networks (VANETs) with respect to vehicle architecture, data, and infrastructure.

Using clustering techniques, vehicles in VANET aggregate together and designate a cluster head (CH). For example, platoon-based driving improves energy efficiency and road capacity. Similar to a wireless access point, the CH acts as a mediator between the cluster and the larger network [2]. To increase the available bandwidth, the authors attempted to utilize cost-effective wireless communication methods, such as Wi-Fi, for the data transmission, while employing long-range wireless communication technologies like LTE/WiMAX for the control functions. Derived from a contemporary software-defined networking (SDN) security framework, the authors aimed to provide strong security and simple management by integrating these technologies. Fig 10 illustrates the security architecture of VANET over SDN in Fig. 9. Displays SDN Security Architecture over VANET [3].

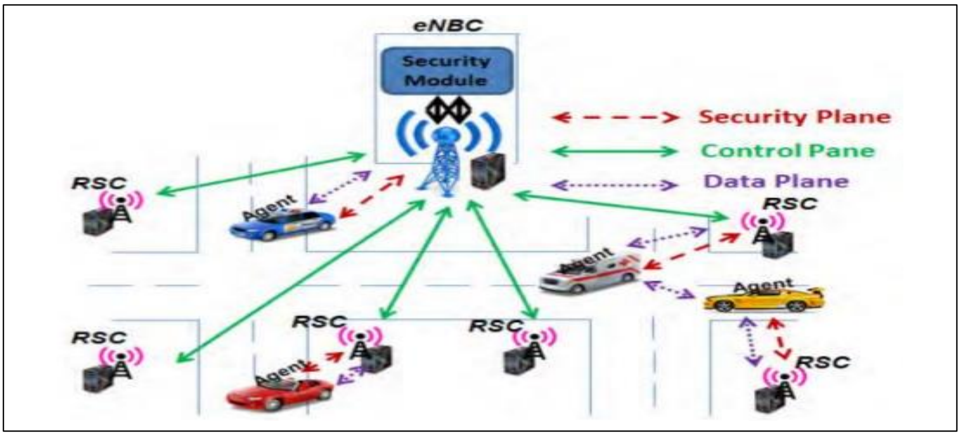

Fig 9. SDN over VANET Security Architecture.

4 Discussion

Thus, the advancements in technologies like IoT, IoV, 5G, FC, and others greatly enhance all elements of SDN. SDN facilitates the accurate and QoS-aware allocation of resources for specific data streams inside each domain. It also effectively adjusts to changes in traffic patterns by implementing strong network reconfigurations. Therefore, due to the use of SDN-enabled VANETs in applications that are crucial for missions and sensitive to human life, security and privacy are essential prerequisites. These VANETs can accommodate vehicles traveling at fasts ranging in 10 km/h to 60 km/h and possess the capability to simulate a stop sign at intersections. The routing mechanism employed in this section is the Cluster-Based Lifetime Routing (CBLTR) protocol. CBLTR outperformed other routing protocols in terms of average throughput by taking into account the maximum lifetime for selecting the cluster head and next forwarded nodes. IDVR reduces end-to-end latency and boosts route throughput, which improves overall network efficiency. Similar to what the authors saw in our simulation findings, this notable improvement resulted from choosing the subsequent section from the best route with the highest throughput. Furthermore, in Fig. 10., Fig. 11. Display End-To-End and Throughput the best path is found in real time at every intersection [1].

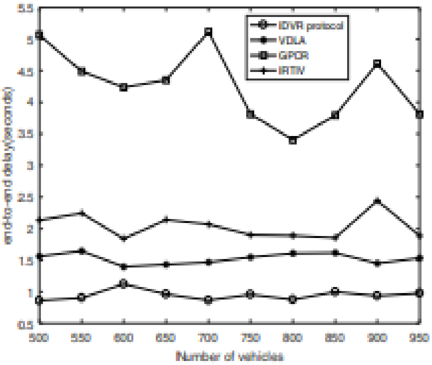

Fig 10. End-To-End Delay

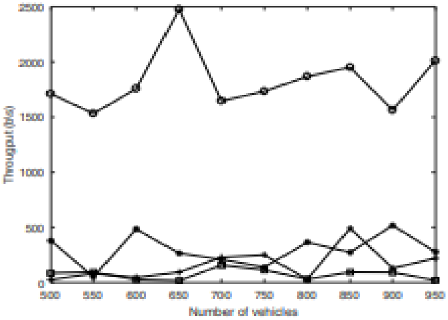

Fig 11. Throughput

5 Conclusion

In summary, this paper discusses how Vehicular Ad Hoc Networks (VANETs) are being modified by Software Defined Networking (SDN) to enable better mobility. SDN functions similarly to a central control system in VANETs, helping to resolve issues like as fluctuating service levels and varying car counts. The concept of a 5G-VANET with SDN capabilities is emphasized, demonstrating how it can adjust to vehicle clusters and improve traffic control. They also discussed how to protect SDN from threats and ensure its proper operation across various environments the suggested modifications demonstrate how SDN might improve traffic management and make roadways safer. In conclusion, SDN becomes critical as the automotive sector transitions to more intelligent and networked transportation. In addition to providing solutions for the present, it also sets the stage for future advancements in technology and road safety.

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