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Integrating D2D And V2X Communication From The Point Of View Of The SDN

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Abstract - In this day and age of the information society and 5G networks, automobiles are becoming more important as mobile information carriers. Automobiles have to be able to communicate with the outside world in order for them to be able to meet the needs of multi-scenario business requirements such as vehicle assisted driving and in-car entertainment. The term "Vehicle-to-Everything" (V2X) communication describes this approach of linking things and exchanging data. Not only does device-to-device (D2D) communication include a component of communication, but it also contributes to the resolution of the problem of a lack of spectrum that is now being faced. The usage of direct-to-direct (D2D) communication in V2X has the potential to satisfy high reliability and low latency requirements; nevertheless, resource reuse also causes interference. Software-defined networking (SDN) offers the highest level of compatibility as well as flexibility when it comes to bridging the gap between V2X and D2D communication. This article takes a look at the integration of D2D and V2X communication from the perspective of software-defined networking (SDN). The most current innovations as well as D2D-V2X design concepts were discussed. It is explained what the parallels are, as well as the characteristics, the route control, the location management, the patch scheduling, and the recovery. The integrated architecture that is the focus of this research has the potential to tackle a number of problems, including those pertaining to route management, interference management, and mobility management. In addition to this, it addresses the D2D-V2X disconnection problem that was present in the SDN and provides several workable solutions.

INDEX TERMS: 5G wireless networks, D2D communication, V2X, SDN, interference management.

1. INTRODUCTION

Since the introduction of the 1G mobile communication system in the 1980s, the technology behind mobile communication has improved at a rate of one generation every 10 years. Since then, it has spread across every aspect of society and had a considerable impact on

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individuals coming from a variety of backgrounds and walks of life. The proliferation of smart terminals and the continued development of innovative wireless services, such as the Internet of Things (IoT), Internet of Vehicles (IoV), and virtual reality (VR), have led to the formulation of stricter guidelines for the performance indicators that will be required of future mobile communication systems. These guidelines have resulted in the formulation of higher standards. Because of this, academic and industrial circles all over the world are encouraged to engage in research on the standardization of 5G mobile communication technologies. Recent research on 5G standards has been continuing in preparation for release 18, which is imminent. Millimeter wave (mmWave) communication, massive multiple-input multiple-output (MIMO) technology, and ultra-dense heterogeneous small cell networks are considered to be the three fundamental key technologies of 5G [1]. With the start of the 5G commercial era, research and development for the 6G mobile communication technology has officially gotten under way [2]. Robust security, wide coverage, complete application support, and the whole electromagnetic spectrum will all be part of the 6G mobile communication system. As a potential enabler for 6G, Massive MIMO is still in the early phases of development at this time. D2D and V2X communication is an essential technology in 4G and 5G communication systems. This technology has the ability to improve system performance, as well as the user experience, as well as the number of cellular communication applications. By using direct terminal-to-terminal (D2D) connection, user data may be sent directly without going via the network. V2X is an abbreviation that stands for "vehicles that use proximity services for communication." This includes vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P), vehicle-to-roadside infrastructure (V2I), and other forms of communication.

2. D2D-SDN COMMUNICATION REVIEW

Academic institutions are now doing in-depth research on the SD-D2D system in order to address problems with in-band spectrum management, interference management among cellular users, mobility management, routing management, and mode switching. These problems need to be resolved. In order for the future 5G network to utilise the D2D technology, a fundamental issue that has to be answered is how to communicate inside an enormously dense heterogeneous network while making use of just a limited amount of spectrum resources. When 5G communication systems are designed with an efficient network architecture, it will be much simpler to include D2D technology. Because of the issues that were just discussed, the operators have an immediate need for cutting-edge technology. To begin, it may make advantage of the transmission resources built up by D2D communication in order to reduce the amount of traffic on the cellular network and improve the quality of experience (QoE) for the user. On the other hand, methods such as virtualization might be used to enhance the adaptability, manageability, and simplicity of D2D communication. The Software Defined Network (SDN) was

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at first designed for wired communication; however, since the OpenFlow protocol is so flexible, it enables network reconfiguration, which opens the door for the possibility that SDN might also be used for wireless communication. Because of the SDN data/control separation design philosophy, the network is very adaptive. This design philosophy also makes it possible to centralize the control of network equipment. SDN research and implementation in wireless communication are now concentrating their primary efforts on the core network, base station (eNode B), and access network layers. This is the case in both academic and commercial settings. In response to the many different application scenarios and genuine needs, researchers have proposed a number of mature and effective typical application scenarios. In order to offer edge computing and mobile tiny clouds, the technology known as SDN was only recently included into the D2D communication architecture, which is founded on the concept of inter-node support. The use of software-defined networking (SDN) in access networks has gradually been the primary focus of academic research. The industry provides the SD-D2D architecture, which is based on the design concept of SDN and applies it to the D2D architecture of mobile communications in order to enhance the flexibility and efficacy of D2D networking in a heterogeneous network environment. This is done in order to meet the need for increased D2D networking capabilities in a variety of network environments. Figure 1 displays its essential architecture. The eNodeB and the mobile terminal make up the data plane, while the SDN controller, top end resource allocation, route management, and other functional modules constitute the control plane. The data plane communicates with the mobile terminal.

Even though it is becoming more comprehensive, research on SD-D2D still faces a number of challenges. When it comes to research, the SD-D2D study focuses mostly on the improvement of network communication performance (such as bandwidth, latency, and throughput), and research that is relevant to this topic still lacks in depth and detail. There are several specific and conceivable situations, such as concert multicasting and direct-to-device communication for Internet of Things devices, but very few authors have investigated these. When viewed from the perspective of the research topic, it is necessary to broaden the applications of the fundamental 5G network. For instance, there is a paucity of research on offloading multimedia content that has substantial bandwidth requirements, while the majority of recent traffic offloading research focuses on the local unloading of very small files that are often used. When it comes to the implementation and use of D2D, recent research has combined social networks with D2D communication to improve resource allocation, interference control, routing, and data distribution. This has resulted in a considerable increase in the network's overall performance. On the other hand, the actual cellular network SD-D2D does not permit the implementation and application of architectural studies. It is essential to bear in mind that, despite the fact that D2D technology has long been a communication focal point, there aren't too many applications that are widely used. Because of this, there is now a

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roadblock in its growth. A robust business application architecture is necessary in order to manage difficulties relating to trust, buddy matching, incentives/charges, intentional fraud, and other considerations. In next research, it will be necessary to consider how data from social networks may be stored in the controller, as well as how social network functionality and social features can be loaded into application terminals. It is envisaged that these problems will be adequately resolved by depending on the SDN to construct a robust ecological chain, and it is possible that related themes may become centers of academic interest in the future.

3. V2X-SDN COMMUNICATION REVIEW

V2X communication is one of the technologies that will make it possible to build intelligent autos and transportation systems. It enables a variety of networking access points and sensing technologies (including cameras, sensors, radars, and positioning devices) between a new generation of automobiles, which in turn makes it possible for such automobiles to communicate with their surroundings in a more efficient manner. The implementation of vehicle-to-everything, or V2X, communication may prove to be a significant boon to the advancement of intelligent transportation systems (ITS). V2X communication is widely seen as an essential technology that may improve both the flow of traffic and the safety of roads. Through the use of V2X communication, vehicles are able to instantaneously detect potentially dangerous and unpleasant road conditions, and they are then able to broadcast these situations to other vehicles, neighboring pedestrians, and roadside nodes in order to spread the word. In addition, since V2X communication can respond quickly to unanticipated traffic events, it may reduce the amount of time that people spend sitting in traffic. It may also give other benefits, such as a reduction in the amount of energy that is used and the pollutants that are produced by cars. Participants, including a variety of automobile manufacturers and companies that specialize in telecommunications, have recently come to terms with the undeniable impact that V2X has had on the global road transportation system. At the same time, a number of highly developed research projects and ideas have been submitted to the industry. As of right now, the majority of countries have set aside certain bands of radio frequency spectrum in order to make it easier for vehicles to communicate with one another using V2X technology and to encourage the development of applications and technologies linked to V2X safety. On the basis of LTE advancements and 5G systems, the Fifth Generation Automobile Association (5GAA) has attracted key automakers and telecom partners to deliver solutions that interact with cellular V2X (C-V2X) technology. During the process of developing technology for 5G vehicle-connected networks, SDN technology is used to advance and separate the network management operations from the network transmission activities. This results in improved network administration. It will become an increasingly important approach for the building of networks. In addition to the advantages it has

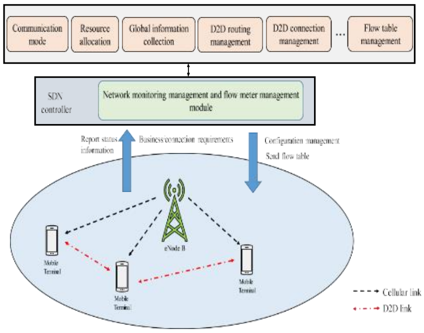

FIGURE 1. Proposed system model of D2D-SDN.

In addition to wired and wireless networks, the software-defined network (SDN) has specific advantages that make it particularly well suited for use in car networks. The logical centralized control function based on SDN is able to efficiently allocate all various types of network resources (such as bandwidth, spectrum, power transmission, and so on), in addition to providing a global awareness of the network architecture. This awareness may be achieved via the use of SDN. Take, for example:

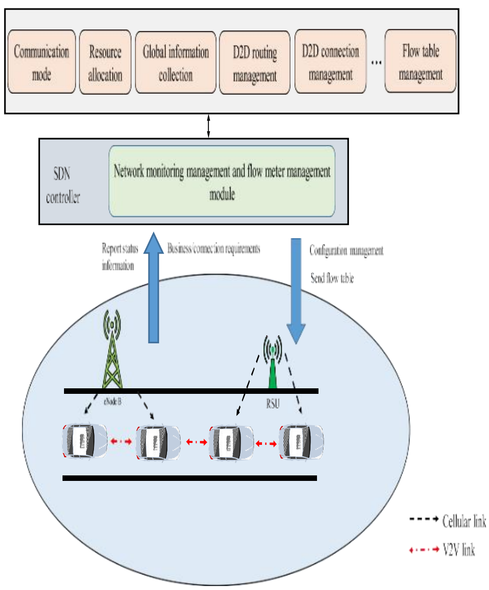

FIGURE 2. Proposed system model of V2X-SDN.

On the other hand, the SDN controller selects the optimal mode for each one-of-a-kind road condition and adjusts the system parameters in accordance with the situation. As a result, the functionality of the already available vehicle design may be enhanced as a result of these changes. On the other hand, the heterogeneous network technologies may be integrated into the network in a simpler and more transparent manner thanks to the virtualization and abstraction capabilities of SDN. As a consequence of this, the business community proposed the SD-V2X network, which is shown in its essential architecture in Figure 2. In terms of its architecture, it has a striking resemblance to the SD-D2D structure that was discussed in Section 2. Figure 2 shows that the eNodeB, RSU, and vehicle-mounted terminal are the components that make up the data plane, while the SDN controller and functional modules for top-end resource allocation and route management are the components that make up the control plane.

Resource Allocation And Optimization Under Sdn Control

Through the use of the V2X network, the SDN's capacity of forwarding data is enhanced. Researchers have investigated the use of wireless resource management systems that are based on SDN in the context of heterogeneous access in order to minimize network congestion, reduce the amount of packets that are lost, and preserve spectrum resources. The SDN controller is responsible for controlling the cluster heads in order to create a hierarchical architecture and improve the overall performance of the vehicle

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network. The authors devised a resource allocation mechanism that could be used in the SD-IoV under a variety of scenarios with diverse access, and the authors jointly estimated the correlation for the resource allocation strategy. It uses V2V communication when it is unable to fulfill the user's quality of experience requirements using V2I communication, and it does this in an attempt to further improve performance. The outcomes of the simulation suggest that the technique may be able to utilise the bandwidth of LTE and Wi-Fi networks effectively, which will better fulfill the requirements that users have for QoE..

Sdn-Based Routing And Forwarding Functions

First, create a global database of dynamic information using SDN, and then choose a routing protocol. They collaborate with one another and share the many bits of information that have been obtained by their own sensors inside the traditional network that is linked to vehicles. During the procedure, a locally-based dynamic information database will be created. The local dynamic information database contains a variety of static data as well, including information on traffic, weather, and road signs. By incorporating the SDN into the vehicular network, the controller is able to preserve and handle the globally dynamic information from a centralized place. Gathering and filtering the local dynamic data that is given by the vehicle allows the controller to compile a global dynamic picture of the whole (or a section of) the network's condition. This is accomplished by the controller. In response to the vehicle's request for a route, it is possible that it will make more considered judgements with greater accuracy. Under the direction of the road section, the RSU acts as a local controller and is in charge of selecting suitable vehicles to move the packets across the area. They do this while remaining under the watchful eye of the road section. The concept implements a two-level design architecture that is both global and local in scope. The global layer employs the "ranking query plan" in order to collect data on vehicles and determine the range that each vehicle may go along a given road section. The local layer is in charge of selecting suitable vehicles for the transmission of data packets within the range that was established by the global layer.

Sdn-Based Iov Traffic Offloading

The decision to offload is not entirely dependent on the limited information available in the network since it is characteristic of a vehicle network. For example, it is unable to depict the current state of the network based on historical data from the network and may even lead to activities that are not beneficial to do. In addition, the centralized global perspective of the SDN controller may be leveraged in the SDN-based vehicle network in order to dynamically make more advantageous offloading decisions depending on the real-time status of the network. This results in a system that is more suited for user requests and adapts to the conditions of the network at the present moment. [25], [26]. The authors of [22] proposed a strategy for offloading the traffic associated with cellular connections using V2V communication over VANET. This strategy offloads the traffic that is being carried by the cellular network in an effective manner

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by measuring the V2V connection that is already existing in VANET. In addition, the solution included the development of an SDNi-MEC, which is a mobile edge computing server. This was done to handle the difficult problem of offloading V2V traffic in VANET. Each vehicle sends its status information to the database of the SDNi-MEC server in order to offload the existing cellular traffic between the two. The SDN controller on the server then uses the status information to decide whether or not there is a V2V route between the two vehicles. According to the results of the performance research conducted on this design, the traffic offloading approach has the potential to enhance throughput on both the cellular network connection and the V2V route when the vehicle density reaches a medium level. The authors of introduced a centralized SDN-inspired IoV traffic offloading paradigm in the article [27]. In this paradigm, the data stream that is created at the source end of the data center is opportunistically delivered to the destination. The SDN controller is one of them. It not only acts as a central service broker (SB), but it also activates a number of offload hotspots, configures the forwarding route of the IoV data flow in the control plane, and configures the configuration of the IoV data flow. It acts in the capacity of a local service agent (SA). The airplane is responsible for putting the data flow forwarding into effect. distribution of floating content (also known as FC) while using an SDN method. It accomplishes scattered and opportunistic content sharing in an anchor zone (AZ), which may greatly increase the performance of FC's distribution. [24], [28]. The authors in [24] propose a content distribution approach for VANETs that is supported by SDN as a content-centric network and FC. Based on the mobility of the nodes, the SDN controller makes decisions like which cache utility node is the best, which distribution channel to use, how to send active content by AZ, and so on. The results of the simulation reveal that the mechanism is able to adapt to a network environment that is both extremely dynamic and unstable. This results in a large increase in the efficiency of content storage, distribution, and forwarding in VANET. The authors of [28] proposed an architecture for the dissemination of VANET FC data that was based on SDN. The RSU serves in this capacity as the SDN controller. Through the collection of data on the position and speed of the vehicle while it is within its coverage area, the AZ may have its size adjusted, which will result in a major improvement in the performance of the FC.

Sdn-Based Vehicle Cloud Resource Management

When using the IoV, a shorter waiting time is required in order to achieve low latency and a highly trustworthy response. Academics have proposed an SDN-based vehicle cloud server as a solution to satisfy the real-time requirements of this problem. In addition to managing the resources of the network and vehicle cloud (including the capacity for compute and storage, for example), the SDN controller is responsible for maintaining the OBU of each terminal. The authors of the article [29] offered a framework for updating the embedded software in automobiles that was based on SDN as well as cloud computing. When combined with other data centers and the SDN controller, which is located in the data center or edge device, the RSU, base station subsystems, and other data centers may establish a mobile vehicle cloud. As a consequence of this, rather than a centrally situated component, the decision-making process for the control plane is influenced by the components in the cloud working together. In the situation that was just described, the automobiles may coordinate their actions in order to get the whole update data while being directed by the SDN controller. This SDN-based technique for delivering software updates improves network performance by reducing the amount of cellular bandwidth that is required. Additionally, the related costs (such as the specialized short-distance communication band-width) and delivery delays for software updates are reduced as a result of this strategy. The authors of the article [30] incorporated the technology of 5G fog computing into the architecture so that switch and track management could be handled more quickly and effectively. Additionally, the architecture was given the capacity to implement varying degrees of real-time user-specified security with little system setup and overhead.

Sdn-Based Vehicle Networking Security

The security of in-vehicle communication imposes higher criteria for the use of SDN, which is also vital to the safety and privacy of apps used in automobiles [30]–[32]. The intelligent and integrated network viewpoint provided by the SDN controller gives it the ability to detect abnormalities, identify malicious or infected nodes, and recognize potential risks via the analysis of data plane traffic. According to the authors of [10], the SDN controller may establish a trust-based authorization system and pick the intermediate nodes that will function as relays based on reputation. This is something that can be done by selecting intermediate nodes. The authors in [17] used a trust mechanism quite similar to this one in order to disseminate information on safety emergencies. The authors of [30] suggested a security architecture that is compatible with SDN for VANET and 5G networks. This architecture contains a wide variety of attacks, including distributed denial of service (DDoS), has a global view and management capabilities, and is founded on the SDN controller. It includes further safety elements, such as prediction and traceability, that mitigate the harmful effects of the threat. In conclusion, the research that is now being done on SD-V2X covers a variety of challenges, including interference control, route management, resource allocation, and security. However, the automobile is not like other mobile devices in that it cannot drive anywhere but on pre-existing roads, and its mobility status is constrained by a number of different parameters. On the other hand, the existing research have not taken into consideration a great deal of the constraints that are placed on the functioning of vehicles. The controller has to increase their ability to anticipate and detect the path of a single vehicle in order to better plan the V2V route in advance. This is especially important when considering the speed and limits of vehicle movement in conjunction with the map overlay. Cooperative V2X takes use of vehicle clusters so that the throughput of the connection may be increased while also improving its dependability. The creation of an appropriate industrial ecological

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environment and the resolution of coordination concerns between numerous stakeholders, such as operators and automakers, are required for the widespread adoption of V2X in the foreseeable future. This is essential for the technology's success. Research hotspots in the field will be based on how to solve cross-industry and cross-vendor coordination issues based on the open architecture of SD-V2X, as well as how to carry out more in-depth applied research on workable business models as SDN and V2X-related technologies in 5G networks gradually develop and mature. These research hotspots are expected to emerge in the next five years.

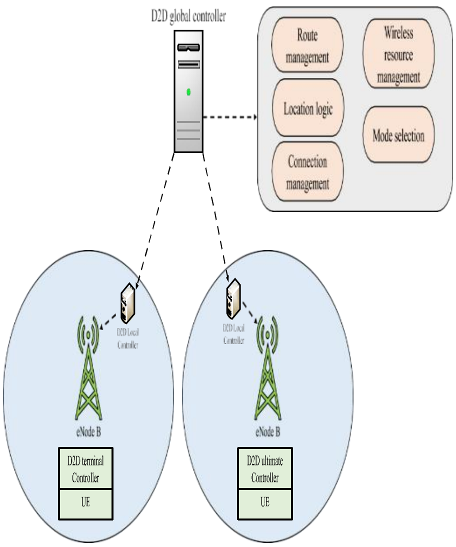

FIGURE 3. Layered architecture for D2D-SDN communication.

4. COMMUNICATION ARCHITECTURE OF SDN IN D2D AND V2X

D2D-SDN ARCHITECTURE

The SDN paradigm is used for D2D communication in cellular networks, and the SDN controller makes real-time adjustments to forwarding priorities based on the information obtained from a variety of sources. The data plane is composed of a great number of base stations. The control plane is in charge of centrally regulating the hardware of the network as well as the distribution of resources. Additionally, it performs queries on data pertaining to the state of the network, such as resource use and base station load. The network assisted system (NAS) that 5G technology employs makes it possible for the base station to manage both the cellular and D2D connections that are being made by the mobile node simultaneously. By loading the application module of the SDN controller, the base station is able to have access to global information such as information on the mobility of nodes and information regarding resources. The mobility and resource information of the terminal nodes located within the coverage area of the base station may be promptly acquired by the base station, at which point it can be sent to the SDN controller. Following this, the neighbor base station j will make use of the SDN controller in order to get information on the terminal nodes that are covered by the base station. The layered architecture that is used for SD-D2D communication is shown in figure 3. Within an SD-D2D architecture, the level of performance delivered by the control plane has a considerable impact on the operation of the network as a whole. Concerning the implementation of SDN controllers in 5G mobile communication networks, the academic community is now divided into three camps: centralized, distributed, and hierarchical.

Because a single controller is unable to meet the challenge posed by a massive network demand, it is possible to take into account the possibility of using a hierarchical deployment of the controller in order to reduce the considerable quantity of signaling exchanges created by D2D communication management. In order to expand the scalability of cellular networks and to satisfy the demands of growing mobile small clouds and fog computing, low-latency application requirements need to be satisfied as well. a centralized control for the access network in addition to local controls on the core as well as auxiliary networks. In an autonomous domain, it is the responsibility of the global D2D controller, which is also responsible for maintaining the control plane of the whole domain, to exercise centralized control over all base stations. The D2D local controller module that is included on each base station is responsible for handling the routing and forwarding between the nodes in the area. This layered architecture's primary benefit is that it is able to make full use of the scalability offered by centralized control, which in turn makes it possible to maintain consistent control and administration of the underlying forwarding hardware. The network's adaptability and the efficiency of mobile communication would both improve if it were made more transparent, if device virtualization could be accomplished, and if more network capabilities could be made available. Additionally, it is believed that the mobility of the node will reduce the amount of D2D communication management signaling contact that occurs inside the core network. The data packets for mobile communication are sent to the base station that is geographically closest to the mobile device. The D2D local controller at that station then decides whether or not local D2D communication or node communication inside the base station may be constructed. In this scenario, a local direct-to-direct link is established. In the event that this is not the case, the D2D global controller selects the forwarding path for the data packet, optimizes the route for storage and forwarding, and then sends the data packet to the designated base station and user. The global controller is responsible for creating a database containing information on the current state of the network in order to regulate the whole system. Additionally, the global controller is in charge of mastering the network topology and load conditions provided by all base stations located within its autonomous domain. The D2D device identity, service identification, information on IP address allocation, user identification number, user security information, user location information, and so on are some examples of the many kinds of information that the status information database could be able to manage. In addition, the mobility management entity (MME), which is controlled by the global controller, is in charge of managing each D2D pair's radio resource management, location management, connection management, and route management. All of these responsibilities fall under the umbrella of route management. The location of the local controller is specified to be at the intermediate execution layer. The primary responsibilities of the upper control plane consist of receiving control commands and providing data about the local network. The specific responsibility is to make use of the OpenFlow protocol in order to send orders to the underlying data plane for execution while simultaneously receiving control instructions from the

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global controller by making use of the status information collected in the base station. The primary objective of the lower data plane is to provide assistance to the base station in its management of the terminal's local D2D communication. This assistance includes the management of location information, the calculation of the distance between nodes, the management of flow tables, and other similar tasks. On the mobile terminal side, the terminal controller operates as a background service and is responsible for selecting the appropriate interface for each application, monitoring the status, and controlling the Open vSwitch and the radio resource mapper. It also keeps track of the current connection state.

D2D-SDN OPPORTUNISTIC AND AD HOC NETWORK

Because it is now possible for cellular communication terminals to establish wireless opportunistic networks and WANETs, the introduction of D2D technology in 5G communication has significantly expanded the range of applications for wireless communication. Cellular networks, for example, may establish ad hoc networks using D2D technology, such as MANET or VANET, in order to offload local traffic, enlarge the communication area, create a communication network for emergency disaster recovery, and other similar purposes. Because to software-defined networking (SDN), the resource utilization rate of the cellular network has increased, and the network's performance has become more consistent.

1) An ad hoc network using standard D2D-SDN technology The requirements for the infrastructure of wireless communication networks are substantial, and if either the access network or the core network facilities are broken, the communication system may become unworkable. When the wireless communication infrastructure is damaged or when the terminal is located in an area where it cannot access the wireless network, the D2D protocol may be used by the terminal to perform end-to-end communication and even access the cellular network. The authors of [37] installed genuine terminal equipment in order to develop and run a disaster-tolerant network based on SDN that combines DTN and MANET—NDN. This network is designed to be resilient in the event of a network catastrophe. During a natural disaster such as an earthquake, the National Disaster Network (NDN), which is a component of the core communication network architecture, has responsibility for maintaining communication. Every SDN switch that makes up NDN is the one responsible for monitoring the performance of the network. As soon as there is a noticeable drop in the network's performance, the NDN controller will switch to one of the available alternatives. Using multi-hop terminal equipment, data is sent from its original source to its ultimate destination, which may be a gateway to the Internet. The results of the experiments show that the network is not reliant on the primary communication network and that it is able to meet the communication and disaster recovery requirements of the shared network. At the same time, it may be possible to considerably minimize the amount of energy used from the terminal battery by cutting off any unnecessary communication connections. Under the category of a specific network

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application, the authors of [38] proposed a D2D-SDN self-organizing network form. This form is an information-centric network virtualization solution that is based on D2D communication. The solution implements SDN, dynamic virtual resource allocation, and internal caching in order to function as the global view controller for the system. The suggested architecture allows for the abstraction of the physical resources such that several mobile virtual network operators (MVNOS) may utilise those resources simultaneously. For example, on the data plane, there may be built three virtual networks in order to carry out conventional, information-centric, and information-centric D2D communication transmission in order to meet the requirements of information-centric network virtualization. On the control plane, you should create three virtual SDN controllers. Each of these controllers should be in charge of monitoring a distinct virtual network. The incorporation of D2D communication into an information-centric wireless network enables the content caching feature to be concurrently activated in wireless operation and maintenance equipment as well as mobile devices. It is possible to find a solution to the problem of virtual resource allocation by treating it as a large-scale combinatorial optimization issue and using a discrete random approximation technique. The findings of the simulation indicate that mobile virtual network operators (MVNOs) may not only benefit from sharing the underlying physical infrastructure but also from the ability of different network components to store data in cache. 2) An opportunity network that is built on SDN and D2D The authors of [39] suggested and implemented a multi-hop MANET with SDN capability utilizing actual hardware in their work. The Open vSwitch protocol is used by the SDN switch, while the Open Network Operating System (ONOS) is utilized by the SDN controller. MANET reaps the advantages of data flow between devices and the flexibility of centralized network administration. The findings of the simulation show that the proposed system is superior than distributed self-organizing networks in terms of its performance. The findings provide compelling evidence that it will be possible to implement this form of network in the foreseeable future. In addition to that, a repository containing all of the development-related components is provided here.

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V2X-SDN NETWORK ING ARCHITECTURE

In its present iteration, the IoV architecture suffers from a number of serious deficiencies in terms of both the administration and integration of its networks. For example, the large-scale, very dense, and continuously shifting architecture of the IoV network cannot be scaled, and therefore presents a significant challenge for the operation of services on top of it. Because of the variety and non-programmability of vehicle equipment, in addition to the dependence on suppliers, the structure of the IoV system is rigid, making it difficult to do maintenance and lacking in intelligence. It is difficult to pick acceptable technologies based on actual conditions and rapid changes in the network parameters due to the diversity of deployment sites and the range of communication technologies, which lack flexibility and adaptability. This presents

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a challenge when attempting to choose appropriate technologies. These defects limit the operation of the system and often lead to an inefficient use of the resources provided by the network. As a consequence of this, the implementation of the IoV architecture that is based on SD-V2X technology may make it possible to improve the adaptability, programmability, and scalability of the existing IoV architecture.

The difference lies in the fact that cellular networks make high-capacity and low-latency communications available to automobiles. This is due to the fact that vehicular communication entails mobility, which necessitates improved real-time performance. In light of the high-speed mobility, every vehicle is supplied with a cellular and an IEEE 802.11p network interface. This is done in order to improve the dependability of communication in light of the situation. The controller's schedule is followed in order to achieve optimal performance of both the associated interface and the communication mechanism. Second, the RSU and the OBU both have wireless OpenFlow protocols built into them and are located in the IoV. They are similar to other OpenFlow switches in that they can be programmed and operated, and they have SDN capabilities. The vehicles have the ability to connect to the fundamental network via a variety of diverse access methods, such as V2I access through base stations, roadside devices, WLANs, or even through V2V multi-hop access. In the initial architecture of the IoV, the SDN controller is often located on the outside of the data center or the base station. In order to improve the scalability, flexibility, and reliability of the IoV, the original controller has to be redeployed. The control function has been brought down to the roadside end in order to give localized control, minimize layered processes, and decrease the time it takes for management to make decisions. The hybrid architecture encourages vehicles to send SDN control requests over the cellular network and makes use of the V2V network for data transmission. This is done while maintaining a balance between the latency and cost associated with network management on the cellular network. The hybrid design, which is based on SD-V2X technology, is shown in Figure 4. The eNodeB, also known as the RSU, is what cars connect to in order to provide contextual data to the central controller. This data includes the vehicles' positions, speeds, directions, and neighbors that they sense, all of which are determined by GPS. A global status report is supposedly generated by the global SDN controller, at least according to the central controller. The control plane places the controller in the middle of the base station and the roadside unit where it can monitor both. The control plane is composed of the base station, the RSU, and a global SDN controller. Together with the global SDN controller, the base station and the RSU collaborate in order to successfully carry out the control task. The choices that the global SDN controller makes are influenced by the base stations, as well as general abstract policy rules and global status information. The RSUs are the ones responsible for enforcing these restrictions, and they do so based on the expertise of the local state. In its current iteration, the SDN controller's control area incorporates the OBU as well. The controller sends instructions to the OBU, telling it to carry out the required data-level forwarding activities. Despite this, it does manage to fix the D2D/V2X problem while simultaneously introducing new problems. For example, there will be an increase in the wireless signaling overhead for the control channel. Routing switching between intra- and inter-domains takes place whenever the network topology is altered, which results in the need for regular updates to flow table information. Signaling overhead, node processing overhead, and communication delay are all going to see additional increases in their respective levels. This will have an impact on the V2X when the car is moving swiftly and the performance effect is significant. In addition, the centralized control sets additional requirements on the terminal. These requirements include the necessity for the terminal chip to have Open vSwitch flow table processing capabilities as well as a wireless resource mapping manager, among other things. In addition to this, it drives up the cost of developing and producing chips in pace with the market.

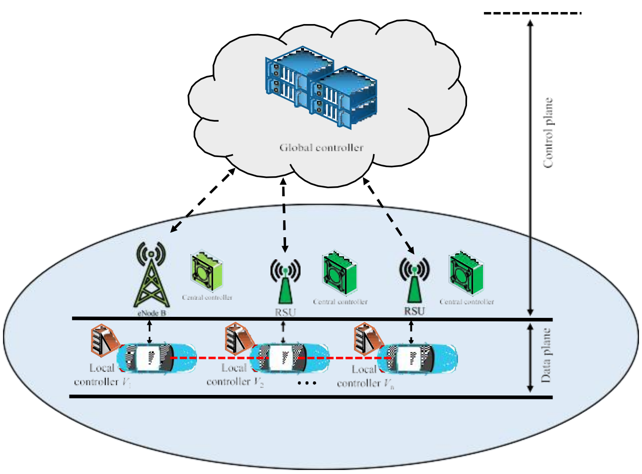

FIGURE 4. Hybrid architecture based on SD-V2X technology.

- D2D architecture based on SDN hierarchical control;
- Location management;
- Discovery management;
- Routing management.

Because the key technology 1) has been introduced in detail in Section 4.1, the last three key technologies will be introduced here.

5. CONCLUSION

SDN has progressively expanded its coverage from single domain, wired management networks (such as intranets and data centers) to wireless dynamic settings (such as cellular networks and VANET). D2D and V2X are quite comparable in terms of their technical aspects. They will ultimately develop into a cohesive one with the support of SDN. This article studies and summarizes the SDN-based D2D and V2X communications, and it also discusses the important technologies involved in these types of communication.

According to the study that has previously been conducted, the SD-D2D architecture for cellular networks is getting close to reaching its final stage of development, and the IoV SD-V2X framework has been initially identified. By taking use of the many advantages of centralized decision-making, the SDN technology may considerably improve the present users of the D2D/V2X communications. More models and concepts based on SD-D2D and SD-V2X architectures are going to be developed in order to solve issues such as interference control, mobility management, and route management between D2D users and cellular users.

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It is now difficult to coordinate the interests of a large number of parties in the development of D2D and V2X, which has led to a reduction in the amount of people who use these technologies. In addition, as a direct consequence of this, research on SDN-D2D/V2X has fallen behind actual implementations, which has impeded the development of new technologies in the future. However, there is no relevant research on how the advantages of an SDN-based architecture would be able to get through this block. study will need to be done on the installation and usage of SDN-D2D/V2X architecture in actual cellular networks in order to boost the scalability of the SDN architecture. This study will focus on real-world cellular networks. To comprehend the collaborative deployment and operation of network servers such multicast servers, cloud computing servers, security authentication servers, and trust servers, more applied research is required. Additionally, it is essential to think about how to store data from social networks in the controller, as well as how to load social network features and social characteristics of the application terminal into the controller. This is because both of these aspects are vital for the social experience.

With the advent of 5G networks and the continued development of the SDN technology that they integrate, SDN-based D2D and V2X communications will gradually be put into use.

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