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A Survey: Use of SDN on DSDV Routing Protocol in VANET

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Abstract— *Today, it is obvious that passengers need safe transportation system. Vehicular Ad Hoc Networks (VANET) plays a major role to satisfy the need for transportation and establishing infotainment services. Those services are provided by using routing protocols which are classified into three: Reactive, Proactive and Hybrid. In this work, we propose a novel technique to improve the performance of Destination Sequenced Distance Vector protocol (DSDV), which is of Proactive type. The improvement is using Software Defined Network (SDN) which enables DSDV protocol to choose the best path to deliver packets from source to destination. Controller and switch are the two main components of SDN which communicates each other using OpenFlow protocol. Nodes (vehicles) consult controller, which have path trust value of each node, to get a non-congested as well as free path and sends the packets to the destination. Using SDN enables us to solve one of the drawbacks of DSDV protocol, packet delay.*

Keywords— *Vehicular Ad Hoc Networks; DSDV; Software Defined Networking; OpenFlow.*

I. INTRODUCTION

In a globalization world, it is common that two or more devices connected through wired or wireless medium together for sharing of resources, data and infotainment files or an electronic communications called networking. The communication can be over long distances or nearby but through the use of routers, switches and servers over internet. Ad hoc is a Latin word which means "for the purpose". Ad hoc network is widely needed within emergency environment such as natural disasters and military actions.

Mobile ad hoc networks (MANETs) are decentralized, dynamic and self-configured systems which contain mobile (portable) nodes which communicate each other through network devices such as a laptop, mobile phone or other gadgets. Those nodes can move everywhere in every direction and also can change its connection to other nodes within the network. Vehicular ad hoc networks (VANETs) [11] are a special type of MANETs which are dedicated for vehicles on the road or highways. Unlike MANETs, VANETs have a predictable mobility since their movement is through roads or highways, while MANETs can move everywhere which makes more complicated to detect its topology. The communication of VANET nodes can be within vehicles or vehicle to roadside units. Since most nodes are moving at a high speed, it needs a highly dynamic network topology to serve accordingly. For every communication between devices, there should be a standard and policy which contains rules, procedures and formats in the network called protocol.

Destination Sequenced Distance Vector (DSDV) protocol [12] is one of the Proactive types of protocol having one or more tables for each node that stores related information about all nodes in the network. DSDV uses Bellman-Ford algorithm which selects shortest paths among candidates to discover routes between the source and destination. Another importance of using this algorithm is that it removes loops so that no nodes are repeated in a single route. Each node periodically sends their routing table updates to its neighbors so that nodes can aware of the network members. When a node receives routing table from its neighbor, it re-calculates shortest paths to all destinations. But, the performance of DSDV protocol is high if the number of nodes is less and becomes low when the number of nodes is more and more. To overcome this problem, Software Defined Networking emerge as a new technology for VANETs. SDN has a capability of controlling a dynamic topological network in a centralized manner. So, depending on the shortest path as well as congestion of the network, SDN selects the best path for communication.

II. CLASSIFICATION OF VANET ROUTING PROTOCOLS

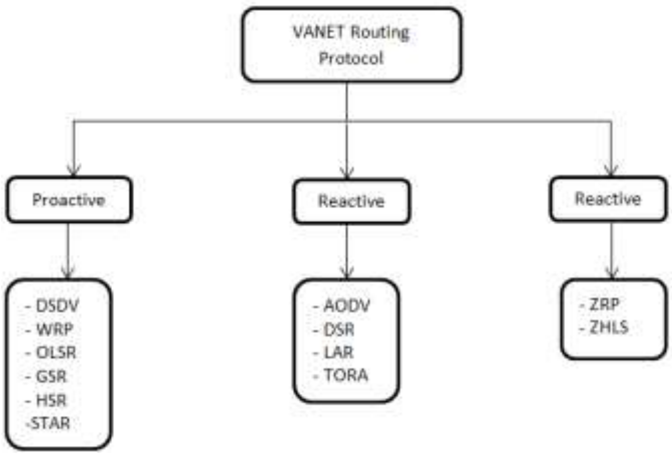

Fig. 1. VANET routing protocols.

Vehicular ad hoc Network (VANET) is a part of Mobile ad hoc networks (MANETs) which provide vehicle to vehicle or vehicle to infrastructure communication. The performance of communication depends on the type of routing protocols used in the network. VANET routing protocols are commonly categorized into three:

i) *Proactive routing protocols:* also known as table driven protocol which means [13] all nodes in the network that uses this protocol should have tables containing information about every node in the network whether that

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node is needed or not. Each node broadcasts its routing table periodically to their neighbors. The broadcast is initiated if there is any change in the network topology. However, this broadcast causes overhead coast due to because of maintaining up to date information so that throughput of the network is affected. Destination Sequenced Distance Vector (DSDV), Wireless Routing protocol (WRP), Optimized Link State Routing (OLSR). Global State Routing protocol (GSR), Hierarchical State Routing (HSR) and Source Tree Adaptive Routing protocol (STAR) are examples of the proactive routing protocol.

ii) *Reactive routing protocol:* also called on-demand routing protocol. [14] In this type of protocol, information collection of nodes is initialized when necessary. Whenever there is need of a path from source to destination the protocol starts finding routes. Route search is needed for every new destination therefore the communication overhead is reduced at the expense of delay to search the route. Ad hoc On-demand Distance Vector protocol (AODV), Dynamic Source Routing (DSR), Location Aided Routing (LAR) and Temporally Ordered Routing Algorithm (TORA) are the most common types of reactive protocol.

iii) *Hybrid routing protocol:* It has the feature of both proactive and reactive protocols. Mostly it is used when the number of nodes increases. It is known for their scalability of using few nodes during route and topology discovery. Zone Routing Protocol (ZRP) and Zone-based Hierarchical Link State protocol (ZHLS) are best examples of the Hybrid routing protocol.

There are two major routing techniques namely: Static routing which stores routing information on tables and dynamic routing that stores routing information on the cache. Table: I showed below demonstrates a comparison of different types of VANET routing protocols upon four parameters: Route availability, storage of routing information, Storage requirements and periodic updates.

TABLE I. VANET protocols comparison.

Destination	Next hop	Metric	Dest. Seq. No
1	1	1	123
2	0	0	516
3	3	1	212
4	4	1	168
5	4	2	372
8	1	INF	432

VANET protocols use different algorithms for selection of the shortest path to send a packet from source to destination. Here one of VANET routing protocols called Destination Sequenced Distance Vector (DSDV) which is of proactive type is discussed.

III. DESTINATION SEQUENCED DISTANCE VECTOR (DSDV) ROUTING PROTOCOL

DSDV is a proactive type of VANET routing protocol. It is more desirable when the number of nodes inside the network is less in numbers. DSDV protocol uses a conventionally modified Bellman-ford algorithm to find the shortest path between source and destination. This protocol gives additional attribute called sequence number for each nodes routing table. Each node has their own routing table and it is used to transmit packets from one node to another inside the network. The routing entry is attached with a sequence number which is maintained by the destination node. In DSDV routing protocol [15], each node updates its routing table periodically. The packet to be sent indicates the address of sender and number of hopes to reach the destination node. The Routing table of each node contains all available destinations, metric and next hope, which helps the source to connect to the destination, and sequence number organized by the destination node.

There are two types of broadcasting in DSDV protocol: - a) Full dump and b) incremental dumps. Full dump broadcasting technique will broadcast whole routing table when an update occurs. Incremental dump broadcasts only updates or changes that occur at a time. Basically, proactive routing protocol uses the rule of a periodic update of the control message and exchanging routing table. Every node in the network has complete routing information about all other nodes. Each node knows its network topology so that it can find the shortest route for the node which is supposed to be a destination. Each table entry has a sequence number that is incremented every time a node sends an updated message.

Each DSDV node maintains two routing tables: one for forwarding packets and one for advertising incremental routing packets. The routing information sent periodically by a node contains a new sequence number, the destination address, the number of hops to the destination node, and the sequence number of the destination. When the topology of network changes, a detecting node sends an update packet to its neighboring nodes. Upon receipt of an update packet from a neighboring node, a node extracts the information from the packet and updates its routing table as follows.

When the router receives new arrival information, it uses the latest sequence number. If this sequence number is the same as the sequence number in the table, the route having better metric is selected. Stale entries are entries which are not been updated for a while. Such entries and all routes that uses those nodes as the next hop are discarded.

DSDV Packet Process Algorithm

1. If the new address has a higher sequence number, the node chooses the route with the higher sequence number and discards the old sequence number.
2. If the incoming sequence number is identical to the one belonging to the existing route, a route with the least cost is chosen.
3. All the metrics chosen from the new routing information are incremented.
4. This process continues until all the nodes are updated. If there are duplicate updated packets, the node considers keeping the one with the least-cost metric and discards the rest.

In case of a broken link, a cost of the metric with a new sequence number (incremented) is assigned to it to ensure that

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the sequence number of that metric is always greater than or equal to the sequence number of that node.

Figure 2 shows a routing table for node 2, whose neighbors are nodes 1, 3, 4, and 8. The zigzag lines indicate no communications between any corresponding pair of nodes. Therefore, node 2 has no information about node 8.

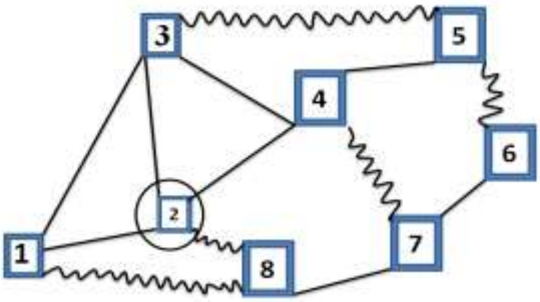

Fig. 2. Routing path.

TABLE II. DSDV routing table for node 2.

Destination	Next hop	Metric	Dest. Seq. No
1	1	1	123
2	0	0	516
3	3	1	212
4	4	1	168
5	4	2	372
8	1	INF	432

The packet overhead of the DSDV protocol increases as the total number of nodes in the ad-hoc network increases. This fact makes DSDV suitable for small networks. In large ad hoc networks, the mobility rate and therefore the overhead increase, making the network unstable to the point that updated packets might not reach nodes on time.

IV. Software Defined Networking (SDN)

Today, Software Defined Networking (SDN) [16] becomes a major call in Information Technology industry. More companies are planning to integrate it into their business growth. The reason is that SDN reduces Capital Expense of Network equipment (CAPEX) and Operational and maintenance expenses (OPEX) of a network, that's why every networking industry's business expects at the end. Basically, traditional networks are unable to handle and also meet the networking requirements like network dynamisms, controlling on a single point (Centralism), small errors on all networking nodes configuration and managing network traffic and data center servers can virtualize traffic. SDN, as the name indicates, is implemented through software. Since SDN is a software layer, it offers many advantages like minimizes manual labors, provides dynamic network scalability and controlling network devices centrally.

The core idea of SDN is to separate the control plane from forwarding plane that enables the forwarding plane programmable directly. In this case, all network nodes only act as efficient forwarding devices. There are lots of protocol standards to use SDN in applications. One of the most common protocols is OpenFlow which is managed by Open Network Foundation (ONF) and helps SDN concept to implement in hardware and software. One of the advantages of OpenFlow is that the existing hardware can be utilized in SDN which helps to design new protocols and verify the feasibility of those protocols. The interaction between OpenFlow switches and controllers supports three kinds of messages: controller-to-switch, asynchronous, and symmetric [17]. The most important message in control-to-switch is the OFPTFLOW-MOD which is used to modify the flow table in the OpenFlow switches. OFPTPACKETIN [17] is the most important Message in asynchronous, and this message enables the OpenFlow switches to send packets to the controller only if the packets cannot be processed by the switches. The most common message of the symmetric is named OFPTHELLO [17]. It is used to build a connection between the Open-Flow switches and controllers. Figure 3 shows the communication between OpenFlow switch and controller.

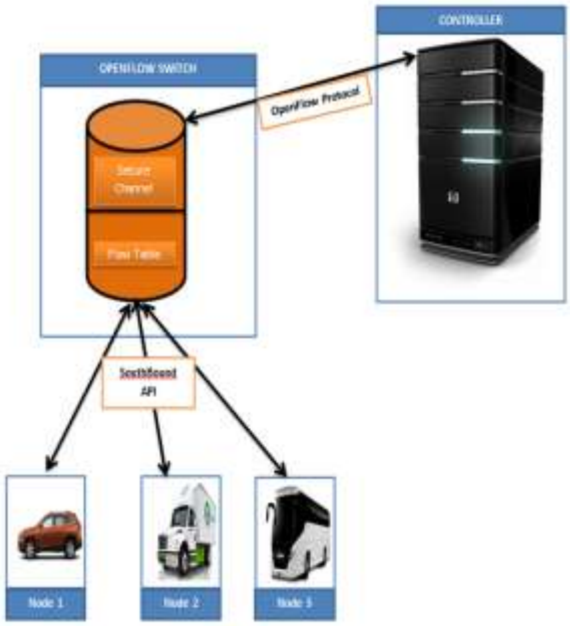

Fig. 3. OpenFlow switch and controller interaction using OpenFlow protocol.

SDN architectures have three major components [18]:

- ✓ *SDN applications:* Are programs which interact behaviors and needed resources with SDN controller through Application Programming Interfaces (APIs). Also the application can build abstracted view of the network by collecting information from controller for decision making. Applications might include network management, business applications to process large data centers.
- ✓ *SDN Controller*: Is logical entity which receives instructions from SDN application layer and transmits to the networking components. The controller extracts information about the network from hardware devices and communicates back to SDN applications with an abstract view of the network.
- ✓ *SDN Networking devices*: It controls forwarding and data processing capabilities for the network like forwarding and processing of data path.

SDN APIs are normally two types: Southbound and Northbound interfaces. Northbound interface is used to connect controller and applications whereas Southbound is to connect controller and physically networking devices or hardware.

SDN in VANETs:

SDN was initially designed for wired networking and after some time it seems like an attractive and promising mechanism to improve the performance of wireless and mobile networks [20]. Some of the aspects that make SDN more profitable for wireless and mobile networks are flexibility, central management, and programmability. Most of the architectures since 2014 [16, 18, 19] assumes that there is a central Road Side Unit Controller (RSUC). RSUC can communicate with all elements in the data plane as well as instructs vehicles and Road Side Units (RSUs) about forwarding rules to apply and which resources for which traffic allocated.

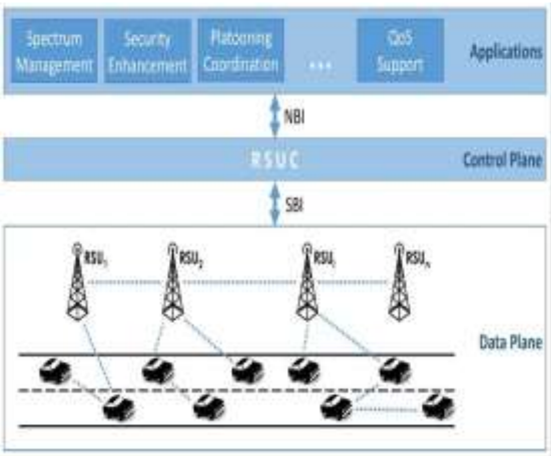

Fig. 4. SDN enabled VANET. [23]

SDN enabled VANET [23] can provide to adopt dynamic topology changes via reconfiguring data forwarding rules in the network. VANET has also the aim of infotainment which needs sharing of large multimedia files. To achieve this, SDN can play a major role in improving the management of content delivery as well as content caching and forwarding. One of the best features of SDN is catching which helps to reduce the delay of content discovery, retrieval, and delivery by providing duplicated sources for the content. Also, SDN can improve and minimize the number of broadcast messages transferred in VANET. Figure 4 represents SDN enabled VANET environment.

V. LITERATURE REVIEW

Zhang, Dajun, et al. [16] proposes SDN enabled VANET with trust management. It separates the forwarding plane of SDN from that of control plane, which controls functionalities like routing protocols as well as trust management for VANET. It states that since AODV routing protocol is mostly used in VANETs, the author utilize AODV as a sample to execute the proposed SDN-enable framework for VANETs. In addition, AODV control logic and trust management are moved in to the control node. So that AODV can improve the performance of the network significantly.

Truong, et al. [19] proposes SDN-enabled VANET with fog computing. The architecture proposed is aimed to solve different challenges of VANET via augmenting SDN centralized control which considers different heterogeneous behaviors such as like mobility, topology, physical medium, V2V, V2BS and V2I communications. It assumes that all SDN wireless nodes are equipped with WiMax/4G LTE/3G interface for control channel and also WiFi/WAVE interface for data channel. SDN wireless nodes required to have an emergency mechanism to turn back to normal operations once SDN controller connection is lost.

Salahuddin, et al. [21] proposed Software-Defined Networking for RSU Clouds in support of Internet of Vehicles. The proposed vehicular cloud architecture known as RSU cloud, which contains ordinary RSU and specialized micro scale data centers. RSU cloud provides services to fulfill dynamically changing demands from vehicle grid. This proposed RSU cloud architecture lies in benefiting from programmability and flexibility of offered by SDN.

Secinti, Gokhan, et al. [22] proposed a software defined VANET architecture for VANET: a test bed implementation with wireless access management. The testbed includes soft-switches at the data plane. Those soft-switches are composed of Raspberry pi as hardware and OpenvSwitch as main software component. Soft-switches have a capability of virtual port that defines virtual wireless access port for each and road side unit.

Publication and year	Applications	Method	Protocols	Limitations
ACM - 2016	Improve network performance of AODV protocol	By applying SDN on AODV protocol	AODV	The improved AODV have higher end-to-end delay than traditional AODV protocol
IFIP - 2015	Supporting fog computing for safety and non-safety services	Data streaming and Lane-change assistance services	OpenFlow	Law service latency caused by not utilizing available resources
IEEE - 2014	RSU cloud Supporting vehicle grid in the Internet of Vehicles (IoV)	Implementing RSU cloud using SDN	OpenFlow	Load balancing not optimized
IEEE - 2017	Utilizing the deployed WiFi networks	SDN enabled Wireless Access Management (SDN-WAM)	OpenFlow	Difficult to implement in large VANET environment

VI. CONCLUSION AND FUTURE WORK

This paper analyzes different applications of Vehicular Adhoc Network (VANET) using Software Defined Networking (SDN). Destination Sequenced Distance Vector (DSDV) is one of VANET protocols which SDN is applied on it and hence the performance of this protocol improved in terms of packet delay. In the future, using SDN we can

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improve the same protocol (DSDV) by applying other metrics or use SDN on other protocols.

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