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Neural Network Based Modified AODV Routing Protocol in VANET

Soumen Saha[1], Utpal Roy[2] and Devadutta Sinha[1]

[1]Department of Computer Science and Engineering, University of Calcutta, Kolkata, WB, India
[2]Department of Computer & System Sciences, Siksha-Bhavana, Visva-Bharati, WB, India
soumen11@rediffmail.com

ABSTRACT

The latest mobile communications is two types of ad hoc networks are introduced; one is Mobile Ad Hoc Network (MANET) and second one is Vehicular Ad Hoc Network (VANET).VANET is based on IEEE 802.11b wireless standard. This helps to communicate vehicle to vehicle and vehicle to roadside communications. According to Federal Communications Commission (FCC)[1] suggestion for VANET frequency spectrum of 75 MHz in the range of 5.850 GHz to 5.925 GHz. It communicates from one vehicle (source) to another vehicle (destination) through different vehicles (intermediate nodes). A numbers of different routing protocols for communication, ie multimedia data, text data etc. from one vehicle (node) to another vehicle are existing. The Ad hoc On-Demand Distance Vector (AODV) routing algorithm is one of the popular routing protocols for ad-hoc mobile networks. AODV is used for both unicast and multicast routing. In this paper, we propose and implement in the NCTUns-6.0 simulator neural network based Modified AODV routing protocol considering Power, TTL, Node distance and Payload parameter to find the optimal route from the source station (vehicle) to the destination station in VANET communications.

Key words: AODV, Neural Network, NCTUns-6.0, VANET, Routing Protocol

INTRODUCTION

Vehicular Ad-hoc Networks (VANETs) identifies an emerging technology, particularly challenging a class of Mobile Ad Hoc Networks (MANETs). VANETs are distributed; self-organizing communication networks built up by moving vehicles, and is thus characterized by very high node mobility with limited degrees of freedom in the mobility patterns[2-3]. Hence, ad hoc routing protocols must adapt continuously to these unreliable and unethical conditions; in the event of growing effort in the development of communication protocols which are originated to vehicular networks. One of the critical aspects when evaluating routing protocols for VANETs is the employment of mobility models that reflect as closely as possible to the real behaviour of vehicular traffic. This notwithstanding, using simple random-pattern, the graphs constrained mobility models is a common practice among researchers working on VANETs. There is no need to say that such models cannot describe vehicular mobility in a realistic way, since they ignore the peculiar aspects of vehicular traffic, such as cars acceleration and retardation in presence of nearby vehicles, queuing at roads intersections, traffic bursts caused by traffic lights, and traffic congestion or traffic jams. All these situations greatly affect the network performance, since they act on network connectivity, and this makes vehicular specific fundamental performance evaluations at the time of studying routing protocols for VANETs.

Wireless technologies [4-5] are extended to ad hoc networks like Mobile Ad Hoc Network (MANET) and Vehicular Ad Hoc Network (VANET) [6-7], [8-9]. Ad hoc networks are one type of network that offers communications within a certain range of areas; even connect to wide areas via basic mobile network and Internet. One of the authors has already published his useful and important findings of various routing protocols [6], mainly many variants AODV applicable in MANET. This study is the modest approach towards the justification for application of AODV routing protocol of MANET in Vehicular Transmission [7-8].

Thus total connectivity in a VANET is assured. VANETs are also known under different name like Dedicated Short Range Communications (DSRC), Inter Vehicle Communications (IVC), etc. Number of projects have been launched for VANET, e.g., FleaNet in USA, FleetNet in Germany, ITS in Japan, etc. [2-8], [12].

The motivation of a VANET project is to create a new algorithm or protocol or modify the existing one for use in vehicular environment. Thus VANET helps the drivers of vehicles to communicate the information in form of voice, data, image, multimedia, etc. Also it ensures safe journey by minimizing road accidents, diverting or instructing the vehicle's direction in less populated roads avoiding traffic jam, etc. Vehicles in a VANET are having high degree of mobility, i.e., the vehicles are moving very fast, especially in high ways. As a result the two vehicles are in a direct communication range staying about one minute time only, i.e., two vehicles remain in one cell about one minute time when they are moving parallel direction or even less than one minute when they are in opposite direction [3-5]. For this, VANET cell configuration and number of nodes present in a particular cell with applicable routing technique is changing in nature.

An advanced artificial intelligence (AI) based Modified Ad hoc On-Demand Distance Vector (aiAODV) routing protocol applying fuzzy neural network algorithm is proposed in this paper. Generally the scientists may not be able to provide error free data or knowledge using fuzzy logic system. For that a neural fuzzy system can be used to tune the system and reject unnecessary or redundant fuzzy rules. A neural fuzzy system has multilayer that embed the fuzzy system. By applying this fuzzy neural network in aiAODV routing protocol we able to determine the optimum route (path) from the source vehicle to the destination.

ROUTING PROTOCOL IN AD-HOC NETWORK

In this section, we discuss the routing protocols available for ad hoc networks like MANETs and VANETs. Routing determines process of communicating information from one station to another station of the network through passing one or more intermediate stations, called intermediate nodes. An ad hoc routing protocol [4]-[12] is a procedure or standard, that controls how vehicles (nodes) decide which way to direct packets called traffic among nodes (computing devices). Routing protocols of mobile ad hoc network require different approaches from existing internet protocols (IPv4 or IPv6), since most of the existing internet protocols are designed to support routing in a network with fixed structure. Lots of various routing protocols are coming to use. Proposed routing solutions are classified into seven types: proactive or table-driven, reactive or on-demand, hybrid, hierarchical, geographical, power-aware, geographical multicast protocols [5]-[12]. Out of these routing protocols, Ad Hoc On-Demand Distance Vector (AODV) routing protocol is an effective one.

Reactive or On-Demand Routing Protocol

This type of protocols finds a route on demand by flooding the network with route request packets. Some of the better known on-demand protocols are such as Robust Secure Routing Protocol (RSRP), Multi rate Ad Hoc On-demand Distance Vector (M-AODV) Routing Protocol, Modified AODV Routing Protocol Explored by Swarm Intelligence, Reliable Ad Hoc On-demand Distance Vector (R-AODV) Routing Protocol, Minimum Exposed Path to the Attack (MEPA) in Mobile Ad Hoc Network (MANET), Ant-based Routing Algorithm for Mobile Ad Hoc Networks, Admission Control enabled On-demand Routing (ACOR), Dynamic Source Routing (DSR), and Temporary Ordered Routing Algorithm (TORA), etc. Among these protocols, AODV routing protocol is more useful in ad hoc mobile networks. We are discussing the AODV protocol in detail.

Features of AODV Routing Protocol

Ad hoc On-Demand Distance Vector (AODV) routing protocol [8]-[12] is more popular and effective one in ad hoc networks like MANET and VANET communications. It is jointly developed in Nokia Research Centre, University of California, Santa Barbara and University of Cincinnati. Since AODV is a reactive protocol, it establishes a route to a destination only on demand. It is capable of both uni-cast and multicast routing. Complexity of a protocol is measured by lowering the number of messages to conserve the capacity of the network, from that point of view AODV assures no extra traffic for communications along the existing links.

AODV is invented from the Bellmann-Ford distant vector algorithm. AODV finds a route from a source to a destination only when the source node wants to send one or more packets (traffic) to that destination through several intermediate nodes. The established routes are maintained as long as they are required by the source. It employs the destination sequence numbers to identify the most recent path. A Route Request (RREQ) is flooded throughout the network and it contains the source address or identifier (SrcID), the source sequence number (SrcSeqNum), the destination address or identifier (DestID), the destination sequence number (DestSeqNum), the broadcast identifier (BcastID), and the time to live (TTL) field.

The Broadcast identifier (BcastID) is incremented each time whence the source node sends a new RREQ, so the pair (BcastID, SrcID) identifies a RREQ uniquely. If for the same destination RREQs are received multiple times by a node, the duplicate requests are discarded. When a RREQ is received by an intermediate node, if the intermediate node has either no route for the destination or no up-to-date route, the RREQ will be rebroadcasted with incremented hop count. If a node has a route with a destination sequence number greater than or equal to that of RREQ, a Route Reply (RREP) message is generated and sent back to the source. Every RREQ carries a time to live (TTL) value which indicates that the number of times this message will be rebroadcasted. Every intermediate node, at the time of forwarding a RREQ, enters the previous node address and its BcastID. All intermediate nodes including the destination node having valid routes to the destination are allowed to send Route Reply (RREP) packets to the source. After receiving a Route Reply (RREP) packet, the source node or intermediate node forwards the data packet to the next node toward the destination. If the source node later receives a RREP consisting of either greater sequence number or the same sequence number with a smaller hop count, it will update its routing information for that destination and starts using the better one. Data packets are buffered locally and transmitted in a FIFO queue when a route is set up. While a node in an active route gets lost, a Route Error (RERR) message is generated to notify the other nodes on both sides of the link about the loss of this link.

Since AODV is a reactive protocol, it uses periodic HELLO messages to inform the neighbours that the link is still alive. The destination sequence number for each destination host is stored in the routing table of a node and it is updated in the routing table when the host receives the message with a greater sequence number. Generally a RREQ is initiated with a small TTL value; gradually it is increased to a certain threshold value for making more efficient route discovery process. In this paper it is proposed to determine the optimum route discovery and the threshold value of TTL by an advanced artificial intelligence based fuzzy neural network in AODV protocol.

There are different types of AODV protocols like Multi rate AODV, Reliable AODV, Modified AODV by Swarm Intelligence, AODV-UCSB (University of California, Santa Barbara), AODV-UV (Uppsala University), Kernel-AODV, etc. The connection set up time is lower; at the same time it does not require any central administrative system to control the routing process. AODV reacts fast to the topological changes in the network as it happens for MANET and VANET, and updates only the nodes are affected by these changes. The HELLO messages supporting the routes maintenance are range limited and easy to identify the faults appearing in the routes, so they do not cause unnecessary overhead in the network. AODV also saves storage place, i.e., memory as well as energy or power and bandwidth. It is the best suited for a limited area ad hoc network, since the hop count remains confined within the certain range.

There are some disadvantages also in AODV protocol that determining a reasonable expiry time is difficult one, because the nodes are mobile in MANET and VANET. A route discovery may flood which causes significant network overhead. In larger networks, the nodes may be misbehaved like becoming malicious nodes by attacking the network or uncooperative (selfish) nodes. In AODV it is assumed that all nodes are cooperative such that they help to create route and flow data through the established route.

Furthermore TTL field value is optimized in accordance with the cell structure and average number of nodes lying in the cell. The main advantage of AODV protocol is to create routing path on demand. The best route or path is discovered from the source station to the destination station according to compare different available routes considering their important attributes by applying fuzzy neural network algorithm[13]-[15].

OVERVIEW OF AI-AODV ROUTING PROTOCOL IN VANET

In AODV protocol, a source station (vehicle) initiates a Route Request (RREQ) in the network for connecting to a destination station (node), the route is determined considering the four attributes or parameters like the distance (D), the overload or overhead (O), the consumption of electric power (P), and the expected time (T) to remain the route in alive (active) condition. First three attributes (D, O, P) are acceptable for lesser or minimum value and the fourth attribute expected time is accomplished for larger value, i.e., longer period. Therefore, the normalized expected time period is deducted from one (1) to bring homogeneity among all attributes. There may be different routes under AODV protocol available from the source station to the destination station having one set of values D, O, P, and T for each route. Now the best AODV route is selected among the different routes by applying fuzzy neural network algorithm [16-17]. The block diagram of the fuzzy neural network in selecting the best route under Modified AODV protocol is described in Fig. 1.

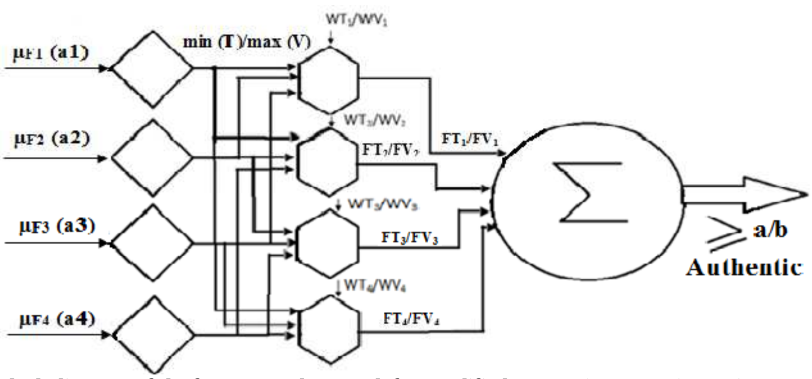

Fig. 1 Block diagram of the fuzzy neural network for Modified AODV (M-AODV) Routing Protocol [17]

IMPLEMENTATION RESULTS AND DISCUSSION

Example: A route under M-AODV protocol is discovered from the source to the destination node with the normalized values of the attributes like distance (*D*), overhead (*O*), electric power consumption (*P*), available expected time (*T*) as 0.35, 0.44, 0.39, 0.49, respectively; find the suitability of the route.

In this problem, $d1 = 0.35$, $o1 = 0.44$, $p1 = 0.39$, $t_n = 0.49$.

Therefore, $t1 = 1 - t_n = 1 - 0.49 = 0.51$,

Therefore, $d1 = 0.35$, $\mu_{F1}(a1) = d1 = 0.35$, hence, $F1 = \{(a1, 0.35)\}$.

Therefore, $h1 = 0.44$, $\mu_{F2}(a2) = h1 = 0.44$, hence, $F2 = \{(a2, 0.44)\}$.

Therefore, $p1 = 0.39$, $\mu_{F3}(a3) = p1 = 0.39$, hence, $F3 = \{(a3, 0.39)\}$.

Therefore, $t1 = 0.51$, $\mu_{F4}(a4) = t1 = 0.51$, hence, $F4 = \{(a4, 0.51)\}$.

Now the fuzzy operations such as fuzzy set intersection (minimum) are computed taking three fuzzy membership functions out of total four fuzzy membership functions.

$T_1 = \mu_{F1\cap F2\cap F3}(a) = min\{\mu_{F1}(a1), \mu_{F2}(a2), \mu_{F3}(a3)\} = min\{0.35, 0.44, 0.39\} = 0.35$

$T_2 = \mu_{F1\cap F2\cap F4}(a) = min\{\mu_{F1}(a1), \mu_{F2}(a2), \mu_{F4}(a4)\} = min\{0.35, 0.44, 0.51\} = 0.35$

$T_3 = \mu_{F2\cap F3\cap F4}(a) = min\{\mu_{F2}(a2), \mu_{F3}(a3), \mu_{F4}(a4)\} = min\{0.44, 0.39, 0.51\} = 0.39$

$T_4 = \mu_{F1\cap F3\cap F4}(a) = min\{\mu_{F1}(a1), \mu_{F3}(a3), \mu_{F4}(a4)\} = min\{0.35, 0.39, 0.51\} = 0.35$

Thereafter, we are applying fuzzy neural network algorithm to these fuzzy operations and accordingly the weightings of these fuzzy intersection operations are taken as $WT_1 : WT_2 : WT_3 : WT_4 = 0.5 : 0.45 : 0.42 : 0.4$

Now the optimum or the final value is obtained multiplying the fuzzy intersection operation by the corresponding weightings, i.e., $FT_1 = T_1 \times WT_1 = 0.5T_1 = 0.5 \times 0.35 = 0.175$

$FT_2 = T_2 \times WT_2 = 0.45T_2 = 0.45 \times 0.35 = 0.1575$

$FT_3 = T_3 \times WT_3 = 0.42T_3 = 0.42 \times 0.39 = 0.1638$

$FT_4 = T_4 \times WT_4 = 0.4T_4 = 0.4 \times 0.35 = 0.14$

Then, all the final values regarding fuzzy intersection operations are de-fuzzified by the Composite Maxima method in fuzzy neural network, i.e., $max(FT_1, FT_2, FT_3, FT_4) = max(0.175, 0.1575, 0.1638, 0.14) = 0.175$

Now the fuzzy operations like fuzzy set union (maximum) are calculated taking three fuzzy membership functions at a time out of four fuzzy membership functions.

$V_1 = \mu_{F1UF2UF3}(a) = max\{\mu_{F1}(a1), \mu_{F2}(a2), \mu_{F3}(a3)\} = max\{0.35, 0.44, 0.39\} = 0.44$

$V_2 = \mu_{F1UF2UF4}(a) = max\{\mu_{F1}(a1), \mu_{F2}(a2), \mu_{F4}(a4)\} = max\{0.35, 0.44, 0.51\} = 0.51$

$V_3 = \mu_{F2UF3UF4}(a) = max\{\mu_{F2}(a2), \mu_{F3}(a3), \mu_{F4}(a4)\} = max\{0.44, 0.39, 0.51\} = 0.51$

$V_4 = \mu_{F1UF3UF4}(a) = max\{\mu_{F1}(a1), \mu_{F3}(a3), \mu_{F4}(a4)\} = max\{0.35, 0.39, 0.51\} = 0.51$

Weightings of this fuzzy union operations are as $WV_1 : WV_2 : WV_3 : WV_4 = 0.9 : 0.85 : 0.83 : 0.8$

The optimum or the final values regarding fuzzy union operation applying fuzzy neural network algorithm are below: $FV_1 = V_1 \times WV_1 = 0.9V_1 = 0.9 \times 0.44 = 0.396$

$FV_2 = V_2 \times WV_2 = 0.85V_2 = 0.85 \times 0.51 = 0.4335$

$FV_3 = V_3 \times WV_3 = 0.83V_3 = 0.83 \times 0.51 = 0.4233$

$FV4 = V_4 \times WV_4 = 0.8V_4 = 0.8 \times 0.51 = 0.408$

All the final values are de-fuzzified by the Composite Maxima method which yields, i.e.,

$max(FV_1, FV_2, FV_3, FV_4) = max(0.396, 0.4335, 0.4233, 0.408) = 0.4335$,

Now applying fuzzy-neural rule, $max(FT_1, FT_2, FT_3, FT_4) = 0.175$, *i.e.*, ≤ 0.21 and

$max(FV_1, FV_2, FV_3, FV_4) = 0.4335$, *i.e.*, ≤ 0.54, therefore, the route detected under M-AODV scheme is accepted and may be used for traffic (data) flow. Thus, TTL must possess the least value, as the best route is obtained.

Simulation

In this study, we used NCTUns-6.0[13] for simulation. We have chosen this simulator because,

- Highly integrated and professional GUI environment.
- Support for various network protocols.
- Support for various important network.
- Same configuration and operations as for real life networks.
- High simulation speed and repeatable simulation result.
- High fidelity simulation results.

Performance metrics

Different performance metrics are used to check the performance of routing protocols in various network environments. In our study we have selected throughput and packet drop to check the performance of VANET routing protocols against each other. The reason for the selection of these performance metrics is to check the performance of routing protocols in highly mobile environment of VANET. Moreover, these performance metrics are used to check the effectiveness of VANET routing protocols i.e. how well the protocol deliver packets and how well the algorithm for a routing protocol performs in order to discover the route towards destination. The selected metrics for routing protocols evaluation are as follows [9-10].

Throughput

Throughput is the average number of successfully delivered data packets on a communication network or network node. In other words throughput describes as the total number of received packets at the destination out of total transmitted packets [9]. Throughput is calculated in bytes/sec or data packets per second. The simulation result for throughput in NCTUns6.0 shows the total received packets at destination in KB/Sec, mathematically throughput is shown as follows:

$$\text{Throughput} = \frac{\text{Total number of received packets at destination packet size (bytes/sec)*}}{\text{Total simulation time}}$$

Packet Drop

Packet drop shows total number of data packets that could not reach destination successfully. The reason for packet drop may arise due to congestion, faulty hardware and queue overflow etc. Packet drop affects the network performance by consuming time and more bandwidth to resend a packet. Lower packet drop rate shows higher protocol performance.

Collision

The Collision of data packet is the number of packets collides to each other due to congestion. It affects the performance directly on the bandwidth. Lower packet collision rate shows higher protocol performance. We found the packet drop and collision is drastically reduced. In-throughput (packet incoming to node) is also diorite from original AODV as number packet to discover is very less in our proposal. But, the out-throughput is remaining same. It indicates with reduced Power (P), Overhead (D), TTL (T) and same distance (D) we got the satisfactory result. That proves the optimal parameters usage to discover the routing path is successful according to our proposal using neural network.

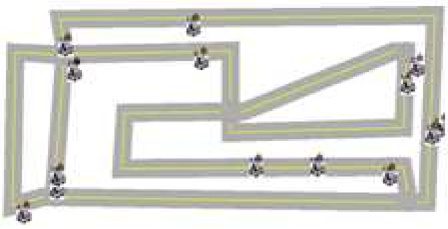

Fig. 2 Testing Scenario

Table -1 Data Set Generation

D	*O*	*P*	*T*
0.32	*0.41*	*0.54*	*0.40*
0.32	*0.45*	*0.58*	*0.43*
0.331	*0.45*	*0.50*	*0.54*
0.32	*0.52*	*0.42*	*0.56*

Table -2 Testing Parameters

Parameter	*Settings*
Transmission mode	*TCP/IP*
Lane Width	*20m*
Simulation time	*400sec*
RTS threshold	*3000bytes (O)*
The car profile (Taken five)	*18km/H, 36km/H, 50km/H, 60km/H, 80km/H*
Number of lane	*2*
The protocol	*AODV*
standard used for each vehicular node	*IEEE802.11b*
cars are selected for three different scenarios	*10,15,20,25,30 (D)*
Transmission power used	*15dbm (P)*
TTL	*7(T)*

Table -3 aiAODV Testing Parameters

Parameter	*Settings*
Transmission mode	*TCP/IP*
Lane Width	*20m*
Simulation time	*400sec*
RTS threshold	*3000bytes (O)*
The car profile (Taken five)	*18km/H, 36km/H, 50km/H, 60km/H, 80km/H*
Number of lane	*2*
The protocol	*AODV*
standard used for each vehicular node	*IEEE802.11b*
cars are selected for three different scenarios	*10,15,20,25,30 (D)*
Transmission power used	*10dbm (P)*
TTL	*3(T)*

Advantages of the Modified AODV Routing Protocol

This route discovery technique under Modified AODV protocol is the most efficient one due to applying artificial intelligence [AI] in advanced stage, i.e., fuzzy neural network used. Also it does not require any further information to supply by the source (host) node while making a call. So it is a unique one. The route is determined by the essential attributes or parameters of the AODV protocol. No cryptography algorithm or any complex functions are applied. This Modified AODV protocol technique ensures the fastest best route discovery.

RESULTS

CAR 10

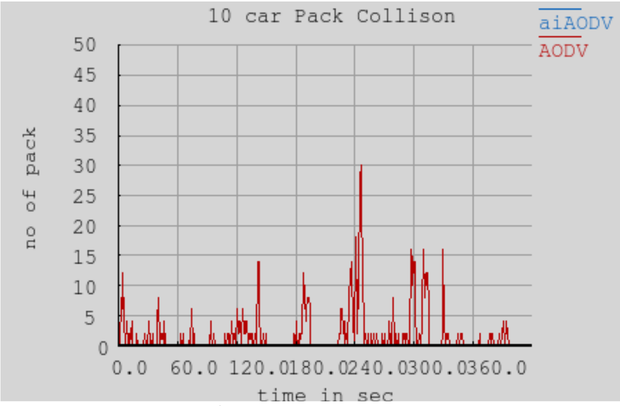

Fig. 3 Number of Packet in collision in AODV vs aiAODV

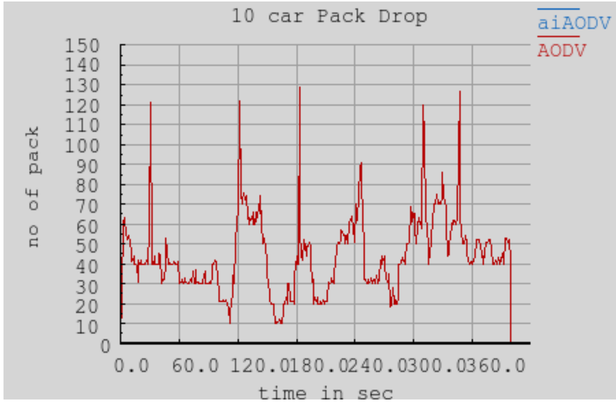

Fig. 4 Number of Packet drop in AODV vs aiMAODV

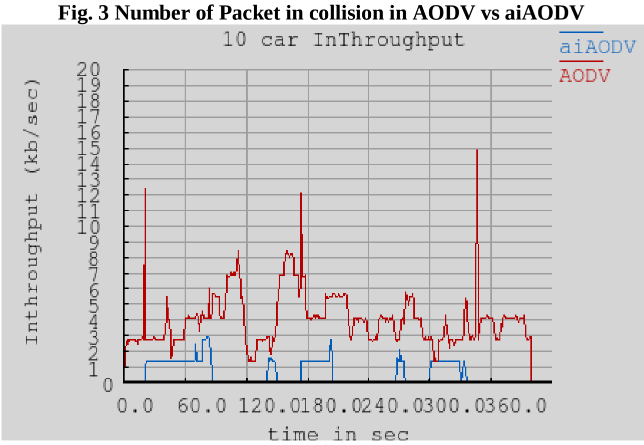

Fig. 5 In throughput of AODV vs aiMAODV

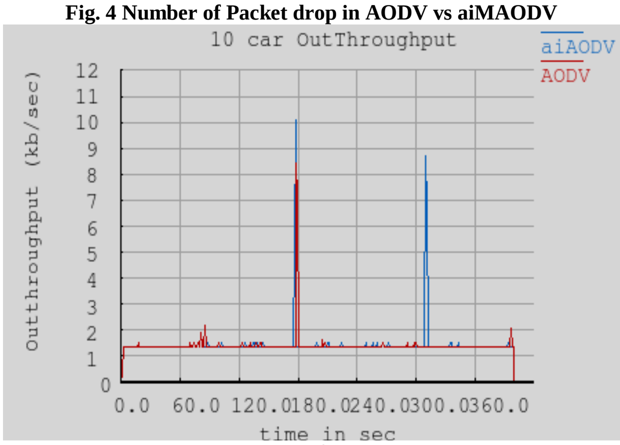

Fig. 6 Out throughput of AODV vs aiMAODV

CAR 15

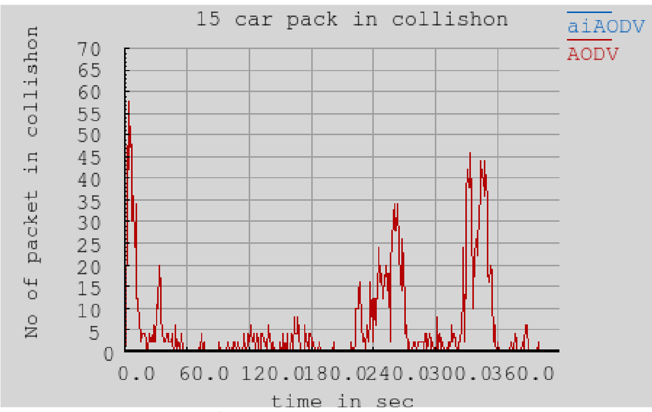

Fig. 7 Number of Packet in collision in AODV vs aiAODV

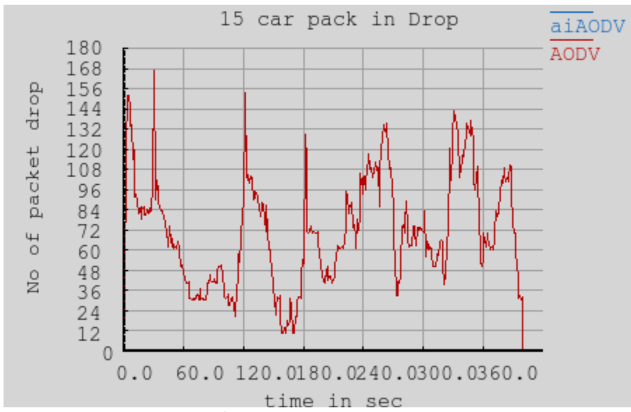

Fig. 8 Number of Packet drop in AODV vs aiMAODV

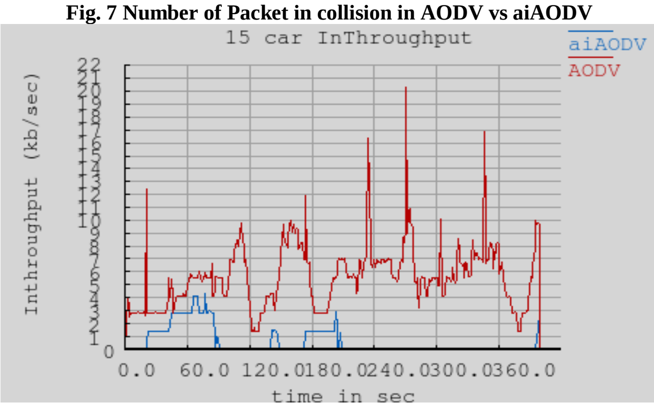

Fig. 9 In throughput of AODV vs aiMAODV

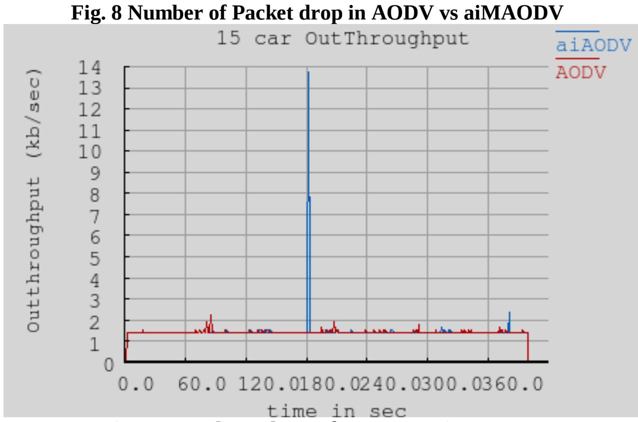

Fig. 10 Out throughput of AODV vs aiMAODV

CAR 20

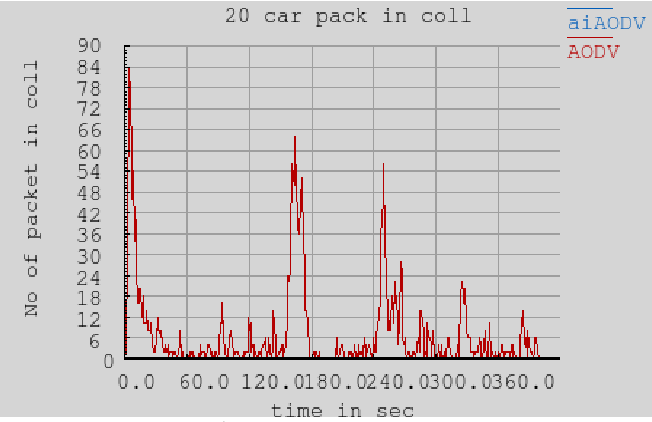

Fig. 11 Number of Packet in collision in AODV vs aiAODV

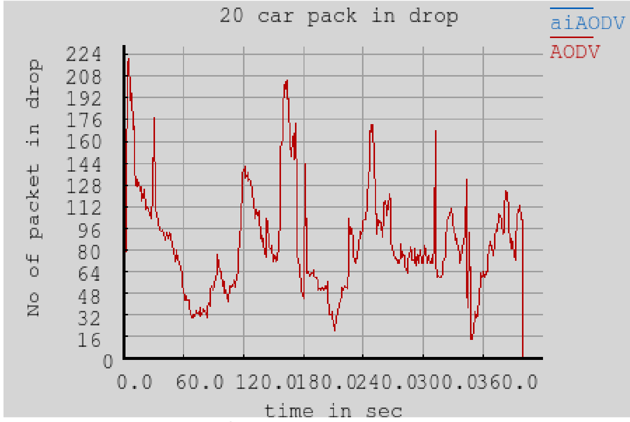

Fig. 12 Number of Packet drop in AODV vs aiMAODV

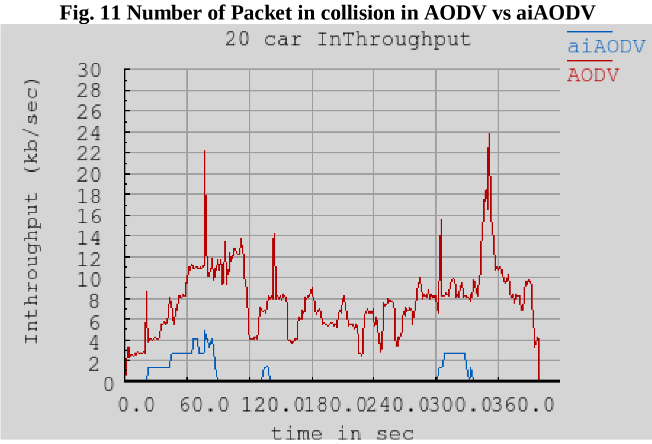

Fig. 13 In throughput of AODV vs aiMAODV

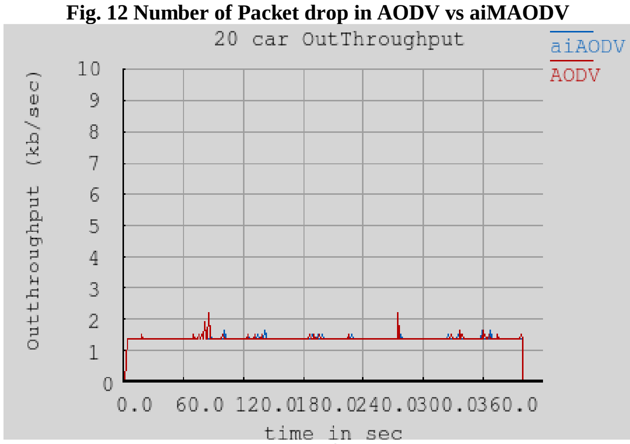

Fig. 14 Out throughput of AODV vs aiMAODV

CAR 25

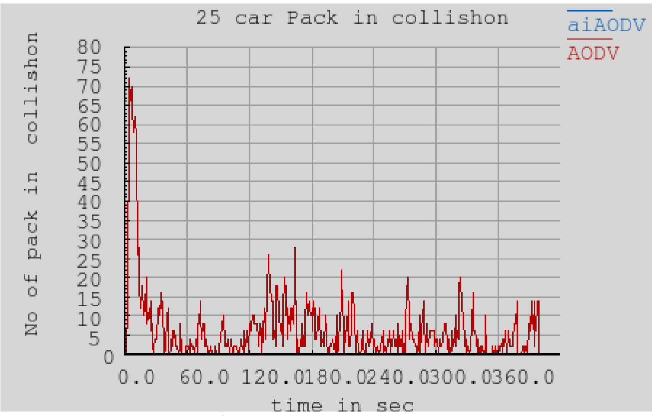

Fig. 15 Number of Packet in collision in AODV vs aiAODV

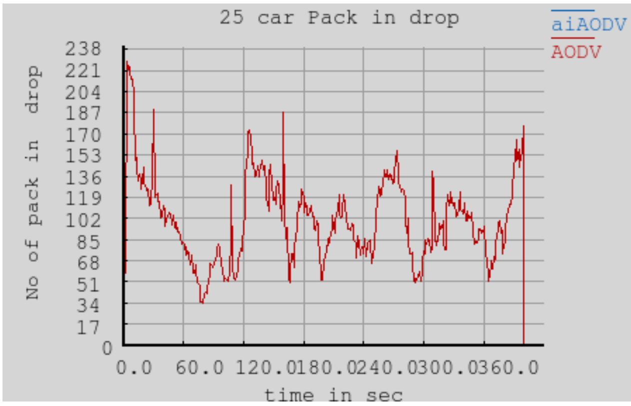

Fig. 16 Number of Packet drop in AODV vs aiMAODV

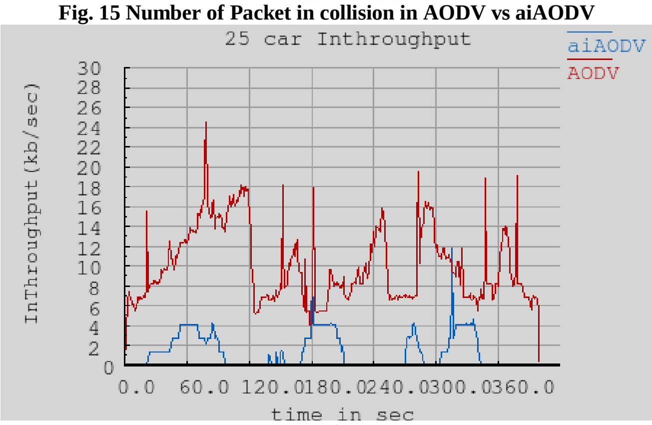

Fig. 17 In throughput of AODV vs aiMAODV

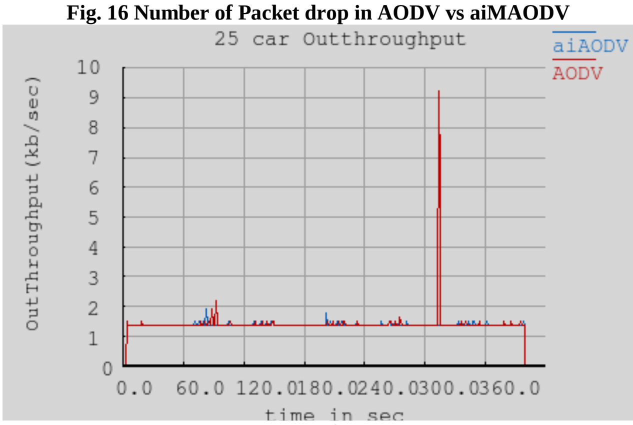

Fig. 18 Out throughput of AODV vs aiMAODV

CAR30

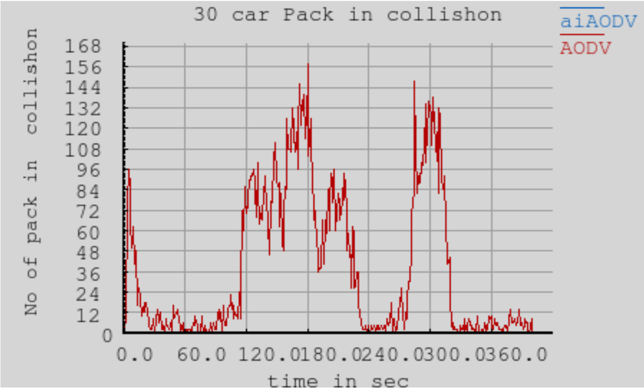

Fig. 19 Number of Packet in collision in AODV vs aiAODV

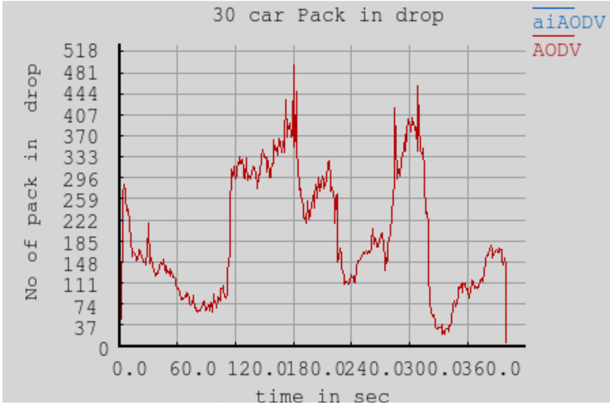

Fig. 20 Number of Packet drop in AODV vs aiMAODV

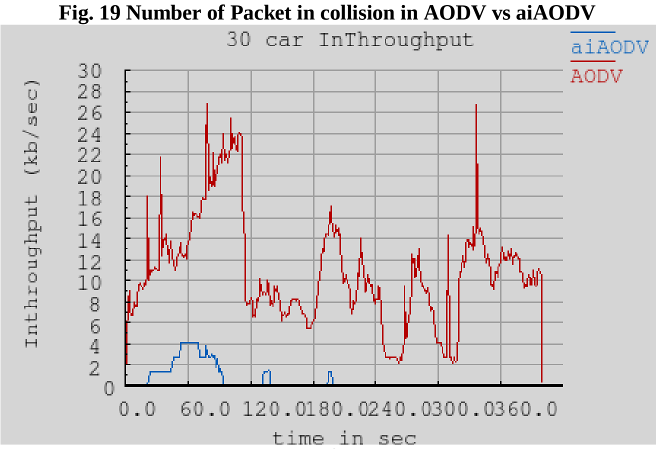

Fig. 21In throughput of AODV vs aiMAODV

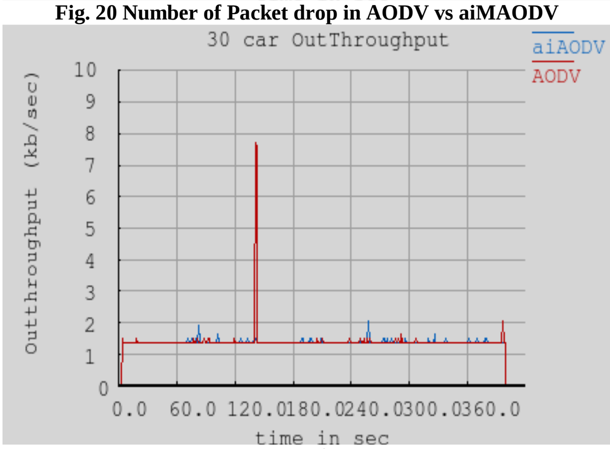

Fig. 22 Out throughput of AODV vs aiMAODV

CONCLUSION

In this paper we have proposed to determine the best route from the source node to the destination node through several intermediate nodes using fuzzy neural network algorithm in Modified AODV (aiAODV) routing protocol of VANET communications. Therefore, the stable connections are set up in a VANET communications by implementing a fast and easy routing techniques like artificial intelligence based Modified AODV routing protocol in the VANET system. There are many variants of routing protocols for VANET transmission have been proposed, those are basically the modified forms of MANET routing protocols. This Modified AODV routing protocol using fuzzy neural network algorithm for the best route searching in VANET is fantastic workable in a real time basis.

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