IMPROVING QOS OF DSR PROTOCOL TO DELIVER A SUCCESSFUL COLLISION AVOIDANCE MESSAGE IN CASE OF AN EMERGENCY IN VANET

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Abstract
Objective: By leveraging the DSR protocol, we intend to develop a collision avoidance system that will successfully transfer emergency messages in the event of an emergency in VANET.
Methods: Initially, it is anticipated that everything would go according to plan and that DSR will be able to communicate with various autonomous vehicles. After that, in the second scenario, a subsequent emergency occurs, but DSR is unable to transmit the emergency message. These two scenarios were analyzed, and it was determined that broadcast storm is the root of the issue. To minimize this and better strengthen the present DSR protocol, several RSU are used together with more stable links with higher link lifetime.
Results: The NS2 simulation is made to replicate the situation, and QoS parameters are shown for both the existing and proposed techniques. In addition to successfully transmitting emergency messages in accident-prone areas to lower risks, the DSR protocol also exhibits better packet delivery ratio and minimal packet loss when the proposed methodology is used.
Conclusion: The deployment of numerous RSUs and selective hopping over a moderate link lifetime can increase the reliability of DSR and assist in reducing the problem of broadcast storms. A successful and assured collision avoidance system can be created using DSR.
Keywords: Autonomous vehicles, Broadcast storm, Collision Avoidance System, DSR, Link Lifetime, Link Stability, MANET, Roadside Units, VANET

1. Introduction

Mobile Adhoc Network (MANET) is a multi-hop wireless communication network that is non-focused and has been set up by wireless mobile networks. The aim of the MANET routing protocol is to create a correct and effective route with minimal control overhead and bandwidth consumption [1]. MANET is mostly utilized in temporary or emergency scenarios, such as military battlegrounds, disaster relief efforts, and field trips, where communication infrastructure are unfeasible and it is the only form of communication present. MANET is a collection of mobile nodes that can be dynamically set up anywhere without the use of any fixed infrastructure. MANET has dynamic topologies consisting of various grids though it has energy-constrained nodes and limited security. It has autonomous behaviour in establishing peer-to-peer connectivity and independent computation. The wireless nature of the links is the reason for high packet loss and recurring route disconnections that pose a greater risk to MANET [3].

A sub-part of MANET known as Vehicular Ad hoc Network (VANET). Certain Issues faced using MANET lead to the use of a new field VANET.

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VANET is a subclass of MANET [2], which is a rapidly increasing research field in the world. The main approach behind VANET is to help in managing and maintaining communication of V2V (Vehicle to Vehicle), V2I (Vehicle to Infrastructure), and hybrid communication [4]. Vehicles usually use VANET communication for safety management, traffic management, and internet services transparent. VANETs are of high use in systems where highly dynamic topology, unregulated network size, high mobility, scalability, and networking are needed. To serve VANET communication multiple protocols are deployed two types of them namely proactive and reactive.

As the name implies, proactive refers to a protocol where the needs and routing paths are predetermined [5]. Communication exists between the source vehicle/node and the destination vehicle/node. There should not be any delay when a node needs to send a packet in proactive. E.g., DSDV

Reactive, as the name implies, refers to the protocol, which is always altering as a result of the activities being triggered. Data is sent and received from each existing subsequent node/vehicle. Routes are assumed to be changed at any time and unlike proactive, they are not set beforehand [5]. E.g., DSR AODV

The proactive protocol approach is mainly used in Routing tables, Sequence number generation, and damping. On the other hand, reactive protocols are used to improvise Energy Efficient Multipath Routing, path reliability and link monitoring repair Efficient Route Discovery and Link Failure Detection Mechanisms [6-7].

DSR is known as Dynamic Source routing. This protocol discovers the route between the source and the destination when required and its operation is based on source routing. The intermediate nodes do not maintain routing information to route the packets to the destination. There is less network overhead as the number of message exchanges between the nodes is very less [1,8-9]. DSR has found its applications in numerous areas such as Range Based Address Resolution, Gateway Location Application, Gateway Location Application, Full Address Based Resolution, MAP-Diameter Interlocking, Policy and Charging Applications, and Charging Proxy Application [10].

DSR being a reactive protocol is able to perform better in a VANET. For different network structures and scenarios, wireless protocols have different performances. DSR protocol is better than AODV and DSDV in terms of throughput and packet delivery ratio [11]. So far different researchers have applied and improved the DSR protocol for different areas and applications. But, nobody has ever applied DSR in the Collision Avoidance System (CAS). When the DSR protocol in VANET is used to transport crucial messages to the target area, it can help in emergency situations. To a certain extent, DSR produces adequate and effective results, although it is often unable to transmit emergency alerts when broadcast storms happen because of a larger vehicle density. The DSR protocol is used in a new way to address these problems.

The proposed method can deal with the broadcast storm impact and chooses the optimum stable link with a modest lifetime to assure packet delivery with the least amount of volatility. And the end result demonstrates that the suggested approach is superior to the existing DSR model, which is illustrated, compared, and explained with the aid of several QoS criteria

The paper is organized in the following way. The Literature review section discusses recent developments in the DSR domain. The discussion of the following two examples illustrates when and where the DSR can successfully transmit a message. The currently proposed technique for DSR working is then thoroughly outlined. The workings of the protocols are shown in the result section that follows, and the conclusion is given at the end of the paper.

2. Literature review

The DSR protocol is often referred to as the "on demand routing protocol" since the nodes only determine the path between the source and the destination when it is necessary to do so [8]. The routing data necessary to direct the packets to their destination is not kept by the intermediary nodes. The route discovery phase and the route maintenance phase are the two stages of the DSR protocol's operation [8]. The source node broadcasts an RREQ packet with the source node ID and destination node ID in order to start a connection. The destination node unicasts an RREP packet and delivers the entire path to the source after the destination has been determined [5]. Additionally, it employs RERR packets to notify the network of any transmission failures. According to the authors of [8], traditional DSR, DSDV, and AODV, DSR can all store several routes' worth of information in their route caches, and that protocol outperforms AODV and DSDV in terms of throughput and PDR.

The performance of two routing protocols, FSR and DSR, with v2v and v2i communication models is compared in similar research [4] utilizing the scenario of altering the number of nodes, changing the speed, and changing the packet size. When the number of nodes is altered, DSR has a greater throughput and a lower end-to-end delay than FSR because DSR is a reactive protocol and FSR is a proactive protocol. DSR has some constraints, but one of them is that it forbids direct repair of faulty links or connections between nodes during the route maintenance period [8].

Due to practical DSR's poor packet delivery ratio in environments with high mobility, protracted delays, and significant routing overhead, better and more efficient results have been achieved [9-11,13].

Authors [11,14] have developed a priority-based DSR solution in a similar way to alleviate issues brought on by packet congestion and lessen broadcast storm. The two methods for increasing DSR that the author suggests in [12] for source delivery and route maintenance are ZRDM and LFPM, which outperform conventional DSR protocols.

Existing DSR only uses the simplest minimum hop count technique when choosing a routing path, and it ignores the energy required for routing by the nodes [1]. Thus, in order to enhance the routing selection algorithm without altering the complexity of DSR, authors [1] proposed the GA-BFO algorithm to carry out optimal routing. It was found that the GA-BFO algorithm significantly reduces control overhead, has a better packet delivery ratio than other various protocols like DSR-IMRP and ILFA-DSR, and also has an improved path finding algorithm.

The typical DSR has issues with energy depletion and does not use energy usage as a routing parameter [6]. Many other academics have put out various energy-efficient algorithms, however they only allow single path routing. To address this issue, the authors of [6] have suggested a DSR technique based on Multi Objective Grey Wolf Optimization (MGWO). The MGWO-DSR protocol is observed to provide better multi-path routing than other protocols with higher throughput, network lifetime, and less end to end delay. According to the authors, it effectively minimizes the energy depletion problem while also ensuring reliable multi-path data transmission in MANET [6].

Dynamic source routing (DSR), a typical prototype of routing protocols, relies only on the least hop count parameter to identify the path, neglecting other factors like energy consumption and node energy level, which have a significant impact on how the routing algorithm is executed [9]. The researchers have proposed a novel and effective routing mechanism based on a hybrid strategy using the minimum execution time (MET) scheduling and moth flame optimization (MFO) scheme to improve the performance of the DSR [9]. It has been observed that this mechanism performs better than the current Bee DSR (BEEDSR) and Bee-inspired protocol (BeeIP) algorithms.

In the modern world, it is essential to increase the Quality of Service (QoS) in MANETs, yet the majority of routing protocols fail due to resource limitations and cause congestion [11]. It has been observed that the priority-based dsr protocol developed by the authors in [11] to improve QoS, improves performance to a higher extent by improving throughput and reducing to improve on-demand source routing protocols, authors in [12] have suggested two mechanisms: a zone-based route discovery mechanism (ZRDM) and a link failure prediction mechanism (LFPM). According to the results, the suggested techniques outperform reliable DSR, zone-based DSR, and segment-based DSR. ZRDM, which attempts to regulate the flooding of route requests, decreases control overhead, and LFPM performs very well in terms of packet delivery ratio [12].

In order to enhance communication quality when moving at high speeds, researchers in [13] suggested a dynamic source routing protocol based on path reliability and monitoring repair mechanism (DSR-PM). The model filters the best dependability path in order to transmit data. The link state information is tracked throughout transmission and damaged links are restored as quickly as feasible in order to guarantee communication stability and reliability of the links and increase data transmission efficiency [13]. The DSR-PM protocol, according to the authors, efficiently lowers factors like overhead, packet loss, and latency while also increasing network throughput and enhancing communication performance.

Due to the likelihood of radio signals overlapping with one another in a given area, straightforward broadcasting by floods is typically very expensive and will lead to significant redundancy, contention, and collision, which is referred to as "Broadcast storm". Broadcast Storm is a situation in which an overwhelming volume of broadcast or multicast traffic overwhelms a network's capacity, preventing it from carrying regular traffic and, as a result, inhibiting the transmission and receiving of regular and emergency messages or warnings [15].

Roadside Units (RSUs) are used to increase vehicle-to-vehicle communication while enhancing safety and security in the traffic. When it comes to RSUs in DSR, the source vehicle calculates the distance that the destined vehicle will travel and then decides whether it will stay within the range of that RSU for the duration of that length or move on to the next RSU [16]. The packet will only be sent to that RSU if the destination vehicle remains within its coverage area; otherwise, it will be sent using the DSR protocol to the next RSU in the direction of the destination [17]. Hence, link lifespan must be taken into consideration in order to determine and use the multi-hop applications' most reliable routes and to take connection instability in VANET into account [18-19]. Here, RSUs serve as dependable links for information transmission and reception.

DSR protocol has a few shortcomings that can only be remedied by enhancing how it works. The routing overhead and locally damaged links cannot be repaired in this protocol. Additionally, as mobility increases, its performance drops down quickly. Compared to table-driven protocols, the time to set up a connection is much longer [18].

3. Methodology

Here, two simulation situations are taken into account. In scenario 1, the regular position and motions of the vehicle are displayed, and DSR is able to transport the data packets properly. However, later in scenario 1, due to some unforeseen events, DSR is unable to send the packets. In order to address these issues, we utilized our proposed solutions in scenario 2, and it is clear that DSR is able to transmit the data packets, hence allowing us to say that the network protocol is able to circulate emergency messages when an accident occurs.

3.1 Scenario 1 – Simulation setup

The scenario presented in Figure 1 includes simulation-based positions of moving autonomous vehicles. The figure depicts a two-way street with two parallel white lines separating the lanes. At no point in the simulation, it is anticipated that any of the cars will deviate from their current path. The simulation starts with two sets of autonomous vehicles traveling in opposition to one another in a straight line on either side of the road. In this case, communication between autonomous vehicles is unhindered and operates efficiently. It serves as the optimum situation for DSR protocol-based vehicle-to-vehicle communication.

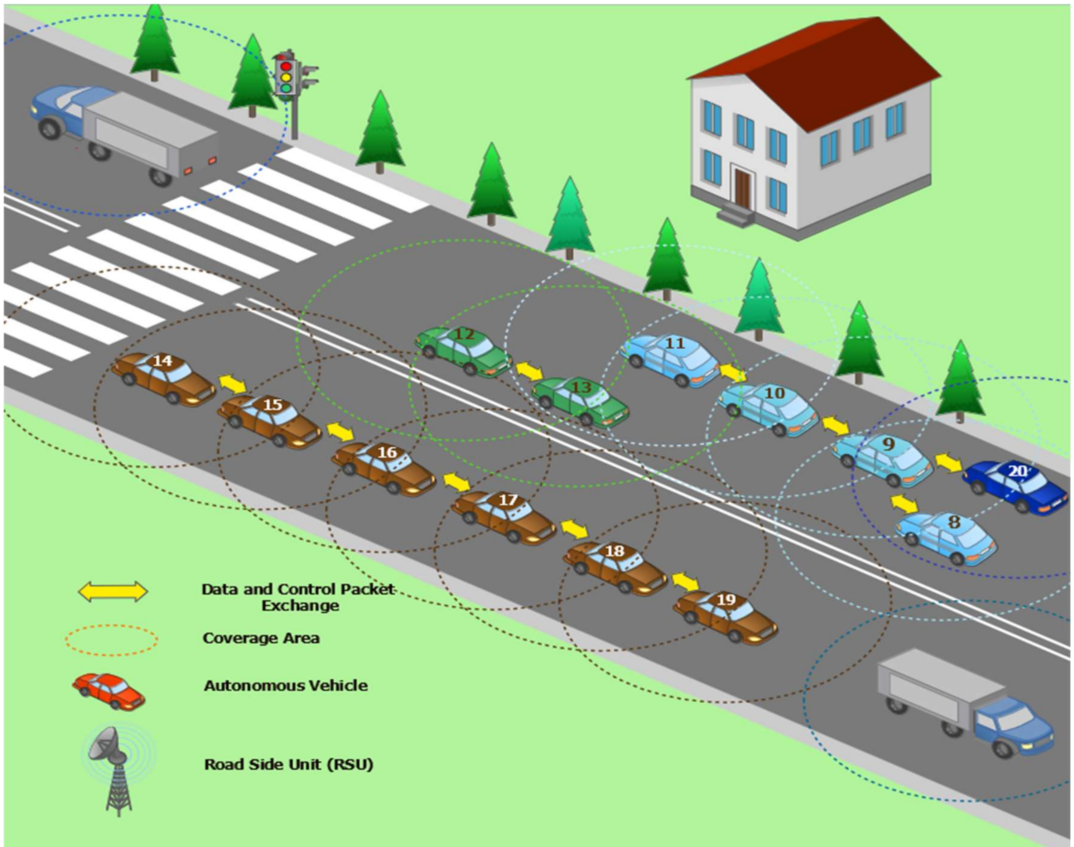

Figure 1: Simulation setup

In the scenario shown in figure 2, only the 20th autonomous vehicle is aware of this. The 20th car is unable to issue warnings to the neighbouring vehicles because of their significant separation from one another. Vehicles 8 to 13 that witnessed the mishap have now halted and are gathered close together. Due to overcrowding of the vehicles, a phenomenon called “Broadcast storm” occurs. “Broadcast storm" is an occurrence that takes place when a network's capacity is exceeded by an excessive amount of broadcast or multicast traffic, prohibiting the network from carrying ordinary traffic and, as a result, preventing the transmission and reception of normal and emergency messages or alerts [20]. Hence, consequently, the messages are not delivered in the situation by DSR protocol.

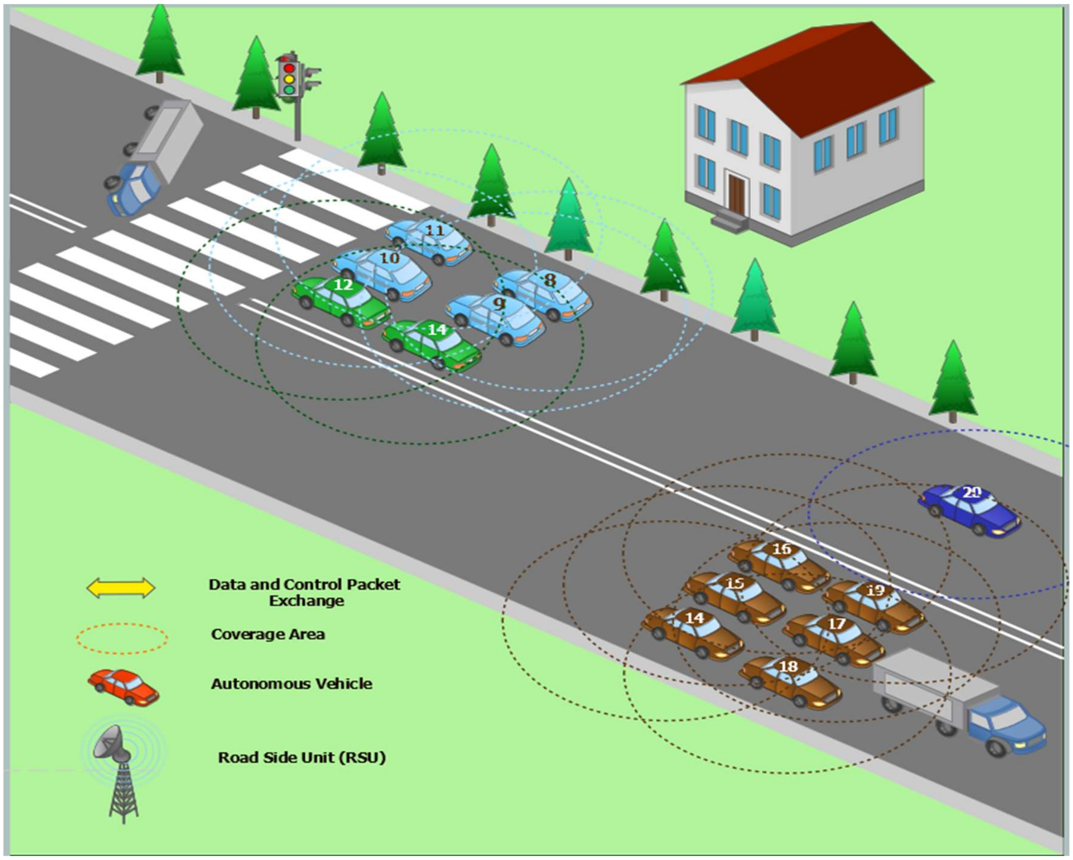

Figure 2: Broadcast storm in case of an emergency

3.2 Scenario 2 – Collision Avoidance System with RSus and Stable links

The second scenario, in which Roadside Units (RSUs) are positioned alongside roadways, is seen in Figure 3. RSUs gather traffic data and disseminate the information to nearby vehicles. An accident is reported to the 8th autonomous vehicle in the figure. Due to its close proximity to vehicle number 7, this vehicle sends an alert to it. Despite being equally close in proximity to both vehicle 6 and the 23rd RSU, vehicle 7 could decide to alert vehicle 6 or the 23rd RSU depending on the circumstances. However, in this specific instance, it chooses the 23rd RSU as the intended recipient of the message since an RSU is a more dependable option than vehicle 6, which arbitrarily changes positions. Vehicle 7 chooses RSU 23rd because while deciding the route it founds that the link lifetime to reach 22nd RSU is higher with 23rd RSU w.r.t. Vehicle 6. Following this, 23rd RSU transmits the message it has just received to RSU 22, which in turn notifies all the nearby vehicles of the accident. For stable pathways to be established between connection participants, stable links must be used. In contrast to scenario 1, scenario 2 is a case where RSUs act as reliable links, hence, facilitating information transmission. Additionally, in the event of a broadcast storm, the RSUs are given higher priority to serve as the next hop in the path, reducing packet flooding in scenarios with a higher vehicle density. Here, after improvements, DSR is working as a Collision Avoidance System.

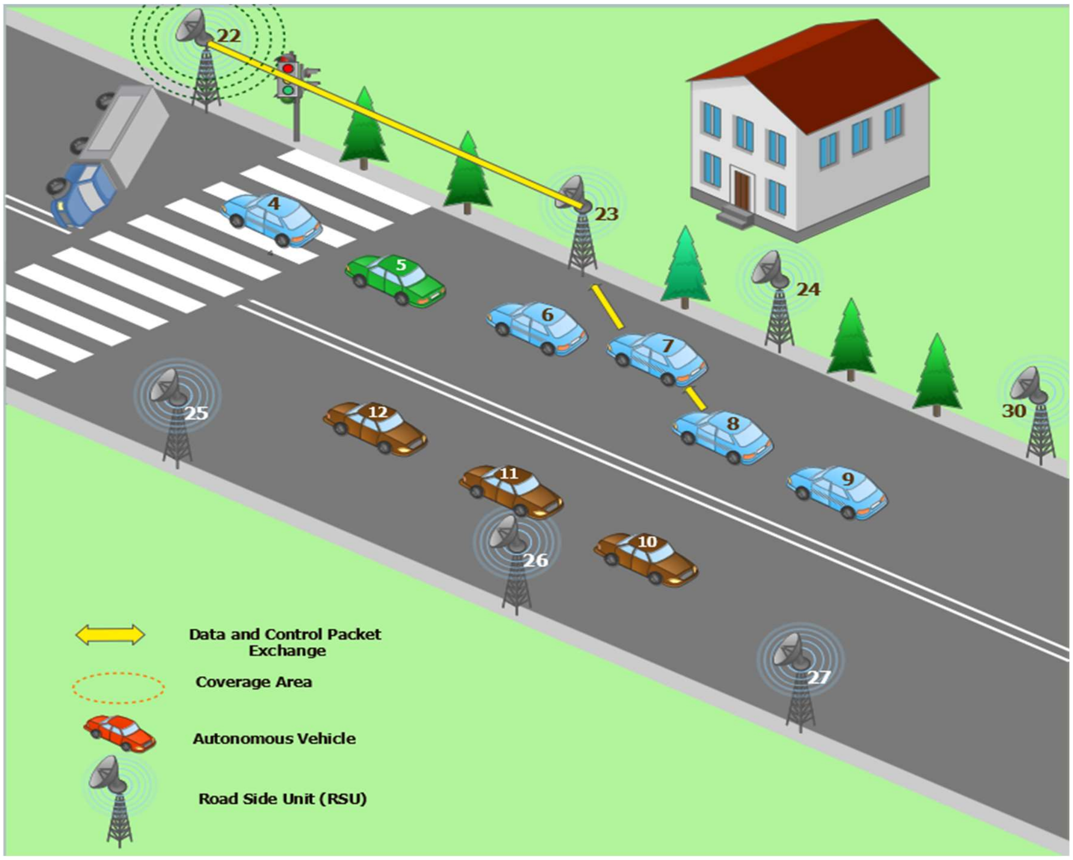

Figure 3: RSUs are deployed to transmit alerts to vehicles

4. Existing and Proposed DSR protocol

DSR is an On-Demand routing protocol that works on the principle of source routing. Source routing means that the source itself knows the path to the destination. In this, the intermediate nodes don't have to store the routing information to the destination.

The DSR Protocol has 2 phases:

4.1) Route Discovery:

This contains RREQ packets and RREP packets.

RREQ packets contain source Id and destination Id and these packets are Route REQuest packets. These travel from the sender to the destination. It has a broadcast communication pattern. (One source to all reachable stations)

RREP packets are Route REPly packets that are sent by the destination to the source and this is done by a unicast communication pattern. (One destination to one source)

4.2) Route Maintenance:

RERR packets are Route ERRor packets that are sent to the neighbors of the node where the error has occurred.

->One more aspect of the DSR protocol is the route cache which stores the path.

***Advantages:**

1)The sender knows the path therefore the intermediate nodes don't have to store the path.

2)Less network overhead due to less number of message exchanges among the intermediate nodes.

3) The intermediate nodes store the route via the route cache. Therefore, there is no need to update the intermediate node root again and again.

***Disadvantages:**

1) Dynamic source routing protocol does not locally repair a broken link; it just sends the RERR packet to the neighbouring nodes.

2) It has an assumption that less number of nodes means less distance which may be wrong in some cases.

4.3 Working of existing DSR:

The source sends an RREQ packet to the destination via a route known by the sender itself. The packet contains a unique id, source address, and destination address. This packet is sent via route discovery. The source broadcasts the packet to the neighbouring nodes who further send the packet to the destination. When the destination gets the packets in the end, it selects the packet which travelled with the shortest path and discards the others. The destination then sends an RREP packet to the source it got the packet from via traversing the path back.

4.3.1 DSR Algorithm :

//[] Represents array collection

//y is the traversing node

//nn: number of nodes

//select_path(x): it returns the path where the path cost is x

//n_arr: array of a number of nodes

```
//n[] <- array of the total number of nodes of the shortest distance path

//i: iterator to go for total n possibilities

//X is a traversing node

//Routing request broadcast method

Send_RREQ_Broadcast(node y)

{

set source_node to x

set nn=0

for i<- 0 to n-1

n_arr[i] <- total number of nodes

Broadcast RREQ to neighboring nodes

End

}

Receive_RREQ(RREQ,node y)

{

IF (y!=Destination) THEN

        UPDATE (Route_cache)

        nn=nn + 1

        UPDATE n_arr[i]

end

ELSE

        START send_RREP_Unicast(node y, RREQ)

end

}
```

```
send_RREP_Unicast(node X)
{
set destination_address to source_address
UNICAST RREP to previous_node
IF (node X=source_address) THEN
        REPLY packet delivered
}
Receive_RREP_Unicast(RREP,node X)
{
D[]<-distance array
Set n=0 //number of paths
di<-distance of the ith path
for i <- 1 to n
{
        D[i]=pathlength(i)
}
return min(D[])  //returns a node with minimum value
shortest_distance=min(D[])
}
Path_selected=Select_path(shortest_distance)
{
//Traversing the shortest path from destination to source in the n[] array to send the RREP packet
for i <- n to 0
```

```
    sendRREPUnicast(node X)
end
}
```

4.4 Improvement Techniques

To improvise existing DSR, multiple RSU deployment and selecting stable links with more link lifetime are applied. They are as follows:

4.4.1 Deploying multiple RSUs

The implementation of Roadside Units (RSUs) would improve vehicle-to-vehicle communication while strengthening security and traffic safety. In contradiction to dynamic vehicle-to-vehicle objects, the carefully placed fixed RSUs provide greater coverage and reliable connectivity for message transmission and reception. The development of vehicle-to-RSU communication was made to improve vehicle-to-vehicle communication [21]. The vehicle must fall within the RSU's transmission range for this exchange to succeed. In this case, messages can be sent from the vehicle to a specific RSU and vice versa. RSUs monitor surrounding activities in addition to sending and receiving signals [22]. They also have the great delivery capability because of their enormous energy, vast bandwidth, and endless storage. Hence, RSUs are heavily utilized in routing, since they enhance performance under extreme load and high mobility [23].

4.4.2 Link Lifetime prediction and selection

The performance of Cyber-physical systems (CPS) applications and mobile ad hoc networks is significantly influenced by link lifetime. Node mobility, low battery power, and a dynamic network environment are the main determinants of link lifetime. In order to identify and employ the most stable routes for multi-hop applications and to account for the connection instabilities in VANET, it is crucial to take link lifetime into account. The formula stated below will help us determine the link lifetime between two moving vehicles, dependent on their relative speeds [24].

$$\Delta V_{12} = V_1 - V_2$$

$$D_{12} = \mathrm{Sqrt}((X_1 - X_2)^2 + (Y_1 - Y_2)^2) \text{ where V : Respective Vector}$$

Here, let D_{12} be the distance between Route Request (RREQ) and the forwarding node as in 1 and 2. Let V_1 and V_2 be the speeds of the particular vehicles, and (X_1,Y_1) be the location coordinates of the forwarding node. In the first case, we consider the RREQ message to contain 2 additional fields which are V_1 and (X_1). Hence, through this formula, we will be able to predict the link lifetime based on the relative speeds of the vehicles involved and also propose a modification to AODV.

4.5 Proposed DSR Algorithm

//Routing request broadcast method:

//X is a traversing node

//[] Represents array collection

//y is the traversing node

//nn : number of nodes

//n_arr: array of number of nodes

//n[] <- array of total number of nodes of the shortest distance path

//select_path(x,LL(p)) : it returns path where the path with x cost and with value close to p link lifetime

//L: lowest link lifetime

//H: Highest link lifetime

//BroadCastStorm(): is a function which returns 1 if Broadcast storm is detected

//NearbyRSU(): establishes the destination path by including nearby RSU node as a next hop

Send_RREQ_Broadcast(node y)

{

set source_node to x

set nn=0

for i <- 0 to n

Broadcast RREQ to neighbouring nodes

end

}

Receive_RREQ(RREQ,node y)

{

```
while (y!=Destination) THEN
        UPDATE (Route_cache)
        nn=nn + 1
        UPDATE n_arr[i]
End
ELSE
        START send_RREP_Unicast(node y, RREQ)
        L=min(Route_time)
        H=max(Route_time)
end
 }
send_RREP_Unicast(node X)
{
set destination_address to source_address
UNICAST RREP to previous_node
IF (node X=source_address) THEN
        REPLY packet delivered
}
Receive_RREP_Unicast(RREP,node X)
{
D[]<-distance array
Set n=0 //number of paths
di<-distance of the ith path
for i <- 1 to n
```

```
{
        D[i]=pathlength(i)
}
return min(D[])  //returns a node with minimum value
shortest_distance=min(D[])
p = (L+H)/2;
Path_selected=Select_path(shortest_distance,p)
If(BrodcastStorm()==1)
Path_selected=NearbyRSU()
//Traversing the shortest path from destination to source in the n[] array to send the RREP packet
for i <- n to 0
        send_RREP_Unicast(node X)
end
 }
```

5. Implementation and Results

A set of connected data blocks form a packet and a coherent message is formed when all the packets are connected together. The size and structure of these network packets can vary depending on the network protocol used. A packet selects the best path from its source to its destination. The proportion of the packet delivered to the destination to that of the packet delivered from the source is defined as the packet delivery factor. It is advantageous to the user to have a higher number of Packet Delivery Factor. The difference in the amount of packet received at the destination to that of the packet sent from the source is termed as Packet Loss Ratio. The additional memory needed to transfer the information from the source to the destination is known as the Overhead. These three parameters packet deliver factor, packet loss, and overhead defines QoS in a network and are often used to determine the performance of a network protocol.

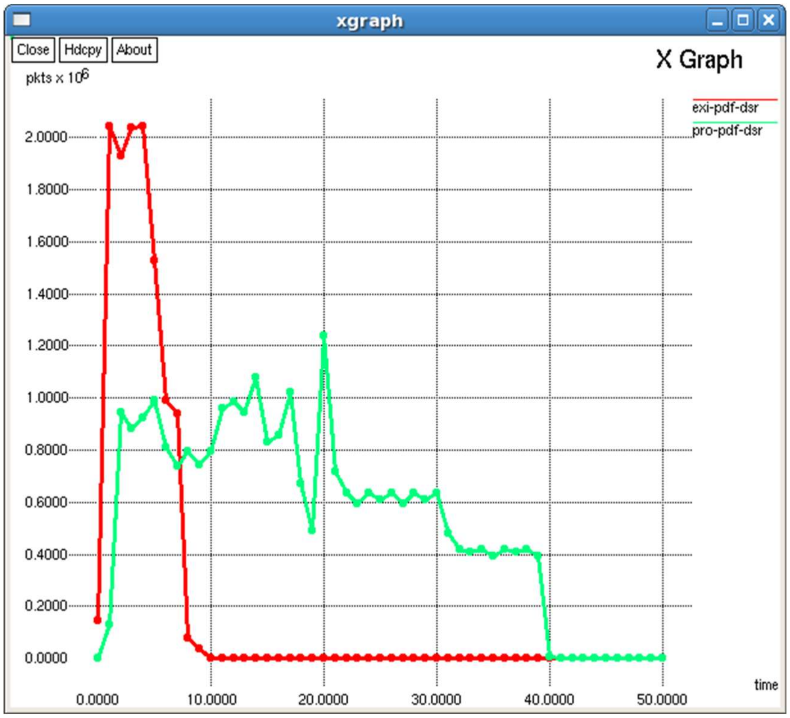

Figure 4: Packet Delivery Factor of existing and proposed DSR protocol

Understanding the movement of the network protocol is made easier by analyzing the packets versus the time graph. In the aforementioned graph shown in figure 4, the number of packets increases rapidly, but as soon as the point of interference is reached, the distribution of the packets sharply decreases due to the broadcast storm which the existing DSR cannot handle. The proposed DSR makes it very clear that the number of packets broadcasted from the source is approximately cut in half when compared to the present DSR model, which greatly reduces interference and allows the packets to proceed ahead properly. The proposed DSR protocol is extending the network time almost by 60% which was very less in the existing DSR due to the interference effect of the broadcast storm.

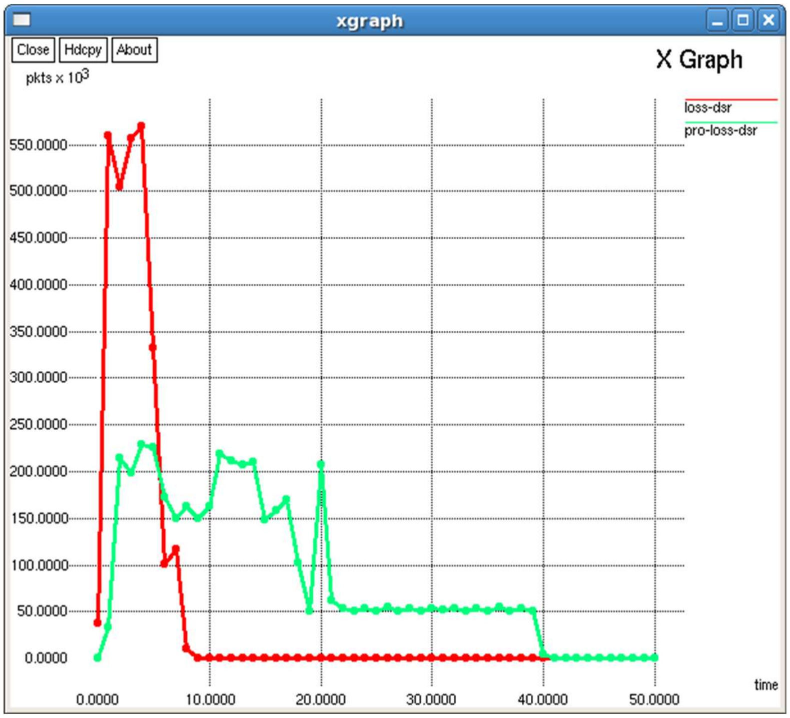

Figure 5. Packet Loss Ration of existing and proposed DSR protocol

From figure 5, It is clear that even when broadcasting is at its highest level, there is a significant loss in packets from source to destination during extremely short time changes, which makes it almost impossible to fully transfer information from source to destination. Since the broadcasting is not stormed in the proposed approach, the loss in the transfer of packets from source to destination is minimized.

Comprehensive Network performance of proposed and existing approach is shown in figure 6. It clearly conveys that the proposed methodology is better than the existing one in terms of packet delivery ratio and packet loss ratio. The network overhead graph of proposed technique is overriding the existing one, which clearly shows that the proposed methodology has no adverse effect, it only improves the existing DSR protocol.

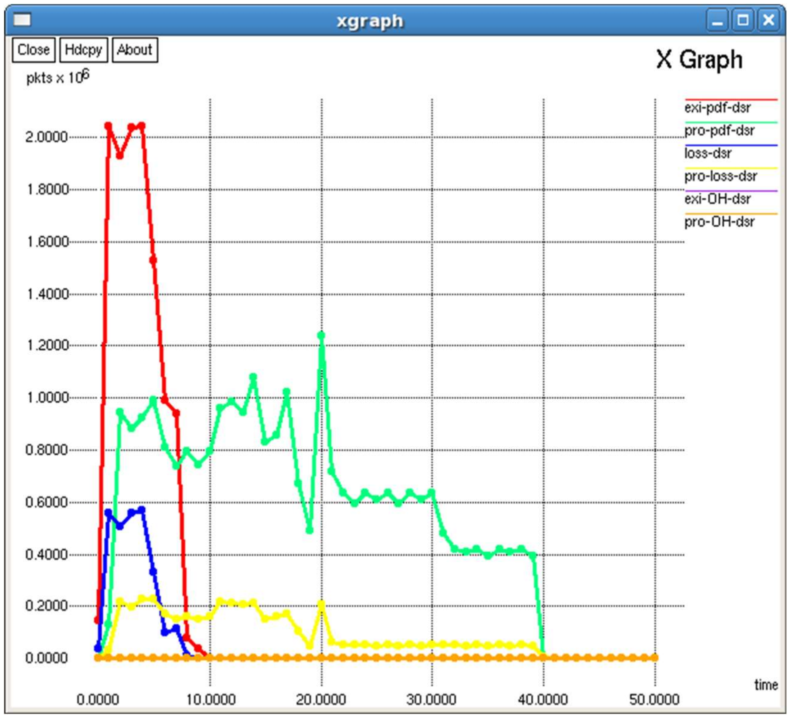

Figure 6: Comprehensive performance of existing and proposed approach

6. Conclusion

Wireless protocols function differently under various network architectures and scenarios. When compared to the throughput and packet delivery ratio of AODV and DSDV, it is discovered that DSR has greater throughput and packet delivery ratio and DSR performs better with VANET since it is a reactive protocol. Due to the capability of DSR to send an emergency warning to several nodes and areas, DSR is an excellent option for collision avoidance systems. However, when we tried to create this situation, we discovered that the existing DSR protocol model was unable to deliver an emergency message because of a broadcast storm, which was later resolved by using multiple RSUs, and the link stability criteria were also taken into account to improve the proposed DSR protocol. Previously, the existing network was overloaded with packets, and the packet delivery ratio dropped suddenly, shortening the network lifetime overall. However, with the proposed approach, the network lifetime is clearly being extended until the communication is not complete by better network service. This shows that the proposed DSR protocol can be recommended in a Collision Avoidance System and it guarantees the delivery of an emergency message to the destination. Thus, this proves that the proposed DSR protocol can be endorsed in a collision avoidance system since it ensures the delivery of an emergency message to the destination to minimize accidental loss.

The RSU deployments offer several benefits, as this study has shown. The same RSUs can be utilized in the future for 5G data processing to function as a Vehicular Fog Computing, where parked vehicles, their duration of parking, their direction of movement, and various forms of data, including GPS location and speed, can be taken into consideration to advance it further.

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