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Research article

Adaptive mobility-aware and reliable routing protocols for healthcare vehicular network

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Abstract: Healthcare vehicles such as ambulances are the key drivers for digital and pervasive remote care for elderly patients. Thus, Healthcare Vehicular Ad Hoc Network (H-VANET) plays a vital role to empower the digital and Intelligent Transportation System (ITS) for the smart medical world. Quality of Service (QoS) performance of vehicular communication can be improved through the development of a robust routing protocol having enhanced reliability and scalability. One of the most important issues in vehicular technology is allowing drivers to make trustworthy decisions, therefore building an efficient routing protocol that maintains an appropriate level of Quality of Service is a difficult task. Restricted mobility, high vehicle speeds, and continually changing topologies characterize the vehicular network environment. This paper contributes in four ways. First, it introduces adaptive, mobility-aware, and reliable routing protocols. The optimization of two routing protocols which are based on changing nature topologies of the network used for vehicular networks has been performed, amongst them, Optimized Link State Routing (Proactive) and Ad-hoc on Demand Distance Vector (Reactive) are considered for Packet Delivery Ratio (PDR) and throughput. Furthermore, Packet Loss Ratio (PLR), and end-to-end (E2E) delay parameters have also been calculated. Second, a healthcare vehicle system architecture for elderly patients is proposed. Third, a Platoon-based System model for routing protocols in VANET is proposed. Fourth, a dynamic channel model has been proposed for the vehicle to vehicle communication using IEEE8011.p. To optimize the QoS, the experimental setup is conducted in a discrete Network Simulator (NS-3) environment. The results reveal that the AODV routing protocol gives better performance for PDR as well as for

PLR and the communication link established is also reliable for throughput. Where OLSR produces a large average delay. The adoptive mobility-aware routing protocols are potential candidates for providing Intelligent Transportation Systems with acceptable mobility, high reliability, high PDR, low PLR, and low E2E delay.

Keywords: healthcare vehicles; ambulance; mobility-aware; reliable; routing protocol

1. Introduction

Due to the high speed of 60-120 Km/h in healthcare vehicles such as ambulances the key issues to be monitored efficiently and optimally are mobility and reliability while exchanging the routing data among ambulances and from ambulances to hospitals. In the later past, government specialists and other security authorities counting distinctive car organizations have appeared sharp intrigued concerning the advancement within the security application for shrewd transportation frameworks [1,2]. They pointed to lessening the effect of roadside mishaps and defining approaches to diminish the injuries and fatalities made by the mischances. Road accidents are thought to be one of the most serious possible hazards to public safety around the globe; as a result, the safety of people has been a primary consideration for transportation shareholders [3]. Governments, regulators, and other security officials, notable representatives from various automobile businesses, have shown a significant role in developing the safety application for intelligent transportation systems in recent [4]. They attempted to lessen the impact of roadside accidents by developing policies to reduce the number of fatalities and injuries caused by them. Drivers' lack of experience, as well as their lack of awareness of reaction time to road hazards, are two major roadside safety challenges.

As discussed in [5] in the year 2014, there were around 25,700 deaths in the EU, corresponding to 51 million people. Both time and resources are wasted due to road congestion. It is reported in [6] that if vehicles on roads are connected in such a way they maintain a certain fixed intervehicle distance also called platoon pattern of connected vehicles, could bring a reduction in road traffic accidents to a great extent. The intelligent transportation system's adoption of a platoon-based structure, rather than driving the automobiles in individual patterns, solve road capacity problem, and fuel efficiency can be optimized. It can also achieve maximum road traffic safety for Vehicular Ad-hoc networks (VANET) [7,8]. Because of the rapid movement of vehicles, the topology changes in proportion to their speed; as a result, reliable and efficient routing protocols are necessary to ensure the correct transmission and reception of messages. The problem observed due to the frequently changing topology and increased speed level of vehicles can be solved by optimizing the performance of routing protocols for vehicular networks [9]. Dedicated Short Range (DSRC) is the potential technical advancement for vehicle to vehicle communication, is an emerging concept based on IEEE 802.11p protocol, which has recently received a great deal of attention [10]. Inter-car safety communication solutions typically impose strict real-time broadcasting requirements to ensure that in a catastrophe, automated vehicles have adequate time to take action [11,12]. To deal with the fast mobility of vehicles number of routing protocols have been discussed, amongst such protocols are the AODV and OLSR discussed and their performance has been optimized.

In this paper, the contribution has been brought in four distinct ways.

First, QoS optimization is proposed using adaptive mobility-aware and reliable routing protocols in healthcare vehicles.

1. Second, a reliable architecture of healthcare vehicles is proposed using an Ambulance-based Remote Primary Care System for the Elderly and Toddlers
2. Third, Modelling of Platooning System is proposed to implement a reliable Ambulance-based Remote Primary Care System for the Elderly and Toddlers.
3. Fourth, a dynamic channel model for healthcare vehicles is proposed considering the increased mobility of fleet of healthcare vehicles.

The following is how the remainder of the article is organized as follows. A detailed literature is presented in Section 2, architecture for healthcare vehicular systems for aged people as well as for infants has been proposed in Section 3. Mobility-aware routing protocols are presented in Section 4. Experimental results and discussion are revealed in Section 5. Lastly, conclusion is presented in Section 6.

2. Related works

In this section, the relevant past work has been discussed for various issues incurred in the routing protocols utilized in V2V Communication. The topology-based mobility-aware OLSR and AODV network routing algorithms are discussed in this paper. In [13] Performance of three routing protocols has been examined, results explain that for different network sizes and varied speeds (pause time) DSR routing protocol provides enhanced performance for packet delivery ratio. When compared with other routing protocols which include AODV, DSDV, and OLSR, which makes DSR protocol better option to be used in high mobility conditions of highly mobile random networks. The authors also agreed that for a large size of network OLSR protocol provides better results for PDR and throughput. The simulations were performed in NS2 simulator. In [14] authors have examined the impact of routing protocols for different propagation models for MANET, which shows no significant effect of radio propagation in MANET. Two different routing protocols are compared, AODV and DSDV. Packet delivery ratio, throughput, and end-to-end delay are computed based on different propagation models. It is concluded that the AODV routing protocol provides improved throughput for all propagation models, whereas Friis and two ray ground models help to increase PDR level and delay is decreased and throughput drops when the Nakagami model is utilized. The authors have noticed the substantial impact because of variation in the propagation model which is usually excluded by other authors. The results show DSDV gives better performance in terms of PDR under the Nakagami model. AODV delivers the best throughput and PDR regardless of the propagation model employed, and gives a considerably greater PDR level if Friis and Two Ray Ground models are employed, but causes more delay than its counterpart DSDV, and delays are enhanced when using the Nakagami model. The authors argue that when compared to the Two-ray propagation loss model, AODV is a more practical routing protocol that can also aid to reduce end-to-end delay. When paired with the Nakagami propagation model, which has a higher PDR and lower delay, the DSDV routing protocol works best. In [15] OLSR and AODV have been the focus of the article. For the low density of vehicles, AODV provides better performance whereas for the high-density traffic scenario OLSR works well. The system uses 10 Basic safety messages to transmit information from one vehicle to another. AODV protocol provides better performance in terms of goodput for the vehicle speeds 10K/m and 20K/m but when the speed of vehicles is increased to 30K/m OLSR gives better performance for goodput than AODV. Whereas the AODV protocol provides better performance for packet delivery ratio for BSM when compared with DSDV and OLSR but when the density of vehicles is increased to 205 OLSR outperforms all other protocols. In [16] routing protocols are studied and their performance for different network sizes and network loads have been compared for the parameters including PDR average end delay and throughput. Keeping in view, the network load parameter, the DSR routing protocol provides better performance, its PDR and PLR along with throughput show consistency in performance, whereas the DSDV protocol has better results for the same parameters for various sizes of the network. In [17] several routing protocols for mobile ad-hoc networks were evaluated and compared. Parameters used for comparison include PDR, delay for packet transmission, PLR and throughput. The findings show that the OLSR routing protocol performs better for the increased number of nodes, which is reduced for AODV and OLSR for the increased density of vehicular nodes. In [18] Quality of Service (QoS) performance of different routing protocols which include AODV, DSR and DSDV have been evaluated for the MANET environment using different parameters such as nodes size, data rates, and the velocity of nodes. The results obtained explain that the AODV protocol outperforms in a mobile ad hoc networking scenario. In [19] for a VANET environment, routing protocols based on network topologies which include AODV, DSR, and DSDV routing protocols are discussed and their performance is measured using various indicators such as delivery ratio, PDR. Throughput and Loss Ratio. The key observation of the paper is the implementation of realistic vehicular traffic. When used in large-scale ad-hoc networks, the AODV protocol responds substantially faster and performs much better in the event of a connection loss. In [20] a comparison of VANET based routing protocols include AODV, DSDV, and DSR is being carried out. Simulations are performed for calculating different parameters such as throughput, PDR, and end-to-end delay. These findings revealed that the DSR routing protocol provides substantial throughput, on the other hand, the DSDV protocol shows improved performance for the average end delay, while AODV provides the highest throughput amongst all protocols. In [21] a survey has been conducted for analyzing different classes of routing protocols including AODV, DSDV & OLSR in vehicle-to-vehicle communication scenarios. The quality of service has been evaluated based on PLR, packet overhead, and throughput, and it has been determined that AODV performs in more ways than all other protocols. In [22] with 50 nodes moving at random order in a mobile ad-hoc network scenario, the performance has been evaluated for AODV and OLSR routing protocols for multiple parameters such as throughput, packet delivery ratio, energy expenditure, and latency. It is established that, regardless of the speed, OLSR performs better in all aspects. In [23] a safety application scenario is considered, and the findings show that, even with the least maximum delay, OLSR does not distribute packets to its neighboring nodes promptly, whereas AODV performs better for a limited number of vehicles. The DSDV routing protocol, which was used in the MANETs scenario, was discovered to be better suited to safety applications. In [24–26]work is based on a discrete queuing model given as M/G/1, it is considered for safety messages, the broadcast mechanism is based on IEEE 802.11, which ignores the saturation criterion, which does not apply to other applications of a similar nature in vehicular communication. A recursive algorithm and a probability-generating function are used to arrive at a solution. PDR, throughput, and packet delay are just a few of the performance indicators they have considered for said broadcast service. The proposed analytical model achieves DSRC latency requirements for a typical environment utilizing a broadcast network directly. Due to message collisions, this method does not guarantee the reliability, but the results are close to simulations. Enhanced packet arrival rates improve throughput, but at the expense of PDR and loss ratio. It has also been observed that a larger bakeoff window and smaller message sizes improve the reliability of broadcast messages Table 1 discussed the features of the existing works and our contributions is compared too.

Table 1. Comparison of existing related work.

Reference	Model	Key Metrics	Main contributions
[2]	Vehicle to RSU	mobility, reliability, and packet loss ratio	A novel reliable and efficient multi-layer fog driven inter-vehicular framework.
[6]	Vehicle to Vehicle	parameterized trajectories	string-stable vehicle-following at very short inter-vehicle distances
[7]	Vehicle to Vehicle	optimal speed control to Connected vehicles	A hypothesis was then made that there shall exist a critical CV penetration rate that can significantly show the benefit of CV to the overall traffic. To prove this concept, this study simulated the mixed traffic pattern under various conditions.
[8]	Vehicle to Vehicle	Performance of a platoon in terms of road capacity, safety, energy efficiency	Analysis of a platoon-based vehicular cyber-physical system (VCPS)
[11]	Vehicle to Vehicle	VANET safety applications and by VANET user applications simultaneously.	The solution to all of these issues probably requires integrating smart mechanisms into more than one layer. This presentation followed the open system interconnection (OSI) reference model.
[13]	Vehicle to Vehicle	Quality of service (QoS)	Manhattan Grid mobility model have been successfully created using Bonnmotion using NS-2 software but with the help of several lines of code were imported to the NS-3 soft.
[14]	Vehicle to Vehicle	Quality of service (QoS), delay, throughput, control overhead and packet delivery ratio	Performance analysis is carried out on Adhoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) protocols using NS2 simulator
[15]	Vehicle to Vehicle	Typical performance metrics are used, which are packet delivery ratio, end-to-end delay and throughput using NS-3 simulator.	Investigate the impact of simulating MANET routing protocols with using various propagation model.
[21]	Vehicle to Vehicle	Throughput, packet delivery ratio, and end- to- end delay	Performance analysis of AODV protocol, DSDV protocol, and DSR protocol The results showed the DSR is much higher than AODV and DSDV, In terms of throughput.
Our Work	Vehicle to Vehicle	Packet Loss Ratio (PLR), Throughput and end-to-end (E2E) delay parameters	Novel Platoon-based System model for mobility-aware routing protocols for Healthcare

In this work, a fleet of vehicles are organized in platoons, and the performance evaluation is based on different parameters of quality of services such as Packet Delivery Ratio (PDR), Packet Loss Ratio (PLR), and throughput. The latency of the vehicular health system is obtained through average end-to-end delay. The proposed work is focused on vehicle density with the environment in an urban, suburban, and rural setting. The message packet size is 256 bytes, with an 8kbps data rate. The vehicle speed is maintained at 20 m/sec, and the distance between vehicles is believed to be constant throughout the voyage. Each vehicle in the fleet sends out non-safety messages regularly with a set frequency and payload size. The proposed research also contains simulations that evaluate proactive and reactive routing algorithms for non-safety applications, covering AODV and OLSR protocols. In the next section, the methodology of the proposed system is carried out. In the first, the system model with mathematical design is discussed after those protocols used in developing the system model is discussed in addition, channel characteristics and performance analysis attributes are discussed in detail.

3. System architecture of healthcare vehicles for elderly and infants

We propose the Remote Medical Education System (RMES) is a framework that allows the elderly and newborns to have easy and quick access to medical care at any time. Our proposed framework consists of healthcare ambulances attached with a video camera to capture the images of patients who are in a gravely ill condition, the captured images are immediately forwarded to a highly professional physician for detailed diagnosis. A physician can determine the serious and concerning state of newborns and diabetes patients based on their injuries when he or she has a video or image, especially on the palms of their hands and the soles of their feet (particularly aged people with diabetics), and face color of newborn toddlers and reactions of both aged patients and newborn babies and doctor prepares quick and effective treatment for patients as soon as they reach to the hospital. Simultaneously, the medical practitioner dispatches the medical report to nursing staff available at the patient's home at a remote location with help of recorded images and provides proper consultation for prescribed treatment dose, food to paramedical staff. Figure 1 describes the scenario for emergency medical care using video images of aged people and toddles in far-flung areas where specialize medical facilities are not available.

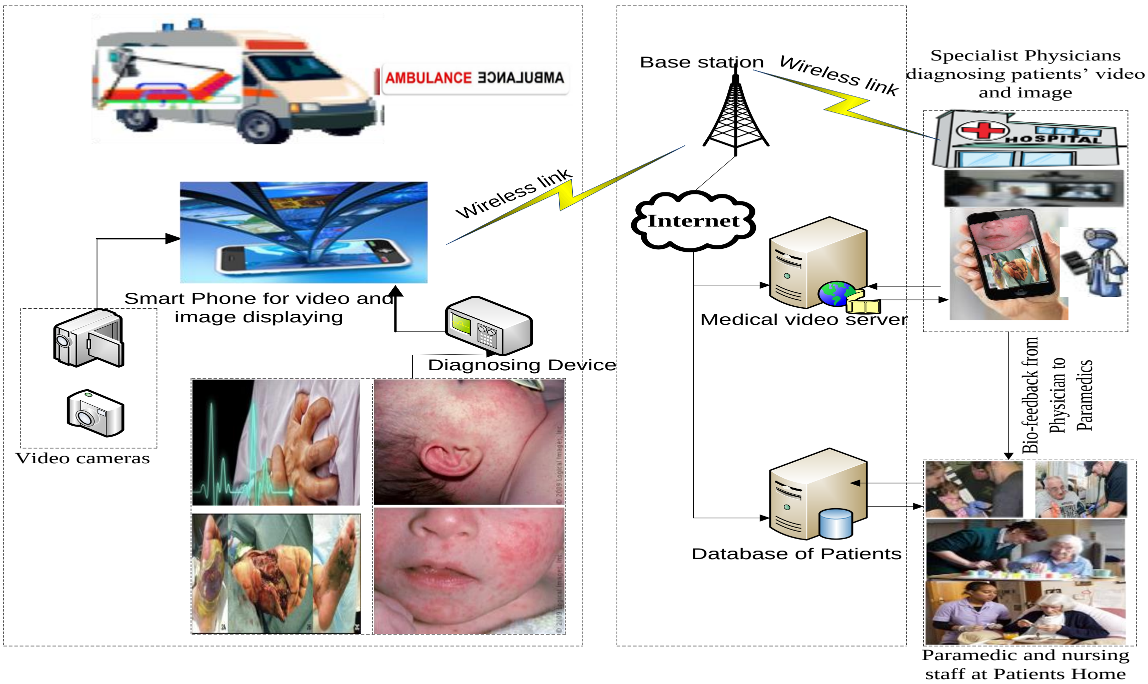

Figure 1. Proposed Ambulance-based Remote Primary Care System for the Elderly and Toddlers. The battery life of such mobile devices is crucial for the rapid and continuous transmission of video images of patients' critical states from specialists to patients on

handheld devices, and vice versa. The shorter battery life of the mobile devices presents a critical problem; therefore, we propose mobility-aware and reliable algorithms to make these mobile gadgets last longer for video transmission in ambulances.

4. Proposed adaptive mobility-aware and reliable routing protocols

This section proposes two different adaptive mobility-aware and reliable routing protocols for VANETs. In addition, systems model, platoon-based scenarios, and dynamic channel models are proposed for QoS optimization in VANETs.

4.1. System model

In this work, a platoon-based scenario has been considered to test the performance of transmission messages for V2V communication. The vehicles are arranged in the pattern as shown in Figure 2.

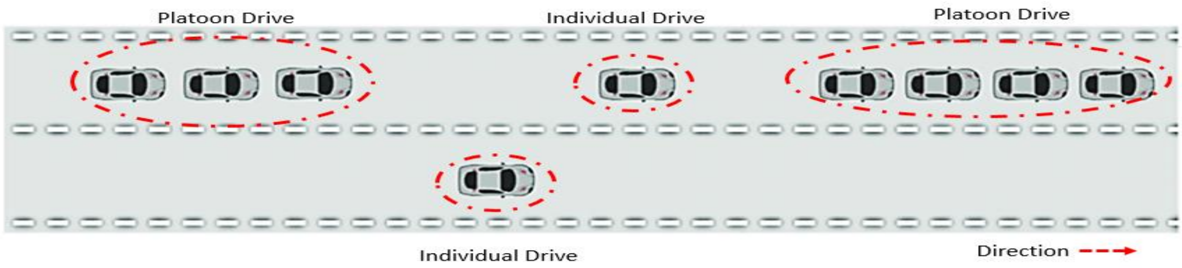

Figure 2. Platoon pattern of vehicles.

In the platoon-based scenario, the vehicles exchange messages are arranged in such a way that one vehicle is acting as the leader vehicle in the platoon, and the rest of the vehicles are following the leading vehicular behavior that inter distance of all the vehicles arranged in the platoon manner has been kept same as of the leading vehicle, the speed of all vehicles is also constant. The reason to select the above platoon scenario it will enhance the traffic flow throughput and will save the fuel consumption of vehicles. The above platoon-based scenario is mathematically modeled as depicted in Figure 3.

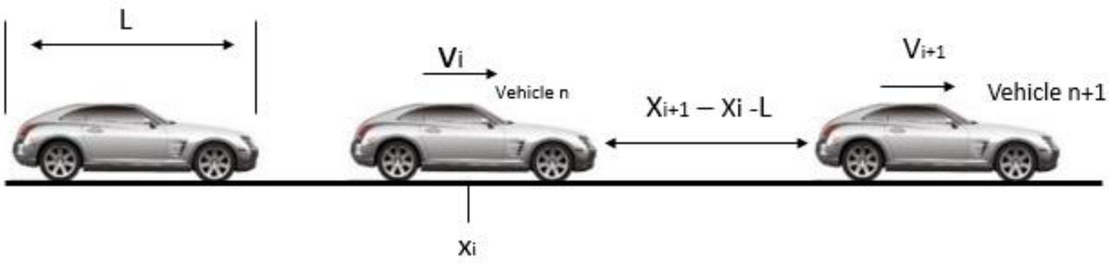

Figure 3. Mathematical model of vehicular behavior in platoon scenario.

The platoon vehicular behavior is defined in such a way that driver is assumed to following his leading vehicle by maintaining the relative speed and space ahead. The relative speed and space ahead are calculated as shown in eq.1 [27].

$$\frac{dx_i}{dt} = v_i \tag{1}$$

Where x_i the initial position of the vehicle is platoon and v_i is the velocity of initial speed as illustrated in eq. 2 [27].

$$\frac{dv_i}{dt} = a_n = f(v_i, S_i, \Delta v_i) \tag{2}$$

Where Spaceahead , S_i has been attained using Eq. 3 and relative speed Δv_i is illustrated using eq.4 [25].

$$S_n = v_{i+1} - x_i - L \tag{3}$$

$$\Delta v_i = v_i - , v_{i+1} \tag{4}$$

It is assumed that there are N cars on the route, and M ≤ N platoons, with each platoon consisting of K_o O = 1, 2 etc. where K_o represent the fleet of vehicles connected in a platoon manner. Here, it's vital to note, a vehicular system based on platoons is complicated and nonlinear by nature, due to a variety of factors like engine, rolling, and brake variations. To have better modeling of the entire V2V platoon vehicular system, there are some assumptions that are considered in developing the model. These are defined as platoon vehicle formation is performed by the vehicles exhibiting the same dynamics, all fleet of vehicles are moving in a single straight line without taking any lane shifting maneuvering in the urban highway scenario lastly speed of all vehicles has been kept constant. These assumptions are used in developing the nonlinear platoon vehicular system of second-order as shown in eq. (5) [27].

$$\begin{cases} {y_{bc,k}}^{K_o}(t) = z_{bc,k}^{K_o}(t) \\ {y_{bc,k}}^{K_o}(t) = w_{bc,k}^{K_o}(t) + x_{bc,k}^{K_o}(t)({y_{bc,k}}^{K_o}(t), z_{bc,k}^{K_o}(t), t) \end{cases} \tag{5}$$

Where, ${y_{bc,k}}^{K_o}(t), z_{bc,k}^{K_o}(t)$ defines the position and velocity of the platoon vehicular system and $x_{bc,k}^{K_o}(t)({y_{bc,k}}^{K_o}(t), z_{bc,k}^{K_o}(t), t)$ is the nonlinear aspect of models vehicle characteristics. Vehicle systems based on platoons are depicted in Figure 4.

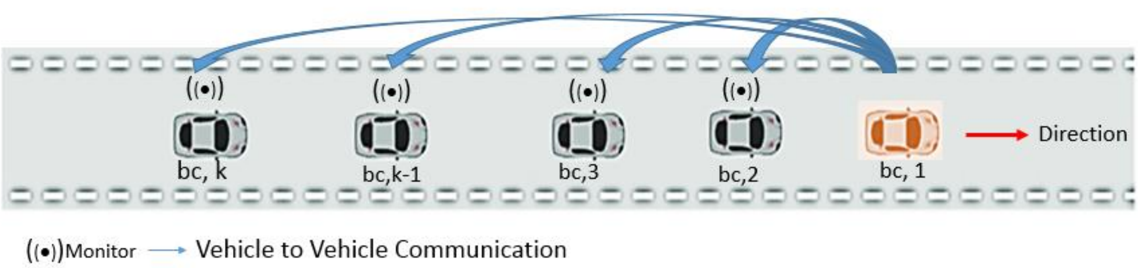

Figure 4. The system design based on Platoon pattern of connected vehicles [27].

Platoon-based vehicular systems are represented in a real-time two-way highway scenario, which necessitates the development of routing protocols and networking interfacing protocols. The above-mentioned aspect of platoon-based vehicle systems will be examined next.

4.2. Platoon-based vehicular system for routing protocols

Single lane highway scenario using IEEE 802.11p based on MAC layer protocols is proposed which consists of evenly distributed ambulances. We have considered two different layer routing protocols which include AODV and OLSR. The network's channel characteristics cause data packet losses in the channel, as a result, we took into account both path loss combined with fading and shadowing models, nodes are highly mobile, and routing remains always issue in this scenario. In the past many routing protocols were discussed in various scenarios, the main issue with these routing protocols are QoS, traffic load in-network, and mobility. For this work, the AOVD and OSLR protocols are adopted and performance is improved.

4.3. Channel characteristics

To design healthcare vehicles i.e., ambulances for vehicle-to-vehicle communication the channel plays a vital role. Multiple propagation factors such as path loss, shadowing, and fading are to be considered. The signal strength of the transmitted signal propagated across the wireless channel is affected by these parameters. The channel model used in our work is briefly described in this section of the paper which is Frii's free space propagation [27]. Frii's Free Space propagation loss model was used in our simulation. The received power and path loss are calculated using Friis' model by the eq. (6) [27].

$$P_r = P_T \frac{G_t G_r \lambda^2}{(4\pi)^2 D^n L} \tag{6}$$

Whereas P_r is received power and P_T is transmitting power, the gain of the transmitter antenna is denoted by G_t, receiver antenna gain is represented by G_r and L is called loss not related to propagation, n is the value of path lose exponent for the range in the environment, and λ is band frequency. The eq. (6) can be represented in terms of propagation path loss that is illustrated using eq. (7) [28].

$$P_L = 20 \log_{10} \frac{4\pi D}{\lambda} \tag{7}$$

The received power is illustrated in a range of environments that is defined using eq. (8) [29].

$$P_r(dbm) = P_t(dbm) + G_t(dbi) + G_r(dbi) - 20 \log_{10} \frac{4\pi D}{\lambda} - 10 \log_{10} L \tag{8}$$

After attaining the propagation model, the next step is to characterize the model with fading effect. We employ the Nakagami fading model in this research since the relevant instantaneous power follows a gamma distribution. Nakagami fading model is applied with a 1 m-shape factor parameter, which follows gamma probability and w-value of 2 is used, its function is given in eq. (9) [28]

$$PDF = \frac{2m^m x^{2m-1}}{w^m r(m)} e^{\left[\frac{mx^2}{w}\right]}, x \geq 0 \tag{9}$$

Whereby, the term "r" represents received signal amplitude where the shape parameter is represented by "m" and "w" is considered as scale parameter. The proposed model discussed above is analyzed using performance attributes, i.e., PDR, PLR, throughput, as well as average delay.

4.4. Optimized Link State Routing (OLSR) protocol

The working principle of OLSR routing protocol has been demonstrated in Figure 5. The algorithm from the routing table checks the route from source to destination as a first step. If information about a route cannot be obtained, the source node sends a broadcast message to all available routes [29,30]. It's a proactive routing protocol that uses pre-existing pathways. Hop by hop, the packet is transmitted. Multi-Point Relay (MRP) is used to transfer network topology information to its neighboring nodes on a regular interval. One of the important functions of MRP, is mobility management of vehicles used in the fleet by determining the shortest paths among the nodes. MPR selection procedure is performed by each node in its one hop neighborhood [31]. Because each node has two-hop neighbor node, it must select a small number of nodes in its immediate vicinity., each MPR transmits to each two-hop neighbor node, thus, reducing control overhead as well as decreasing control signals [32]. Each node transmits a message called HELLO message to the nodes in its immediate vicinity, updating link status periodically. This message has three node lists: the first list contains the addresses of nodes that have issued HELLO packets, the second list contains the addresses of neighbor nodes, and the third list contains the addresses of multipoint relay nodes. The connection between source and destination is established by sending the HELLO message, which indicates that the source is ready to send packets [33,34]. When a node gets a route reply message it starts sending data packets to the reciever end. If the connection is failed at any node, the alternate paths are updated through TC control signals for updating the entire network.

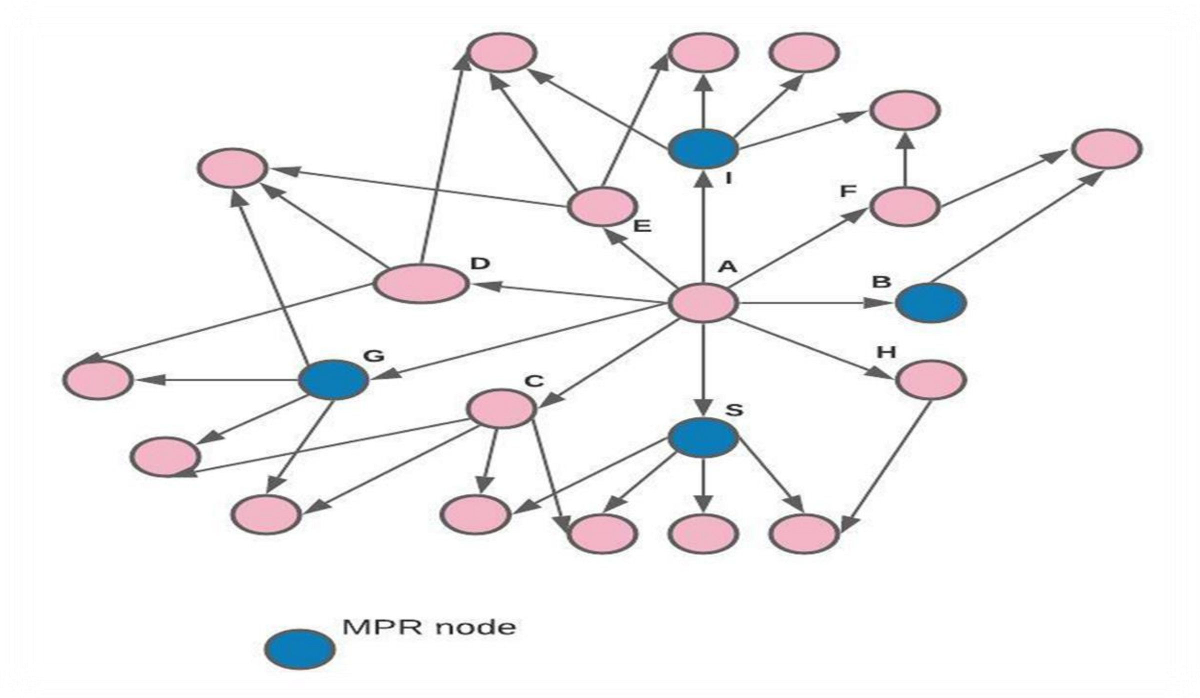

Figure 5. Multipoint Relay used in OLSR routing protocol.

The functionality of Multipoint Relay is shown in Figure 6, where HELLO message is broadcasted by each node to sense the link. The HELLO message contains the address of the node itself and the neighboring node. Each node present in the network gets information from its two neighboring nodes.

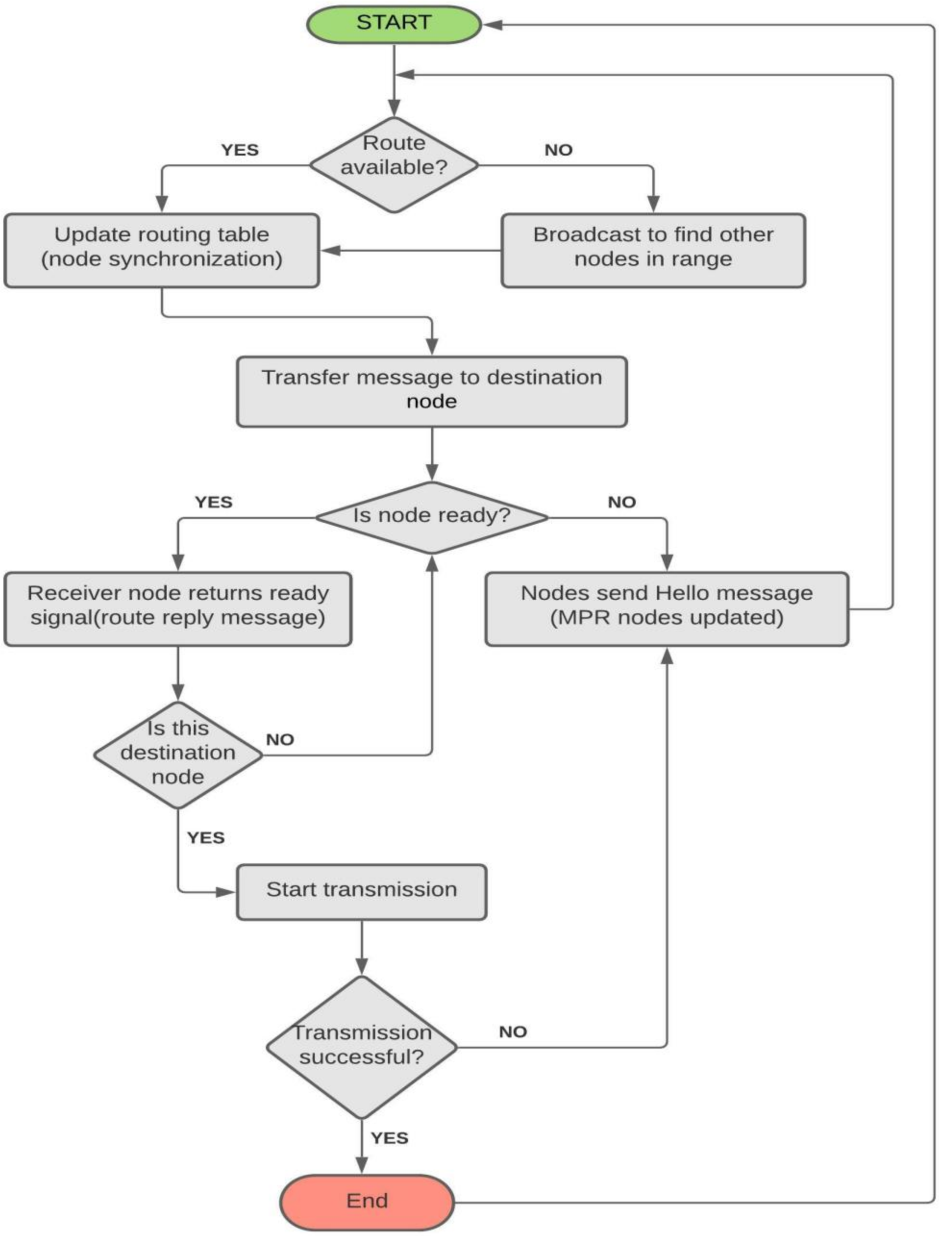

Figure 6. Message formation and Processing using OLSR Protocol.

4.5. Ad-hoc On-demand Distance Vector (AODV)

AODV routing protocol is also classified as a reactive routing protocol that established the path among the vehicle node only if desired. Routes for sending data packets are created only when the request is received, rather than being determined in advance. It can be applied in either unicast or multicast types of traffic. For route finding, control messages are employed. When a node needs to transfer data, an RREQ request from the source vehicle node is sent to the destination of the vehicle node. The RREQ message signal is the combination of both source and destination IP and it is tsent in form of a control message signal. A nearby node responds with a unicast message when it gets an RREQ message that includes hop count, source and destination sequence numbers, and IP address. When a link fails, a RERR signal is generated, which includes information about the inaccessible destination sequence number.

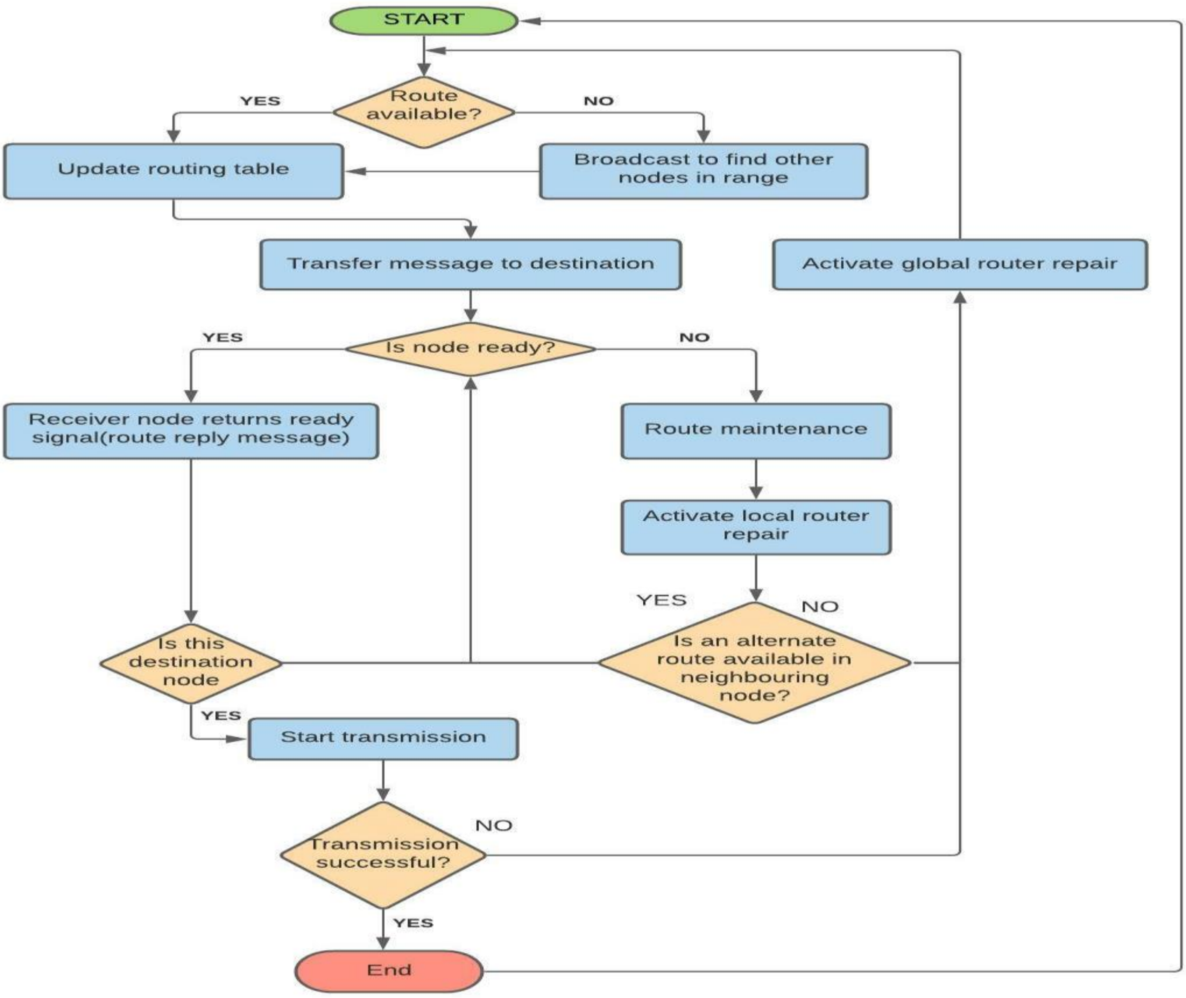

Figure 7. Message formation and Processing using AOVD Protocol.

AODV routing protocol falls in the category of reactive protocol working in a distributed manner as shown in Figure 7. It does not store information about nodes in its routing table in advance like its counterpart protocol [28]. It only stores information on one or two routes recently used. Nearby nodes are detected by periodically transmitting beacon signals, and loops are avoided via hop-by-hop routing. A route discovery technique is begun by a node using a route request message whenever it needs to distribute packets in a network. When there is no activity for a particular amount of time, AODV utilizes the HELLO message to remove the route from the routing database, which is signaled by a time-out message. A route error signal RERR is issued for error packet broadcasting in the event of a link failure. A distributed environment is demonstrated in Figure 7, for working on the AODV routing protocol. It does not, like its counterpart protocol, retain information about nodes in advance in its routing table [28]. It merely keeps track of one or two recent routes. To avoid loop-free routing, the protocol uses periodic beacon signals to determine the identity of neighbor nodes, and the route is calculated hop-by-hop using sequence numbers. Whenever a node requires a new data packet to be sent in-network, it is sent through the route discovery technique by sending a route request which consists of source and destination node addresses, the node discovery request also includes a destination sequence number, hop count, and broadcast ID, are part RREQ message. In a route discovery process, two connection points are established at the intermediate node across transmission and receiving nodes. Reactive type protocol takes time to find new routes in case of link failure. The process adopted for transmitting packets is shown in the flow chart, in case of a link missing the message is generated for the global route repairing process from the source node.

In the next, the designed system is evaluated based on performance attributes such as PDR, PLR, throhghput, and end-to-end delay.

5. Experimental results and discussion

This work is conducted through simulations performed in a discrete network simulator platform NS-3 which is installed on Linux operating system. From the conFigureuration point, selection of the type of routing protocol, number of packets, node density, and some other parameters including speed of ambulance node is being controlled by the routing helper, it also controls inter-vehicular distance and type of mobility model used for this system. Vanetclass was used to govern the overall program structure. Three distinct network sizes were explored in the simulation, with vehicle numbers ranging from 15,30, and 45. All the fleet of vehicles moves in a platoon manner which is shown in NS-3 diagram in Figure 8.

Figure 8. Vehicles are joined in a platoon pattern in NS-3.

To generate routing traffic, the two routing protocols employed in this research are used; each unit of nodes inside the fleet generates one to two messages per second. The data rate for message transmission is kept at 8 kbps whereas packet size is fixed at 256 bytes. To examine the behavior of routing protocols, the Friis propagation loss model is combined with Nakagami fading and a random waypoint mobility model [36].

The state-of-the-art technique in designing the vehicle platoon for healthcare vehicles is that two protocols are deployed in order to maintain the adaptive mobility in comparison to existing work [37–39]. In [37], the computation resources of individual vehicles are demonstrated for video scenario. The problem is solved using the task offloading scheme by exploiting multi-hop vehicle computation resources, in addition the optimization is performed to minimize the weighted sum of execution time and computation cost of all tasks. The results demonstrate the offloading scheme to bring improvement in response delay. In [38], the work related to the mobility knowledge of predicting the user location and delivery of processed is carried out using spatio-temporal trajectory data. The results attained the reduction in delay in information and power consumption of the mobile device compared to the existing mobility-aware task delegation approach. In [39], the proposed system is based on the solution of V2V communication for local traffic. The main focus of system was on contention factor. This factor classifies the overall congestion level. The solution is considered for the comparison of DIVERT, PANDORA and s-NRR. The results show the network and traffic congestion metrics as performance analysis.

In comparison to that our work that has been discussed in [37–39], the problem nature and its solution is considered to be different. Our work is more challenging in the manner as, first the mathematical model of the vehicle platoon for healthcare vehicles generates the transmission instantly with the mobility-aware routing protocol to address the emergency communication for Primary Care System for the Elderly and Toddlers, and second, the performance analysis of the deployed system is also necessary. The first one solved by two protocols deployed in order to maintain the adaptive mobility and second problem is solved using combined the Friis propagation loss with Nakagami fading and a random waypoint mobility model that will maintain the complete performance analysis of designed novel mathematical model of the vehicle platoon for healthcare using mobility-aware routing protocol for handling the Primary Care System for the Elderly and Toddlers.

It is important to note that in the past, the single type routing protocols were used in the autonomous vehicles, and for the few cases of ambulances. In comparison to that our work proposed the mobility-aware routing protocol approach for Primary Care System for the Elderly and Toddlers for the first time by deployment of two routing protocols at each unit of nodes. This arrangement seems unique as inside to that architecture the designed novel mathematical model of the vehicle platoon for healthcare vehicles generates the transmission instantly due to the mobility-aware routing protocol the data rate seems high with large packet size. In addition, to above novel design, it is also important to analyze the behavior of routing protocols. In the past, this analysis is carried out using either Friis propagation loss model or other models. In comparison to our approach is also novel as we have combined the Friis propagation loss with Nakagami fading and a random waypoint mobility model with maintaining the complete performance analysis of designed novel mathematical model of the vehicle platoon for healthcare using mobility-aware routing protocol for handling the Primary Care System for the Elderly and Toddlers.

In designing the state-of-the-art technique, the parameters selection criteria of the designed system are also challenging. In order to resolve the issues various studies have been referred and after the detailed analysis the baseline methods and parameters of the existing work. The protocols, rate of transmission, packet size, Ambulances density in platoon system, the type of scenario in which ambulances are travelling, Speed at which ambulances are travelling and most important operating system is chosen as the system designed. It is worth to note that the selection of baseline parameters is crucial and in the past it was only considered for general medical conditions but here in our case it is different and situation is more critical in comparison to existing work. In order to showcase some of the main parameters that were used in developing the proposed simulation design for novel mathematical model of the vehicle platoon for healthcare vehicles the Table 2 summarizes the various features, as shown below.

The parameters for the proposed system listed in Table 2 are processed form the massage formation structure and processing using selected routing protocols i.e. OLSR and AOVD. In the next massage formation and processing of discussed algorithm are discussed in detail. To perform vehicle to vehicle communication the protocol used must be reliable to ensure all transmitted messages are correctly delivered at receiving vehicle node. The performance of message transmission and reception is evaluated through different measuring parameters in this work which include PDR and PLR, whereas Throughput and average end delay is also measured. The PDR is set as PDR > 100% for avoiding the overflow of packets as the vehicle should receive packets that are within its range. The PDR is calculated using eq. (10) [29].

$$PDR = \frac{received\ packtes\ (in\ range)}{transmitted\ packets\ (in\ range)} \quad (10)$$

Furthermore, the Packet loss ratio and loss packet is calculated using eq. (11) and (12) respectively [29].

$$LossPackets = TxPackets - RxPackets \quad (11)$$

$$LossRatio = \frac{LossPackets}{TxPackets} \quad (12)$$

Throughput for the scenarios as are calculated as following as in eq. (13) [30].

$$Throughput = \frac{\frac{totalBytesRecieved*8}{1000}}{totalSimTime} \quad (13)$$

Average delay is calculated as in eq. (14) [31].

$$\text{Average delay} = \frac{\text{Time a data packets takes to reach at destined node}}{\text{number of packets transmitted}} \quad (14)$$

The next section discusses the generation of messages from source to destination for both routing protocols, to complete mathematical modeling for V2V communication performance analysis.

Table 2. Simulation details.

Features	Description
Category of protocols	topology-based routing
Protocol used	AODV/OLSR
Transmission rate	8 Kbits/sec
Data packet size	256 bytes
Ambulances density	15 to 45
Environment type	Rural, Suburban, Urban
ambulance Speed	20 m/s
Simulation Time (Run Time)	20 sec
Traffic pattern	Constant Bit Rate (CBR)
Simulation tool	Network Simulator ns-3
Operating system for simulator	Linux

5.1.System performance analysis

Simulations yielded results for two different routing protocols for non-safety traffic generated by the fleet of vehicles: OLSR and AODV. Metrics like PDR, Throughput, PLR, and delay are computed for comparing the performance of both protocols.

5.1.1. Routing message traffic generation

The On/Off Helper library in NS-3 is used to generate routing messages. The duration of a state is determined by random variables called onTime and offTime. There is no traffic generated in off-state mode, however, CBR traffic is generated in onTime mode. A data rate of 8 kbps is employed in the simulation, with a packet size of 256 bytes. The platoon scenario of vehicles is formed using a for loop, in which the first node receives packets from the second node and the second node receives packets from the next available node. To obtain reception of an on-off application generated packet, an on/off trace is used ON/OFF trace has been used for obtaining received packcts which are generated through ON-OFF application of the simulator. IP address "10.0.1.0" is used with port number 80. Flow monitor library is used for calculating metrics used in simulations. After simulation, plots are generated using the completed process output method.

5.1.2. PDR for multiple inter-vehicle distance

Figure 9 indicates the PDR comparison of both OLSR and AOVD routing protocols in V2V scenario. Figure 9(a) represents the PDR for the OLSR protocol and Figure 9(b) depicts PDR for AOVD protocol. PDR is calculated against different distance ranges of vehicles 15, 30, and 45. The graphs show that AODV performance remains consistent until a distance of 500 meters is achieved, whereas OLSR performance rapidly degrades after 350 meters. AODV gives the highest PDR for the shortest distance, which is higher than its counterpart.

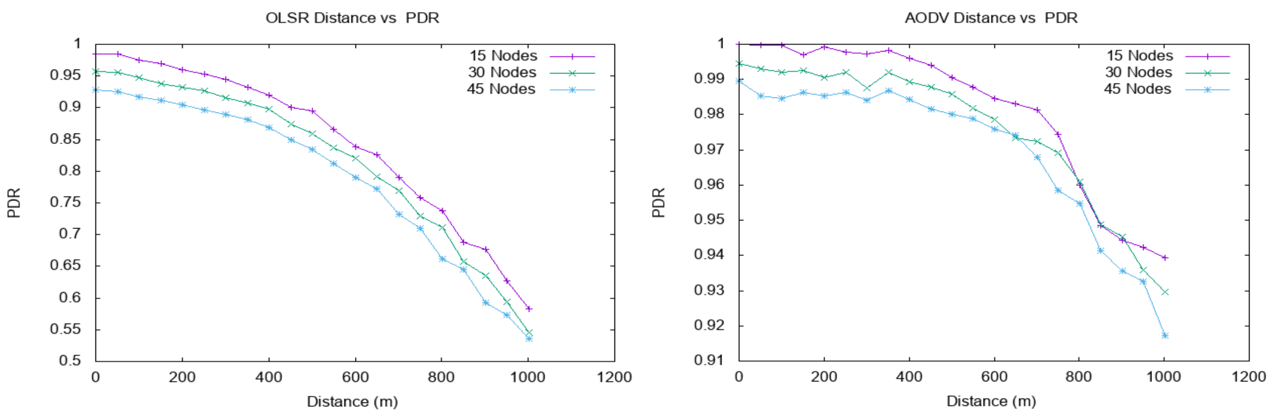

Figure 9. PDR for various nodes (a) (OLSR), (b) AODV.

5.2. Throughput for multiple inter vehicle distance

Throughput performance of both routing protocols is calculated for different healthcare vehicular environment, the number of vehicles considered in the simulation are 15, 30, and 45 for different intervehicle distances using the Nakagami channel distribution and Friis propagation model. The

AODV routing protocol achieves nearly constant throughput for all vehicular environments until intervehicle distances of 800 m are reached, but the OLSR performance drops once distances of 200 m are reached. Figure.10 illustrates the throughput based on different nodes. Figure 10(a) defines the performance for OLSR and Figure 10(b) for AODV.

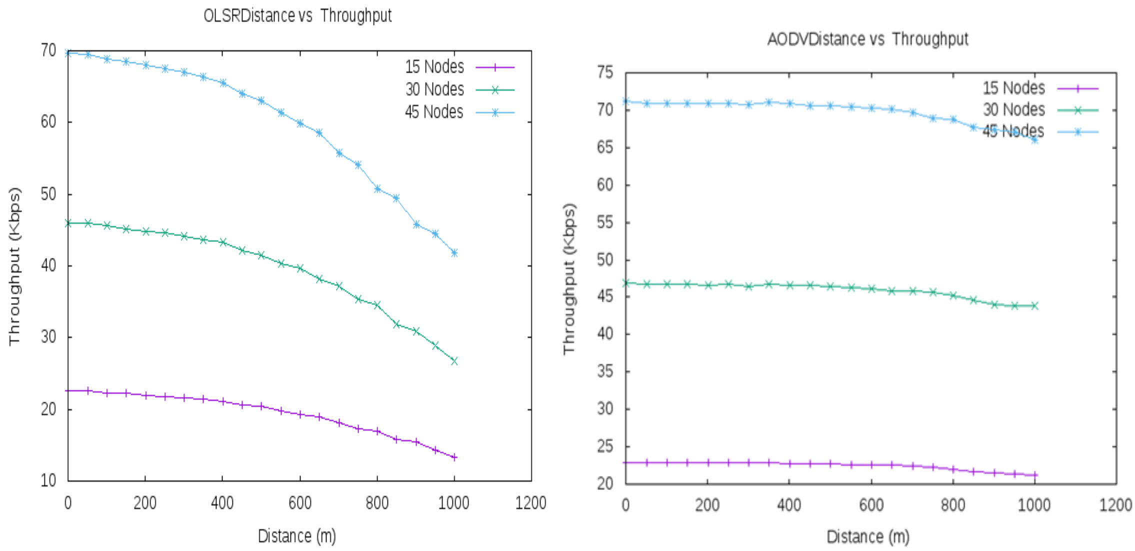

Figure 10. Throughput for various nodes a. (OLSR) and b. (AODV).

5.2.1. PLR for multiple intervehicle distances

PLR is calculated for different intervehicle distances of different network sizes (15, 30, and 45) and is defined as the ratio of transmitted packets to received packets. Figure 11(a) shows the performance for OLSR, and Figure 11(b) shows the response for AODV protocol. Because CSMA/CA is inherently supported limited number of channels that are assigned for transmission, therefore, traffic congestion increases, and the loss ratio of AODV for denser network sizes of 45 starts to decrease rapidly beyond 800 m. However, because OLSR is a more unstable routing protocol, its loss ratio increases significantly as the intervehicle distances increases for all network sizes. The constant degradation performance of the OLSR routing protocol is due to routing loop problems that are observed due to changes in interface state therefore routing table is adjusted manually hence increasing the delay to find alternate routes for transmission.

5.2.2. Average end-to-end delay

It is the total time duration a data packet takes from its source to reach its destination node. It is depicted in Figure 12 for different nodes, where Figure 12(a) shows the performance for OLSR, and Figure 12(b) shows the response for AODV protocol. Due to its proactive nature, OLSR outperforms its counterpart routing protocol AODV in terms of delay. It takes less time for OLSR to find the route of transmitting packets because it has already maintained its routing table where paths for packet transmission are already known, whereas AODV has no path defined and finds it when requested, as shown in the graphs. The graph shows that when the OLSR routing protocol receives a request, it takes less time to establish a connection with vehicle nodes. In the event of a densely populated vehicle environment.

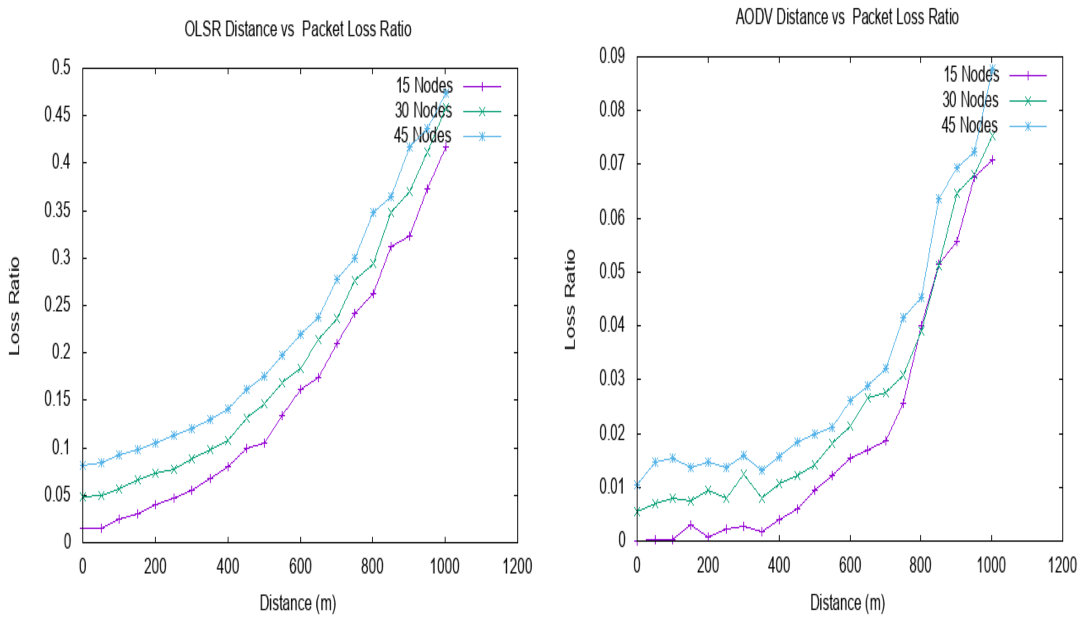

Figure 11. PLR for different nodes a. (OLSR) and b. (AODV).

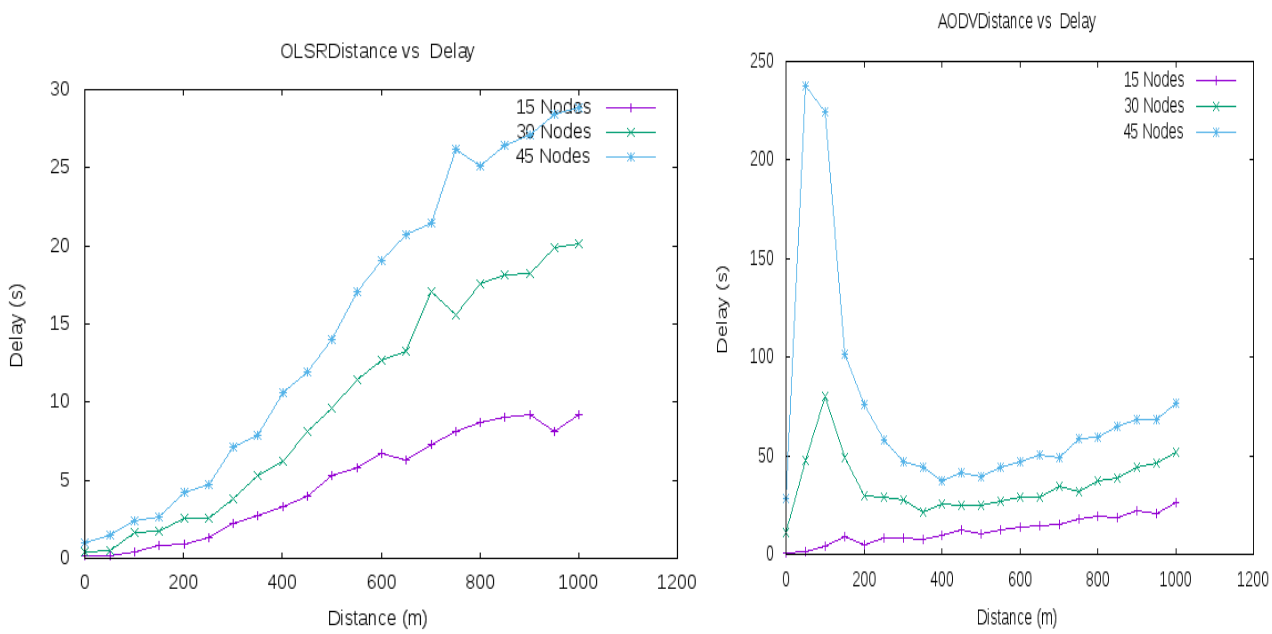

Figure 12. Average E2E Delay a. (OLSR) and b. (AODV).

6. Conclusion and future work

Because of the fast speed, (60–120 km/h), mobility and reliability in healthcare vehicles such as ambulances are crucial entities to be monitored. Furthermore, adaptive and intelligent routing protocols must be created for effective and proper communication and content distribution among vehicles and from vehicle to hospital. Thus, VANET routing protocols used for vehicle to vehilce communication are studied in detail in this paper. For a fleet of vehicles operating in a platoon pattern, the behavior of routing protocols is monitored. Random waypoint mobility models are used in conjunction with the Nakagami fading model and the Friis propagation loss model. The research concentrates on non-safety applications in a vehicular setting. For two protocols, proactive OLSR and reactive AODV, NS-3 is used to run all the simulations. PDR, Throughput, and PLR are the key parameters that have been set to analyze the behavior and performance of routing protocols with various network sizes, whereas to check the latency of the system for a total distance of 1200 m, average end to end delay is calculated. As per simulation results, it is evident that AODV routing protocol provides improved performance and its delivery of packets is better than its counterpart, more data packets are delivered at the destination and improved perfroamce in terms of PLR. If compared in terms of throughput parameter AODV has improved performance but in the case of average end-to-end delay OLSR emerges as the better option.

In the near future, an efficient and adaptive channel modeling for reliable multimedia transmission in 5G healthcare networks will be suggested, and for safety application in vehicular healthcare more improved power control algorithm will be introduced with enhanced energy efficiency.

Conflict of interest

The authors declare there is no conflicts of interest.

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