VAWKUM Transactions on Computer Sciences
http://vfast.org/journals/index.php/VTCS@ 2024, ISSN(e): 2308-8168, ISSN(p): 2411-6335
Volume 12, Number 2, July-December 2024 pp:137-148

Distance and energy aware DEAODV routing protocol in disastrous situation

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Keywords: *AODV, MANET, NS-2, distance aware routing , disastrous situation*

Journal Info:
Submitted:
November 08, 2024
Accepted:
November 17, 2024
Published:
November 21, 2024

Abstract
In the disastrous or emergency situation a reliable and robust ad hoc mobile network communication is important. The natural disaster when occurs in the urban populated areas which damage Information technology infrastructure and other valuable assets within a movement. In such emergency situation when the disaster victims stuck in debris, lifesaving of people are important. The purpose of this study is to enhance lifetime and improve network performance when the lives of disaster victims are matters. Distance and Energy aware AODV (DEAODV) reactive routing protocol enhance the network performance and ensure the reliable data transmission during crisis situation. The DEAODV reactive routing protocol considered node Energy and shortest distance as a routing metrics during route decision process. DEAODV routing protocol is compared with traditional AODV routing protocol to evaluate the performance of network. The proposed routing protocol is more efficient in emergency situation than AODV in terms of Packet Delivery Ratio, End to End Delay and Consumed Energy.

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DOI: 10.21015/vtcs.v12i2.1977

1 Introduction
A disaster is a bad event or critical situation which may occur at any time. When natural disaster such as earth quake, Flood, Tsunami and Tornado hits some urban area of city, a high rising residential, commercial buildings and other infrastructure have been suddenly collapsed, which cause a completely or partially disturbances in routine work [1].

In disastrous situation the role of Governmental and Non-Governmental Organizations are rushed to the disaster site and control the law and order situations. Relief and rescue operation for the disaster victims has been started by the skilled workers under the supervision of their respective departments to save the lives of people and reduces infrastructure and property losses. The evacuation process of disaster victims and save their movable assets from the debris are challengeable task.

The main role of governmental agencies is used to provide medical first aid, shelters and fresh drinking water to the victims. In emergency situations first responders use latest technology such as information technology, information security, IoT and mobile ad hoc network to handle the emergency situation within limited time frame [2]. The deployment of mobile ad hoc network (MANET) in disastrous situation is the best choice. The first responders are equipped with mobile nodes and some other necessary tools, they share voice, videos, images and some other textual material with their concerned supervisors about the actual picture of disaster losses. A MANET do not used infrastructure and may easily be deployed at the disaster site to handle emergency situation. Mobile node received and transmit emergency related information and act a router [3].

To discover a feasible route from source to destination, MANET usually uses routing protocols. Reactive and proactive routing protocol routes the data packet from source to destination. AODV routing protocol produces good results in large network [4]. AODV reactive routing protocol used to discover routes when required. During the route discovery process routing protocols are allowed each mobile node to participate and share packet information to other neighbor nodes. Mobile node actively participate and moves within the radio range which form topology dynamically.

MANET routing protocol faces battery issues [5] and do not consider node energy level during the broadcasting of data and control packets. Researcher focuses on the energy issues, link stability. Researcher designed energy efficient and link aware routing protocol which helps to enhance lifetime of network. Energy efficient [6], link aware [7] and distance aware routing protocol [8] uses routing strategies to enhance the performance of mobile ad hoc network. Distance aware routing select shortest path for the data transmission based on the distance between the neighbor nodes. To find the shortest path Dijkstra, Bellman Ford algorithms are commonly referenced is distance aware routing and these algorithms are used in computer networks [9]. Routing table is maintained by each node. The distance of each node which participate in the route discovery process is included in routing table. The transmitting node calculates the distance among the first hop neighbors before transmitting the data packet. A node with shortest distance is selected by routing algorithm. The energy inefficient, un stable and long distance nodes have been avoided during path selection procedure. The distance aware routing algorithms optimizing the routing path, improve throughput, reduces packet losses, reduces End to End Delay, minimizes network congestion and improves the performance of the network.

The remaining paper is organized as follows. The literature review is discussed in Section 2. The proposed methodology is discussed in Section 3. Section 4 summarizes the simulation scenario and comparative analysis of results. Finally, the conclusion has been discussed in Section 5

2 Literature Review

In [10] Emergency Centers setup model for first responders is proposed. In the suggested approach rescue workers at the disaster site launch rescue and recovery operation by building emergency rooms. The distribution of rescue and emergency rooms help first responders to provide first aid to disaster victims in order to reduces human losses. This study focuses on the construction of such emergency rooms for the disaster victims for better performance. The suggested model facilitates the deployment of ad hoc network for optimal communication.

In [11] a geospatial framework for smart cities has been introduced by the authors. The proposed framework has been designed which helps to understand and handle emergencies in disastrous situation. The authors focused on the development of smart cities as to reduce the risk of property and infrastructure losses associated with disaster. People of developed era are live in cities, and the number of people living in cities is increasing gradually. Smart city development is becoming more and more popular in many emerging nations. The infrastructure of these cities is modified in order to achieve the objectives of smart cities. Jahir et al. [12] proposed a disaster area wireless network (DAWN). Authors divide the major area of metropolitan cities in to disaster zones.

In disaster zones, a DAN is utilized to provide robust, energy efficient communication that can adjust to changes in topology and movement. DAN aims to lower latency, raise bandwidth for multimedia applications, reduce overhead, and use less energy. Over the past ten years, there has been a notable increase in the usage of social media for disaster management. People from different discipline share the images of disaster sites into their respective groups. This is mostly brought on by the widespread usage of mobile devices and the range of data types and formats that social media platforms offer. In recent years, there has been an increase in interest in social media visual analytics study among scientists.

Research on social media visual analytics for disaster management, however, hasn't been done extensively [13]. In [7] authors proposed an ENH-AODV routing protocol which is the enhanced version of AODV reactive routing protocol. In the proposed model authors focus on the Node Quality Estimation Model. To maintaining the link quality of nodes, protocol broadcast Hello packets to check the status of neighbor nodes. Link failure is the main issue of MANETs routing protocols. Hello packets are used to maintain the network resources. The proposed protocol discover routes based on node energy level and link quality. ENH-AODV improves the overall performance of entire network and perform better in terms of PDR and End to End Delay. Pandey, P. and Singh [14] proposed a STAB-AODV routing protocol. The stable AODV routing protocol selects a route based of residual energy and received signal quality. To reduces the frequently link breakage protocol transmitting node increases the link stability factor. During the route discovery process a better link stability factor is considered to discover efficient and stable route from source to destination. Proposed protocol improves the performance in terms of throughput, End to End Delay and Node Energy Consumption. In [15] authors proposed AODV-ETX routing model for the transmitting of data packet from source to destination. Expected transmission count metric is introduced to discover a best feasible path. A network with smallest ETX produces a highest throughput. AODV-ETX is implemented in NS-3 network open source simulator. The proposed model produces better results in terms of packet loss, packet , End to End Delay, throughput and permeability. In [16] authors evaluate the performance of energy based AODV routing protocols under User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) internet protocol in NS-2 environment. Authors simulate different scenarios in both TCP and UDP protocols.

UDP consume less energy in small network whereas TCP perform better than UDP in large network. In [17] authors proposed Energy and Distance Aware EDA-AODV routing protocol. In the proposed protocol routes are discovered on the basis of node energy factor and node distance. During the route discovery process routes are discovered based on two routing metrics such as node energy factor NEF and node distance. The NEF is computed from initial node energy, residual node energy and current node energy whereas the node distance is computed from distance formula. Network simulator NS-2.35 has been used to simulate the proposed scheme. The proposed scheme produce better results in terms of throughput, normalized routing overhead and enhance over all network life time. The integration of geospatial and artificial intelligence frameworks for emergency management has also been explored to further enhance the capability of handling disasters effectively. One such study by Zhou et al. [10] proposed a multi-agent geospatial AI model that incorporates spatial data from multiple sources, including satellite and sensor data, to support emergency response decision-making. This model offers a sophisticated approach by not only visualizing disaster impact areas but also predicting potential hazard zones, enabling responders to plan more accurately and strategically. Additionally, by utilizing AI algorithms that adapt in real time based on incoming geospatial data, this model provides a dynamic system well-suited for the constantly evolving conditions of a disaster site. Such developments in geospatial AI can enhance the efficacy of disaster communication networks, as they allow more accurate real-time data integration and adaptability.

In addition to AI-based models, block-chain technology has emerged as a viable solution to improve security and data integrity in emergency response systems. Recent research by Rao [11] explored the use of block-chain in disaster management networks, proposing a decentralized communication model that protects sensitive data from unauthorized access or alterations. Their model leverages block-chain's immutable ledger to store disaster response data, ensuring that all information relayed between emergency responders remains authentic and unaltered. This approach is especially useful in disaster situations where security breaches or data manipulation can lead to misinformation and inefficiency in response efforts. The incorporation of block-chain into MANETs for disaster response could significantly enhance data security, ensuring that critical communication channels remain reliable even under extreme circumstances.

3 Proposed work

The proposed Distance and Energy aware DEAODV routing protocol considers both energy efficiency and node distance when selecting the best path for data transmission in the network. In the disastrous situation sharing of critical information between the first responders and managerial staff is important. The proposed routing protocol is used to design for the sharing of emergency related information . The proposed routing protocol select routes based on node energy level and the shortest node distance. The DEAODV protocol is considered node energy level (En) and shortest node distance (SDn) for the transmitting and receiving of RREQ control routing packet to the one hop neighbors. To avoids network Delay and reduces routing overhead, protocol selects energized node with shortest distance. A node with low energy level having longest distance is avoided. A route setup process to discover feasible route is discussed in route discovery process.

3.1 Methodology

The methodology for the Design and Implementation of DEAODV reactive routing protocol comprises on phases. In design phase, a crucial or critical data for the disaster victims has been gathered from the disaster site by first responders and same as shared with higher officials to carried out recue and relief operations.

In the second phase research frame work has been prepared to generate different emergency scenario for disastrous related operations. A mobile ad hoc network has been designed and deployed at the disaster site. Mobile nodes are connected with internet through access points and gateways. Implementation is the third phase of the design proposed routing protocol. DEAODV has been implemented in NS2.35 network open source simulator software. NS2.35 has been installed in Ubuntu version 14.0 environment. Tool Command Language (TCL) a programming language has been used as a tool to design emergency scenarios. A source code of emergency scenario has been written in the text editor of TCL programming language. TCL has been generated two files Network Animator (NAM) file and Trace file. Ns2.35 support both trace files namely Old trace and New trace file. The routing parameters about the routing protocol are assigned in TCL before running the .tcl file. Fifty mobile nodes which form Mesh topology may join or leave from the disaster stricken areas. Each node participated as a first responders in the evacuation process for the victims. For this mobile nodes broadcast Route Request RREQ and RREP control packets to its one hop neighbor for finding the shortest or best feasible path. Shortest Node Distance among the participating nodes and Node Energy Consumption routing metrics are helps routing protocol to discover shortest route from source to destination. AWK scripting file has been used to analyzed the behavior or results of emergency related scenarios from trace files.

3.2 Route Discovery Process

DEAODV reactive routing protocol discover routes on demand when there is no any route to the destination. For the shortest route, Source node S initiates route discovery process by broadcasting RREQ control packets to its one hop neighbors. The one hop neighbors or intermediate node acted as router so as to send and receive control and data packet. Intermediate nodes as shown in figure 1 are actively participated during route discovery. Intermediate nodes consume receiving and transmitting power during the broadcasting and unicasting of control packets. Source node S broadcast RREQ control packets to node n1, n2, n3 and n4 as shown in Figure 1. Before accepting the RREQ control packet DEAODV protocol test two conditions such as node energy level (En) and shortest distance (SDn) of neighbour node. The energy level of each node (En) is compared with energy threshold level (Thre) and shortest node distance (SDn) between the two transmitting and receiving nodes. Assume that node n1,n2, n3 and n4 has a good energy level. Energy level (En) of each node is greater than the threshold level (Thre) whereas n1 has shortest node distance (SDn) with the Source node S, in such situation node n1 accepts RREQ control packet and make a reverse path entry other participating nodes n2,n3 and n4 are dropped. The dropped nodes do not participated in route discovery process further. In the second instance of the route discovery node n1 participated as router initiates to broadcast RREQ control packets to its one hop neighbors n5 and n6. Now assume that the energy level (En) of node n5 is less than the energy threshold level (Thre), so node n5 has been dropped and do not accepted RREQ control packet. This route discovery process is continues until the RREQ control packet reaches to the destination node D.

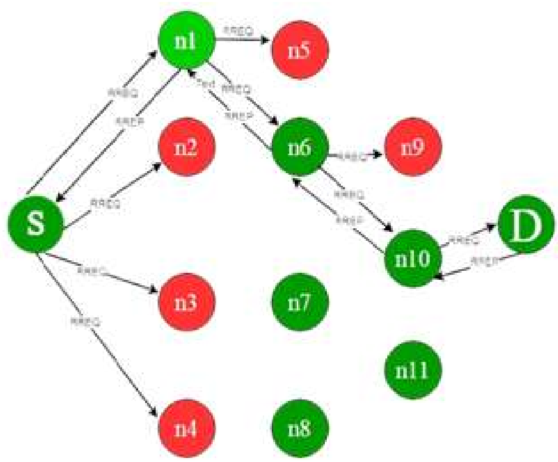

Figure 1. Forwarding of RREQ and RREP control packets of DEAODV

The second phase of route discovery process is started when Destination node D unicast RREP control packet to its one hop neighbor. Destination node D unicast RREP control packet to its neighbor on the reverse path such as node n10 as shown in Figure 1. After accepting the RREP control packet, intermediate node n10 act as router and unicast RREP control packet to their neighbors. This process is continued until the RREP control packet reaches to the Source node S. protocol discover shortest feasible route S – n1– n6– n10– D during route discovery process for the sharing of data as shown in figure 1. The route has been discovered based on shortest distance among the participating nodes. Once the routes has been established source node sending data packet through the along with a path to the destination node.

4 Performance evaluation

The proposed protocol is evaluated with respected to different aspects and their results are summarized here.

4.1 Simulation Environment

DEAODV reactive routing protocol is evaluated in disastrous emergency situation. Open source Network Simulator software NS2.35 is installed in Ubuntu version 14.0 in desktop computer. A common version NS2.35 is used to simulate the various disastrous scenarios in Ubuntu environment.

Table 1. Simulation parameters

Parameters	Values
MAC Layer	IEEE 802.11
Item	Item
Routing Protocols	DEAODV, AODV
Coverage Area	1000X1000 meters
Mobile Nodes	50
Mobility Model	Random Waypoint
Topology	Flat-grid
Packet Size	512
Node mobility	0 m/s to 8 m/s
Traffic Load	2 ,4, 6, 8, 10 active connections
Network Traffic	CBR
Network	CBR
Buffer Size	50
Simulation Time	1000 seconds
Initial Energy	30 Joule

Wireless communication standard IEEE 802.11 is used to simulate different emergency scenario. A Flat grid topology of 1000X1000 meters are selected for the deployment of 50 mobile nodes. Each mobile node of the network uses Random Way Mobility (RWM) model to move freely within the coverage area. Mobile node may join or relieve easily from the network. The mobile node moving with the speed of 0 m/s, 2 m/s, 4 m/s, 6 m/s and 8 m/s. 250 meters are the transmission range of mobile nodes for the broadcasting of control packets. Network uses 30 joules of energy during the simulation of disastrous scenarios. The traffic load of the network varies from 2 , 4, 6, 8 and 10 active connections. The simulation time of the network varies from 200 seconds to 1000 seconds. The packet size for the Constant Bit Rate (CBR) traffic is 512 bytes. 1000 seconds of simulation time is assigned to run each emergency scenario. The parameters of simulation are given in Table 1.

4.2 Comparative analysis

The DEAODV reactive routing protocol is designed and implemented in NS2.35 network simulator software. The performance of DEAODV routing protocol is evaluated in terms of Packet Delivery Ratio, Consumed Energy and End to End Delay of the mobile ad hoc network. To compare the performance of DEAODV and AODV routing protocol many disastrous emergencies scenario has been designed in TCL environment and same also RUN in NS2.35 simulator software. The results of proposed DEAODV reactive routing protocol shows that DEAODV reacting routing protocol performs better than AODV routing protocol. The description of routing metrics is given below:

Figure 2 shows the comparison of PDR with traffic load of the network. From the figure result shows that the PDR of the network decreases gradually when the traffic load of the entire network is increases. Initially network produces more PDR when only two CBR active connections are running, there was no packet in the buffer most of the data packets reaches within timeframe. As the network load increases gradually more routing overheads are generated which causes of dropping PDR. During 10 active connections more number of packets are buffered in the queue or dropped which causes to decrease PDR of the network. It is also observed that in terms of PDR the performance of DEAODV is better than AODV.

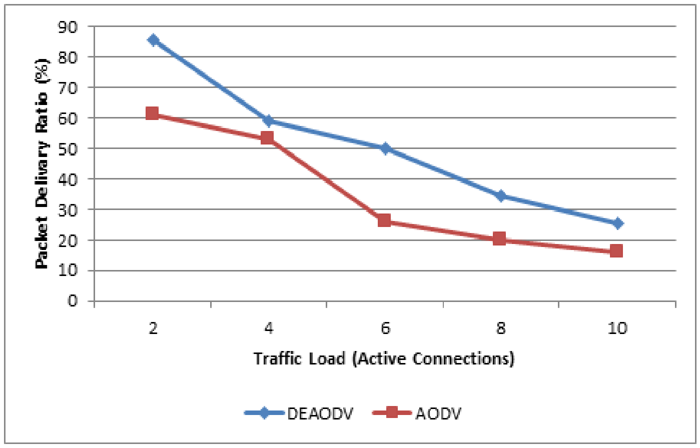

Figure 2. Packet Delivery Ratio with Traffic Load

In the figure 3 End to End Delay of network is compared with traffic load. The figure depict that the End to End Delay of the network increases gradually when the traffic load of the entire network is increases. When the traffic load of the network increases from 2 active connections to 10 active connections, Due to the heavy load of the network more number of packets are buffered in the queue which takes more amount of time to reaches to destination. It is also observed from the results that in terms of End to End Delay the performance of DEAODV is better than AODV.

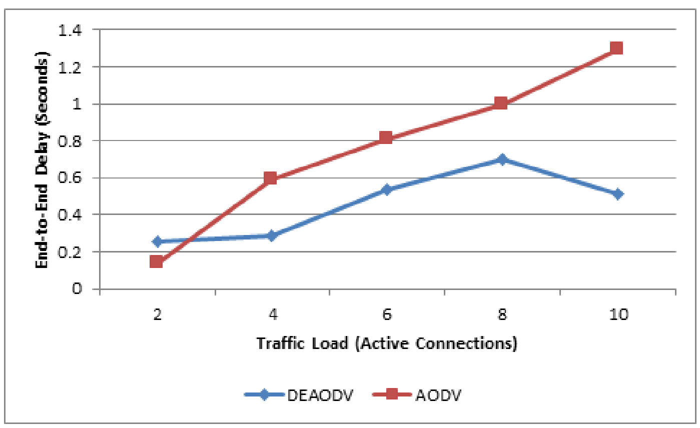

Figure 3. End to End Delay with Traffic Load

Figure 4 shows the comparison of node Energy consumption of entire network with traffic load. The figure shows that the Consumed Energy of the network increases gradually when the traffic load of the entire network is increases. The network with heavy load, more number of control packets are generated which causes more node energy consumption. It is also observed from the results that in terms of Consumed Energy the performance of DEAODV is better than AODV.

Figure 5 shows the comparison of PDR with network simulation time. From the figure result shows that the PDR of the network increases gradually when the simulation time of the entire network is increases. The simulation time of the network increases from 200 seconds to 1000 seconds. When the simulation time increases gradually more number of packets are generated which causes more number of packets reaches to destination. It is also observed from the results that in terms of PDR the performance of DEAODV is better than AODV

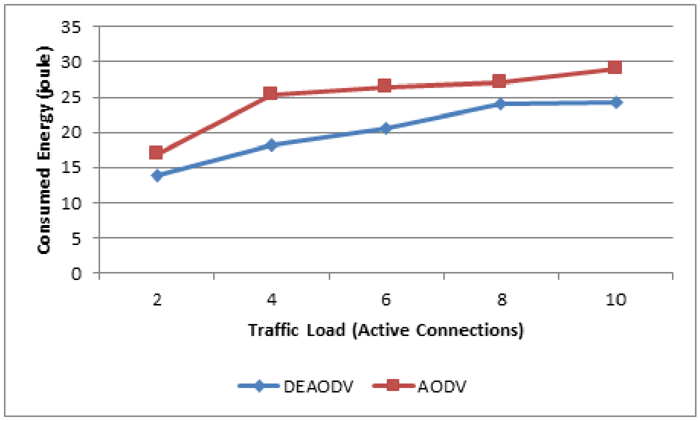

Figure 4. Consumed Energy with Traffic Load

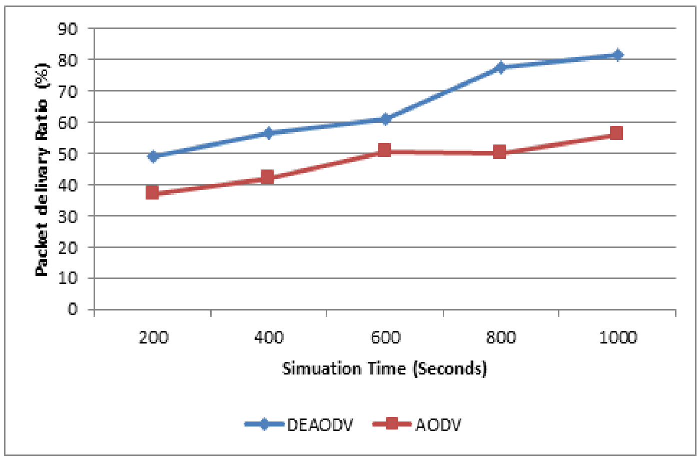

Figure 5. Packet Delivery Ratio with Simulation time

In the figure 6 end to end delay of network is compared with Simulation time. The figure shows that the End to End Delay of the network decreases gradually when the simulation time of the entire network is increases. Figure shows that the network is stable and less number of packets are dropped, which causes reduction in network Delay. It is also observed from the results that in terms of End to End Delay the performance of DEAODV is better than AODV.

Figure 7 shows the comparison of node Energy consumption of entire network with Simulation time.

The figure shows that the Consumed Energy of the network increases gradually when the simulation time of the entire network is increases. At the time 200 seconds a less number of packets are generated which causes less number of joules are consumed, because at the receiving and transmitting end mobile nodes consume energy. Figure shows that huge amount of node energy is consumed when simulation time is increases more than 600 seconds. It is also observed from the results that in terms of Consumed Energy the performance of DEAODV is better than AODV.

Figure 8 shows the comparison of PDR with node mobility speed of the network. At speed 0, the network is static and none of the node is moving within the transmission range, which causes network produce more packet delivery ratio. At speed 2 meters per seconds, link is established network becomes more stable, which causes increase in PDR. From the point 4 meters per seconds the PDR of the network decreases gradually when the node mobility speed of the entire network is increases. It is also observed from the results that in terms of PDR the

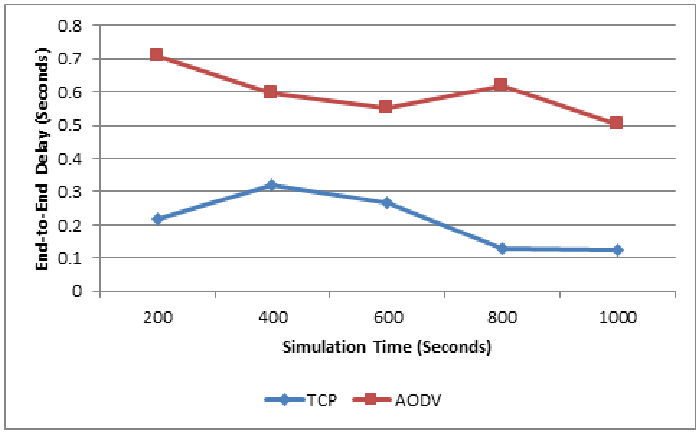

Figure 6. End to End delay with Simulation Time

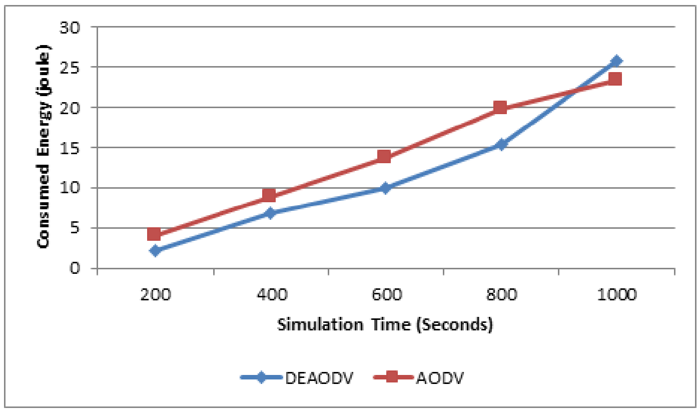

Figure 7. Consumed Energy with Simulation Time

performance of DEAODV is better than AODV.

In the figure 9 end to end Delay of network is compared with node mobility speed. The figure shows that the end to end delay of the network increases gradually when the node mobility of the entire network is increases. Figure shows that the network produces less Delay because less number of packets are buffered in a queue. It is also observed from the results that in terms of End to End Delay the performance of DEAODV is better than AODV.

Figure 10 shows the comparison of node Energy consumption of entire network with node mobility speed. The figure shows that the Energy consumption of the ad hoc network increases slowly when node mobility speed of the entire network is increases. At the time 0 meters per second less number of joules are consumed, because at the receiving and transmitting end node consume energy. Figure shows that huge amount of node energy is consumed when node mobility speed is increases more than 4 meters per seconds. It is also observed from the results that in terms of Consumed Energy the performance of DEAODV is better than AODV.

5 Conclusion

This study proposed DEAODV reacting routing protocol which is based on a conventional AODV routing protocol. The DEAODV routing protocol focuses on the effective usage of MANET in the disastrous or emergency related situation. A traditional AODV do not considering node energy and frequently link failure issues during the broad-casting of control packets, which causes huge amount of node energy has been drain out during the receiving

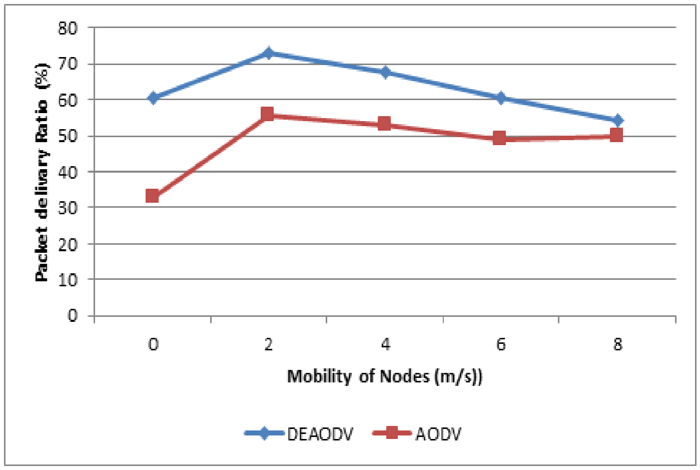

Figure 8. Packet Delivery Ratio with Mobility of Nodes

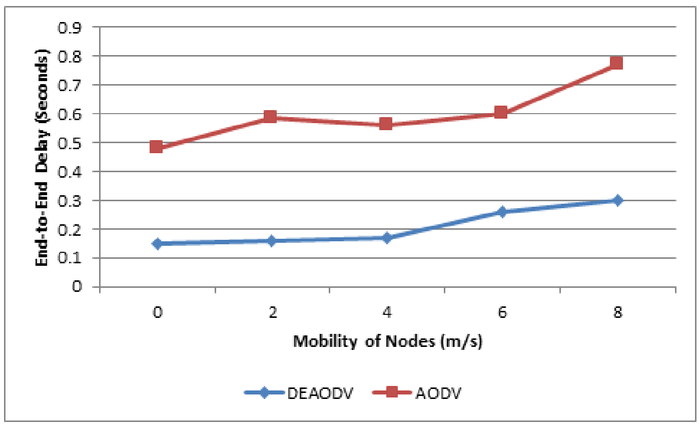

Figure 9. End to End Delay Mobility of Nodes

and transmitting of data packets. For the better performance of the network, DEAODV select best feasible routes based on node energy consumption and shortest distance among the participating nodes. The proposed DEAODV significantly enhance network lifetime by improving packet delivery ratio, reduces End to End Delay, improves throughput, reduces packet loss, reduce normalized routing overheads and reduces the node energy consumption. This study helps researchers to develop new real time applications in future which support first responders in evacuation process in disaster management system. The new developed applications helps to improve network performance in disastrous situation. The proposed DEAODV protocol sets a foundation for numerous future research directions, particularly in enhancing disaster-resilient communication networks. One promising avenue for future work is the integration of more advanced energy optimization techniques, such as adaptive power control mechanisms. By dynamically adjusting transmission power based on network conditions, such protocols could further extend node and network lifetime. Researchers could explore hybrid approaches that incorporate both energy-awareness and additional environmental factors, like signal interference and varying terrain in disaster zones, to create more resilient routing solutions.

Another potential direction lies in the exploration of AI-driven algorithms for route optimization. Machine learning models could be trained to predict node energy depletion rates and adjust routes preemptively to avoid energy-drained nodes, enhancing the network's adaptability in real-time. Additionally, incorporating reinforcement learning could help MANETs autonomously learn optimal routing paths based on previous data patterns,

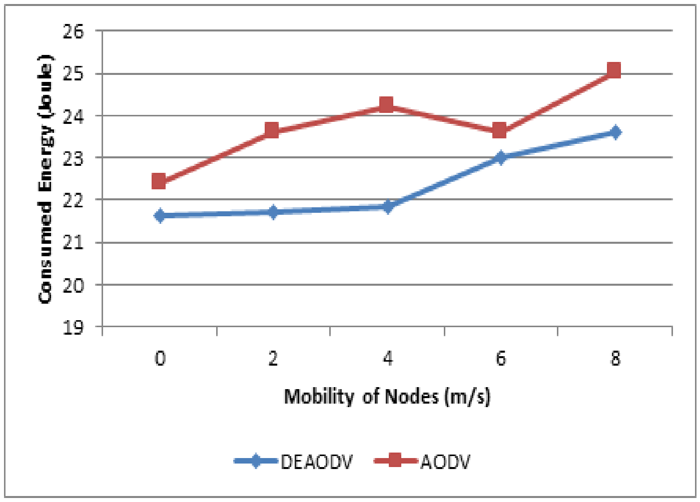

Figure 10. Consumed Energy with Mobility of Nodes

improving routing efficiency over time. This would be especially beneficial in unpredictable disaster scenarios where communication demands and environmental conditions fluctuate rapidly. Furthermore, the DEAODV protocol could be extended to support multi-tier network architectures involving drones or unmanned aerial vehicles (UAVs) alongside ground-based nodes. UAVs can act as relay points or mobile nodes to cover more extensive areas, particularly in hard-to-reach or heavily damaged locations. Future work could focus on optimizing routing in these multi-layered MANETs, ensuring seamless data relay between aerial and ground nodes for maximum network coverage and resilience. Integrating such flexible architectures with DEAODV may offer critical advantages in complex, large-scale disasters.

Author Contributions

Mohammad Ali Soomro: Idea, Methodology, Writing- Original draft preparation **Mohammad Ibrahim Channa**: Supervision **Shah Zaman Nizamani**: Analysis **Mohammad Aamir Bhutto**: Simulation work **Abbas Ali Ghoto**: Software, Validation

Compliance with Ethical Standards

It is declare that all authors don't have any conflict of interest. It is also declare that this article does not contain any studies with human participants or animals performed by any of the authors. Furthermore, informed consent was obtained from all individual participants included in the study.

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