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Improved-QoS-AODV Protocol considering BWMD factors and Performance simulation in NS-3

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Abstract

Obstacles occur in mobile ad hoc networks (MANETs) due to packet loss, which may be efficiently mitigated by combining congestion management strategies (comprising routing approaches) with control inflow at the network layer. Congestion is the key challenge for routing in the mobile system, which overall degrades network performance owing to insufficient accessibility of wireless network resources of the nature, node mobility, and dynamic topology of the wireless network. Congestion results in packet loss, as well as time and energy waste due to connection failure and mobile node failure. Congestion can be identified by a node's mobility, connection bandwidth capacity, and geographical distance. To conclude, we suggested Improved AODV, a unique modified Ad Hoc On-demand Distance Vector (IAODV). The IAODV protocol's purpose is to find the multi-objective route that will decrease route congestion and thereby packet drops. The route construction algorithm was created with many trust characteristics in mind, such as geographic distance to the target node, node velocity, and bandwidth availability. Using the dynamic weight-management technique, we calculate the integrated trust score for each mobile node while picking the forwarding relay. The I-AODV protocol has a straightforward design to reduce the impact of connection conditions. The simulation results demonstrate the suggested model's efficiency in comparison to existing procedures. We have measured the performances of the proposed protocol and existing protocol in terms of average throughput, packet delivery ratio (PDR), average end-to-end delay, jitter, and average energy consumption.

Keywords- *MANETs, Congestion, Improved AODV, packet drops, average & end delay, Jitter, & average energy consumption.*

I.INTRODUCTION

Wireless ad hoc networks are self-organizing devices that may be installed without the need for infrastructure. Mobile Ad hoc Networks (MANETs) are self-contained networks of mobile nodes connected by wireless connections that do not rely on existing network infrastructure [1-7]. Each node serves as both a host and a router, forwarding packets from other nodes to enable communication between nodes that are not physically connected by wireless networks. The creation of dynamic routing protocols capable of effectively finding paths between communicating nodes is a key challenge in the architecture of ad hoc networks. The routing protocol must be able to keep up with the high degree of node mobility, which often and unpredictably modifies the network topology [8]. The combination of link-quality volatility and the broadcasting character of Wireless channels has revealed a new area in wireless networking research, termed cooperative communication.

Advantages and Drawbacks

The following are some of the advantages of a mobile ad hoc network: - Service and information access are offered by mobile nodes regardless of their geographic position.

- Such networks can be readily set up anywhere
 and at any time.
- Affordability.
- Development infrastructure does not require
 any assistance.

The following are some of the downsides of the MANET network:

- There are fewer Network resources.
-There is a reduction in the MANET network physical security.
- Because of the open nature of MANET communications, MANET's potential is increased.
- Authorization is not supported.
- Malicious nodes are difficult to detect due to the variable network structure.
- Protocols that are utilized in wired networks are not supported in wireless networks.

II PROBLEM STATEMENT, OBJECTIVE & RESEARCH WORK

Problem Statement

On-demand routing protocols, in particular, have received a lot of attention since they require less bandwidth than proactive protocols. The two most widely studied on-demand ad hoc routing protocols are On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Previous research has revealed the limits of the two techniques. The fundamental reason for this is that they both construct and rely on a hop-based route for each data session. When a link on the current route fails, both routing protocols must initiate a route discovery process frequently. The route formation is the core part of protocols like AODV. Therefore, the selection of the forwarder node should be according to the key terms that affect the overall network performances like node mobility, the available bandwidth of the node, and distance towards the destination node. The problem statement of this project is to design the I-AODV protocol to establish more reliable routes in the MANETs and improve the overall QoS performances.

The core objectives of the proposed research on MANETs are listed below.

- To study the various bandwidth-aware routing protocols of MANETs.
- To simulate and analyze the performances of the existing routing methods of MANET.
- To propose the novel route discovery algorithm using the trust-based approach.

- To design the novel modified routing scheme for the MANETs using the proposed route discovery algorithm,
- To model, simulate and evaluate the performances of the proposed protocol.

Research Work or Literature Work

- The authors [53] describe the SLA (Simple Load Balancing Approach) approach with the goal of reducing traffic concentration by allowing any mobile node to give up packet forwarding or reject RREQ.
- The author of [54] provided yet another novel load balancing methodology as well as a new method for evaluating bandwidth for MANET
- on-demand routing protocols like AODV. In this strategy, the destination node uses the path information from the RREQ packet to choose the most efficient route.
- [55] proposed a competent routing protocol for deceptively controlling network congestion and load balancing in MANET. Using the provided method, multiple alternate paths between two nodes were discovered. Based on the available power of the participating nodes, the cost, stability, and traffic load of the link were determined. When a link's traffic load reaches a given threshold, the traffic is distributed across other lines.
- Adaptive reliability and congestion control routing protocol were proposed in [56] for resolving congestion and route problems in MANETs utilizing bypass route selection. Many pathways are created. The shortest pathways are found among these for effective data transmission. On the basis of connection and path utilization and capacity, congestion is detected.
- The bandwidth-aware multipath reactive (BAMR) routing system for mobile ad hoc networks was proposed by the authors in [57]. The suggested protocol was a mobile ad hoc network modification of the ad hoc on-demand multipath distance vector (AOMDV) routing protocol. BAMR is a proposed protocol that aims to find pathways with sufficient bandwidth and fewer network failures.
- The authors of [58] created congestion control load balancing adaptive routing protocol (CCLBARP) methods to reduce latency, system routing overhead, congestion, and network life in MANETs

Summary

This chapter presented the survey on various aspects of MANET routing. We have first studied the AODV and DSR routing schemes in detail and then reviewed the QoS-based MANET routing solutions.

III PROPOSED METHODOLOGY

This chapter presents the design and methodology of the I-AODV protocol which is proposed to overcome the challenges of MANET routing considering the mobility and link bandwidth utilization factors. Along with the mobility and bandwidth resources, we have introduced the geographic distance parameter also for reliable forwarding relay selection in the routing formation algorithm. This section first presents the detailed methodology of the I-AODV protocol and then the experimental environment is discussed.

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I-AODV Protocol

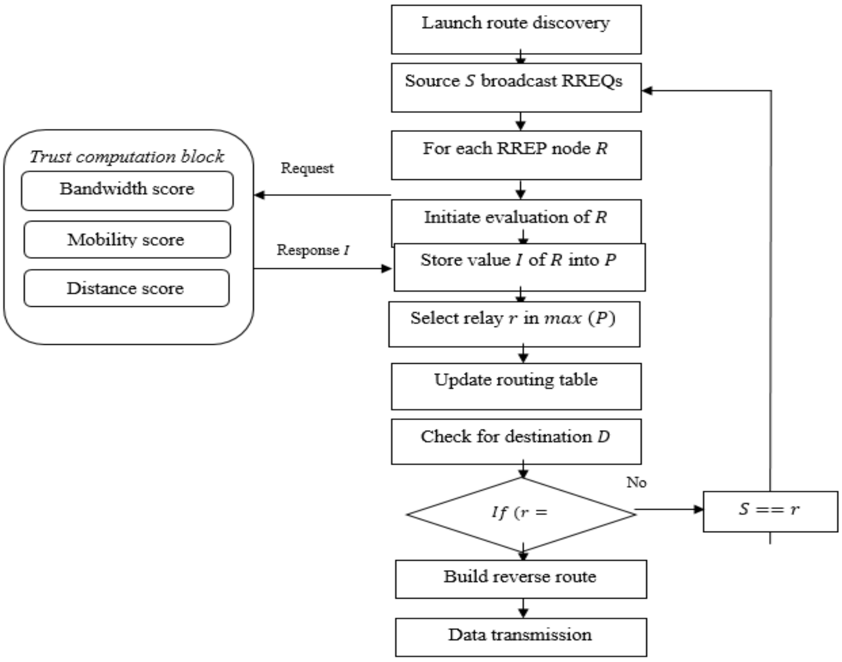

Fig 3.1Architecture of proposed route discovery algorithm

This section presents the methodology of the proposed protocol. Figure-3.1 shows the architecture of the route discovery algorithm in the I-AODV protocol. As shown in figure-3.1 and its corresponding algorithm 3.1, each source node launches the route discovery process periodically in the network. Accordingly, the route request messages (RREQ) broadcasts to the nearest neighbors. On receipt of RREP, the behaviors of each RREP node are analyzed using three parameters such as bandwidth score, mobility score, and distance score. The integrated trust score is then computed for the evaluation of that particular node. The node with a higher score will be selected as the forwarding relay node. This process is repeated until the destination reaches. Once the destination node is discovered the reverse route forms and data transmission begins.

Notation	Symbol
□	Source node
□	Destination node
□□□□	Route request
□□□□	Route response
□	Current node under evaluation
□	Selected relay node
□	Stores the integrated trust value for each □

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□	Computed integrated trust score for □
□	Number of neighbors discovered
□*1*	Trust value for bandwidth factor of □
□*2*	Trust value for mobility factor of □
□*3*	Trust value for distance factor of □

Table-3.1. Symbols used in algorithms.

Below we explained how to compute the various trust parameters of each mobile node.

The bandwidth trust parameter of node R is determined by using the bandwidth availability metrics of that node. The bandwidth is computed as the amount of data transferred from one node to another node in a specific amount of time. The current available bandwidth-based trust evaluation of the node R is computed as:

$$□□ = □ - \left(\frac{□□□□□□□□□□\ (□, □)}{□□□□□□□\ □□}\right)$$

Where utilized BW (R,t) represents the currently utilized bandwidth of node R at time t. And maximum BW represents the maximum bandwidth set for each node at the time of the network deployment which is 2 Mbps. The higher value t1 represents the maximum reliable node to become the forwarding relay node.

The mobility speed of the mobile nodes in MANET is also vital as it leads to frequent route operations. Therefore, to build reliable and stable routes, we need to select the node with minimum mobility speed.

We first estimate, the current mobility speed of the node R at the current time as:

Speed=getVelocity (R,t)

The get Velocity (R,t) function is the standard mechanism that estimates the current moving speed of the node R at time t. According to the speed outcome, we formulate the mobility trust score value using Eq. (3):

$$□□ = □ - \left(\frac{□□□□□}{□□□□□}\right)$$

Where the max speed represents the maximum velocity for each mobile node in the network. In this study, we set the default value as 100 m/s. Thus, the higher t2 of node R represents the lower mobility speed of the R.

The geographical distance between the current node R and intended destination D is another vital parameter. In conventional AODV protocol, the minimum hop count parameter is selected for the route formation. Here, we select a related node with minimum geographical distance towards the D. This trust value is computed as given below.

$$t3 = 1 - \left(\frac{dist\ (R, D)}{dist}\right)$$

Where the max dist represents the maximum allowable distance for each mobile node in the network. In this study, we set the default value as 500 meters. Thus, the higher t3 of node R represents the lower distance from R to D.

Integrated Trust Score: After the computations of t1, t2, and t3 for each R, weight computation is performed as:

I(R)=w^1×t1+〖w〗^2× t2+ 〖w〗^3× t3

Where I(R) is the trust score for node R. The weight components 〖w〗^1, w^2, and w^3 are used to convert and normalize the weight of each node in the range of 0 to 1. In this study, we set values as 〖w〗^1=0.4, w^2=0.4, and w^3=0.2.

Network Design Assumptions

The following are the assumptions considered in the research

- All nodes had a perfect communication coverage disk and were located in a two-dimensional space.
- All nodes have equal communication ranges and all links are bidirectional.
- Multihop communication is preferred over single-hop communication
- All nodes have a single mobile and have a perfect sensing coverage disk.
- Nodes in the network do not have information about their position, orientation, or neighbors.
- The initial graph, the one formed right after the deployment using the maximum communication range is connected.
- Using GPS technology, vehicles can locate their position in the network which is used to compute the distance parameters.
- Additionally, it is assumed that every vehicle is aware of its direction and its moving speed.
- Packet loss is not considered in the data link layer.
- There is a mechanism by which a node can be awakened when its radio is off.
- The network duty cycle is 100% – The network is always active.
- The time units of the simulation clock are approximately 1 second.
- Lambda is the Poisson process density and it is related to the density of the network.
- Two widely used propagation models are used a) Free Space model (Ƴ = 2) and b) Two-Ray Ground propagation model (Ƴ = 4).
- All the nodes have the equal capability of processing power, transmission range and the other features of the device.
- Connection between the nodes is not transitive.

- Nodes are identified by fixed ID's.
- Nodes are free to move in the network without any restriction and can leave or join the network at any time.
- The range of transmission of all nodes in the network from source to destination is restricted by the route availability described in the thesis.
- Because there are no bad invader nodes, all of the nodes trust each other by utilizing predetermined keys.
- During wireless network transmission, packets may be lost or damaged.
- The routing protocol is evaluated under the premise that mobility is low.
- The evaluation of load balancing routing protocols will be carried out in a variety of situations in order to get a basic understanding of how the protocols behave under various conditions.

Simulation Tool

NS-3 is chosen due to the subsequent benefits of utilizing it:

1. Open end & free software system for the simulations.
2. simply accessible for the download & installation.
3. Programming is finished in C++.
4. additional options enforced for the simulation.

System needs

As per the simulation tool designated, the system needs through considering the software system & hardware parts for this work are:

- Software needs
- Ubuntu twelve.04
- Ns-allinone-3.34
- Virtual machine eight.0
- Bonn Motion [210]
- Hardware needs
- 20 GB free area of HDD
- 3 GB of RAM
- Installation Assumptions

A. Windows is put in in C drive.

Network eventualities and Performance Metrics

We have designed networks below 2 completely different network eventualities like variable density and speed. Table-3.2 and Table-3.3 show the list of simulation parameters for each eventuality. Review comments albeit you're well assured concerning your paper.

Number of Nodes	**50, 100, 150, 200, & 250**
Simulation Time	200 seconds
Traffic Pattern	CBR
Network size	1000 x1000
Antenna	Omni Antenna
Topology	Random Waypoint
MAC	802.11
Mobility speed	20 m/s
Number of connections	5
Channel	Wireless channel
Propagation model	Two-ray ground
Queue type	Drop-tail pri-queue
Routing protocols	AODV, COCO [59], and I-AODV

Table-3.2 Network parameters for mobile nodes density variation

Number of Nodes	100
Simulation Time	200 seconds
Traffic Pattern	CBR
Network size	1000 x1000
Antenna	Omni Antenna
Topology	Random Waypoint
MAC	802.11
Mobility speed	15, 30, and 45 m/s
Number of connections	5
Channel	Wireless channel
Propagation model	Two-ray ground
Queue type	Drop-tail pri=queue
Routing protocols	AODV, COCO [59], and I-AODV

Table-3.3 Network parameters for node velocity variation

In this work, the performance of proposed protocols & state-of-art protocols are evaluated utilizing four well-known parameters such as normal throughput, Packet Delivery Ratio (PDR), normal start to finish postponement, & correspondence overhead.

1. Average Throughput

$$T = \left(\frac{R}{T^2 - T^1}\right) \times \left(\frac{8}{1000}\right)$$

Where R is finished, obtained bundles at all objective hubs, T2 is reproduction stop time & T1 re-enactment start time.

2. PDR

$$P = \left(\frac{p_r}{p_g}\right) \times 100$$

3.Average Delay

$$D = \frac{\sum_{i=1}^{N} \quad d_t^i + d_p^i + d_{pc}^i + d_q^i}{N}$$

Where N is no. of complete transmission joins,d^i_{pc} is handling postponement of i^{th}link, &d^i_q is transmission postponement of i^{th}link.

4.Communication Overhead

$$O = \sum_t \quad : \ldots : \left(\frac{RT^t}{DT^t}\right)$$

Where, RT^t is complete number of routing parcels & DT^t is all out number of information bundles at time t.

5.Average Energy Consumption

$$E^{tot} = \sum_{i=1}^{N} \quad E_i^{initial} - E_i^{consumed}$$

Where E_i^initial and E_i^consumed square measure initial and consumed energy of i^th node severally. N is that the total no. of nodes in an exceedingly network. the typical consumed energy is computed as:

$$E^{avg} = \frac{E^{tot}}{N}$$

IV SIMULATION RESULTS AND DISCUSSIONS

According to the objectives of the proposed research, we have simulated and evaluated

The proposed I-AODV protocol and compared with two routing protocols AODV and COCO [59] routing protocols. We have designed the MANETs with varying mobile nodes and mobility rates.

As discussed in chapter 3, there are a number of network scenarios prepared to evaluate the reliability and efficiency of proposed routing methods such as varying mobility speed and varying number of mobile nodes. We first discuss the visual outcomes and then present the graphical results. For network visualization, we used the NS3 visualizer model. Below figures from 4.1 to 4.2 are showing the visualization snapshots. Figure 4.1 is showing the system model designed in which 50 mobile nodes are randomly deployed under a 1000x1000 network area. The mobile nodes are randomly moving inside this area with respect to time. Once the simulation starts the mobile nodes in the network start sensing their frequencies and hence the neighbor mobile nodes. This process is shown in figure 4.2. As per the property of MANET, each mobile node is sensing its neighbor's mobile nodes for communication purposes.

Figure 4.3 presents two cases, route request broadcasting process and congestion indication. The green lines indicate the normal packets broadcasting among the nodes in order to select the routing path. The red lines are indicating the congestion impact and claim as packet drops in the network. Figure 4.4, similarly shows the data communication through the selected paths (green lines) and packet loss (red lines) due to the presence of congestion in the network.

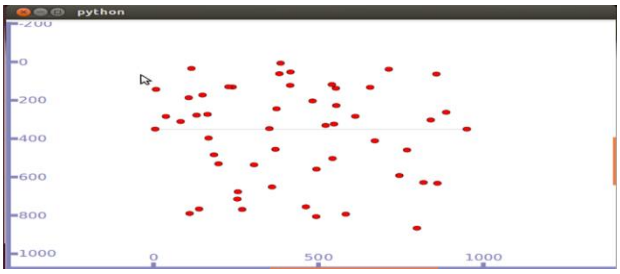

Fig4.1-MANET of 50 Mobile Nodes

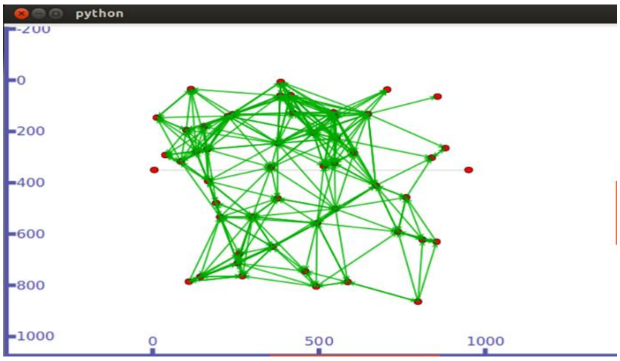

Fig 4.2-Network Sensing

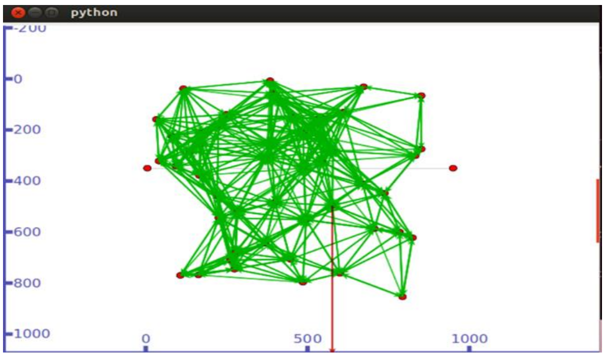

Fig 4.3-Route Request Broadcasting

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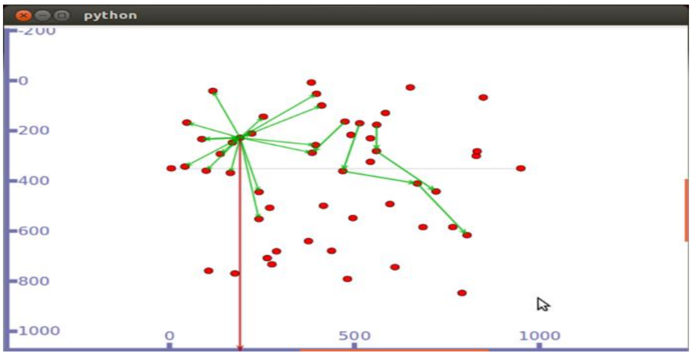

Fig 4.4-Data Transmission and Packet Dropping in Presence of Malicious Attacker

From the visualization point of view, there is nothing to read as performance metrics. Hence the scope of visualization for any research work is very limited; rather the main focus is on performance parameters measurement using traces of simulation. The below section presents the results for each contribution in terms of different performance metrics.

Comparative Analysis

This section presents the comparative results for the density scenario and mobility scenario.

Density Analysis

The second scenario was the varying number of mobile nodes to claim the scalability performance of the proposed routing protocol. We have designed five different MANET networks to evaluate AODV, COCO, and the proposed I-AODV routing protocols such as 50, 100, 150, 200, and 250. Figure 4.5 is showing the throughput performance for each network scenario using each routing protocol. The proposed IAODV shows the throughput improvement as compared to state-of-art routing protocols. Figure 4.6 is showing the PDR performance for each network scenario using each routing protocol. The proposed IAODV showing the PDR improvement as compared to state-of-art routing protocols. Figure 4.7 is showing the delay performance for each network scenario using each routing protocol. The proposed I-AODV showing the delay is minimized as compared to state-of-art routing protocols. Along with delay, jitter is also an equally important parameter for evaluation. Figure 4.8 showing the jitter performance for each network scenario using each routing protocol. The proposed I-AODV showing the jitter is minimized as compared to state-of-art routing protocols. The energy consumption of the mobiles analyzed in the figure 4.9 where the average consumed energy of each routing protocol was measured. It shows the proposed I-AODV protocol reduced the energy consumption compared to AODV and COCO protocols. These performances are improved as the proposed I-AODV protocol overcomes the limitations of basic AODV protocol by incorporating the route formation algorithm using the three different trust parameters such as mobility, distance, and bandwidth availability. In COCO protocol, authors considered only congestion parameters for the route formation which is not sufficient for the stable and efficient routes in MANETs.

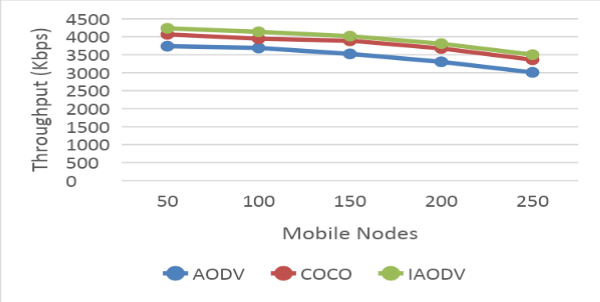

Fig 4.5-Average throughput analysis for density situation

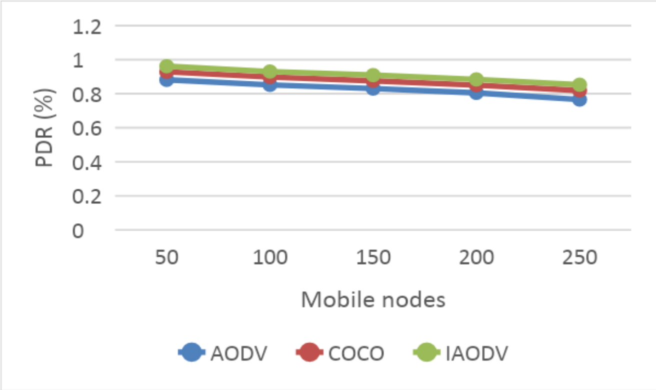

Fig 4.6- PDR analysis for density situation

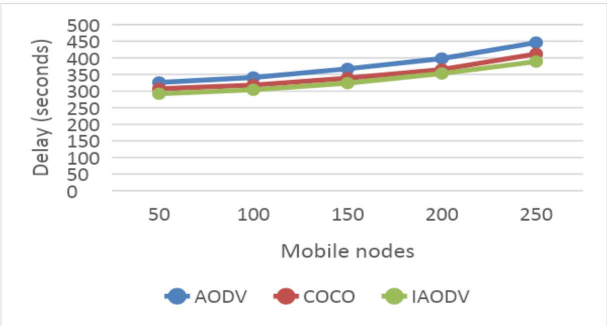

Fig 4.7-Average delay analysis for density situation

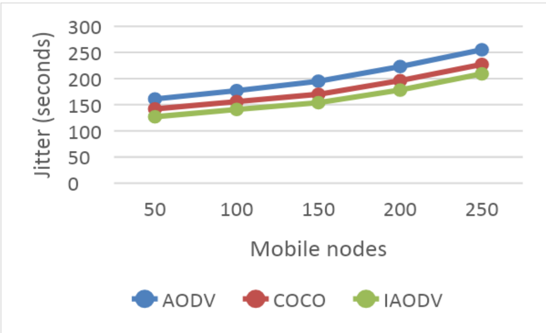

Fig 4.8- Ji-tter analysis for density situation

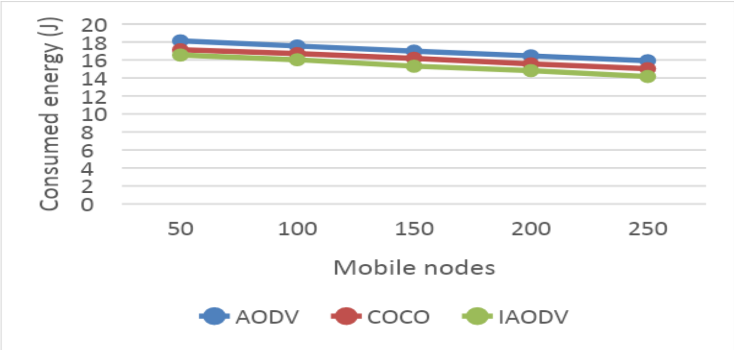

Fig 4.9-Average energy consumption analysis

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Mobility Analysis

This section presents the comparative analysis of the variable mobility situation. we've varied the mobility speed from 15 m/s to 45 m/s with 100 mobile nodes within the same. Figures 4.10-4.14 demonstrate the outcomes for average turnout, PDR, average delay, jitter, and average energy consumption parameters severally. These results, it's proving the projected I-AODV protocol overcomes the AODV and coco protocols considerably.

Figure 4.10 is showing the performance analysis of ways AODV and coco against the projected I-AODV routing protocol in terms of average throughput. For wireless networks it defines the QoS and rate performance. The coco technique is showing its throughput performance is healthier as compared to AODV. The projected I-AODV routing outperforms each coco and AODV routing protocols in each situation of quality speed. The results conjointly indicate that with reference to increasing quality speed, the throughput performances go less. Figure 4.11 and 4.12 square measure showing the performance for PDR and delay for all routing protocols. we've varied the quality speed of mobile nodes by keeping the whole variety of mobile nodes a hundred to every quality speed. The I-AODV protocol is showing improved performance as compared to existing protocols for QoS potency. The performance of I-AODV is showing Associate in Nursing improvement by solely 20-30 of roughly as compared to AODV in variable quality speed eventualities. Similar case is shown in figure 4.13 of ji-tter performance. Also, the notice regarding increasing delay and ji-tter as the quality speed will increase. this means the quality results in frequent routes breaks due that performance gets degraded.

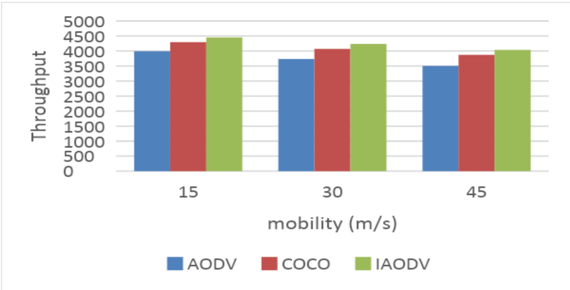

Figure 4.10 Average through-put analysis for mobility situation

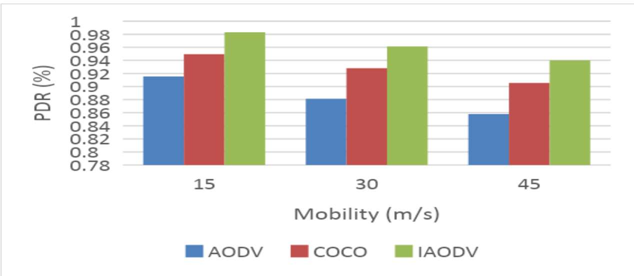

Figure 4.11-PDR analysis for mobility situation

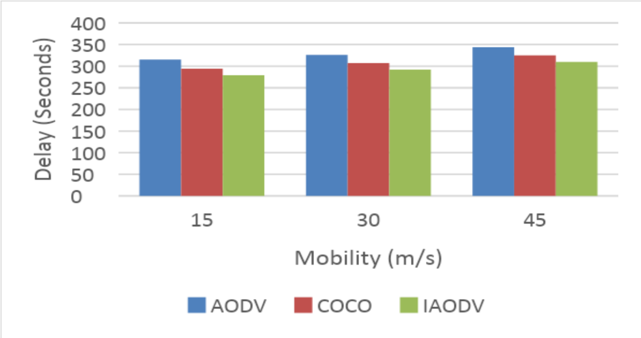

Figure 4.12-Average delay analysis for mobility situation

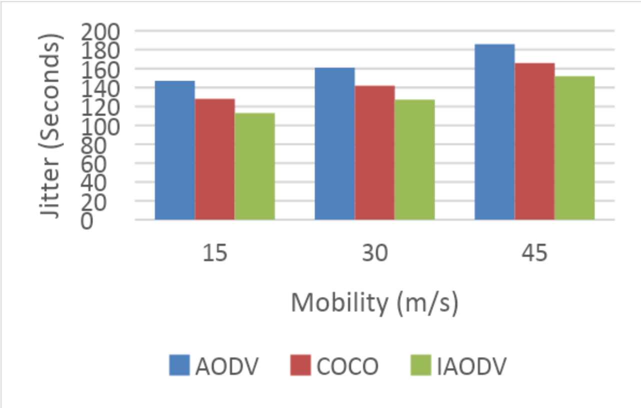

Fig 4.13-Jitter analysis for mobility situation

Finally, the typical consumed energy performance has been analyzed in figure 4.14 that shows that with increase of quality speed, the consumption of energy has inflated additionally. this can be due to the upper range of retransmissions caused by the highquality speed. because the I-AODV protocol was designed considering the mobility parameter, it delivered the lower energy consumption compare to different protocols

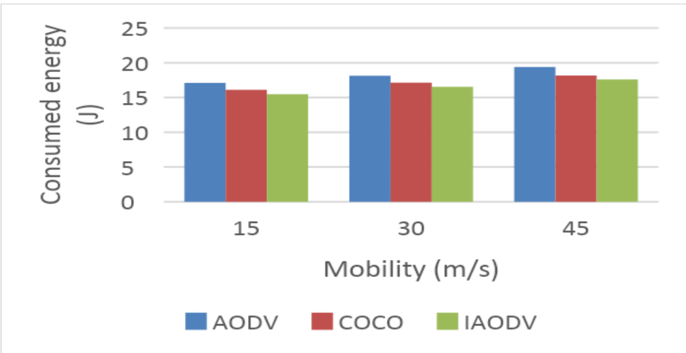

Fig 4.14. Average consumed energy analysis for mobility situation

CONCLUSION AND FUTURE WORKS

In order to increase communication performance in a MANET, efficient path selection is always crucial. Because of frequent route breakdowns in MANET communications, classic MANET routing techniques suffer from increased routing overhead and a lower packet delivery ratio. In our initial contribution to this research, we presented a unique optimization technique-based path selection routing method. We gave a comprehensive literature analysis on MANET route optimization in terms of several characteristics such as mobility speed, energy consumption, load, and so on. The majority of QoS enhancement approaches rely on routing protocol-based algorithms. We began by discussing congestion-based routing techniques for MANET and other wireless networks in order to improve QoS. We have proposed a modified AODV protocol called IAODV in this report. The protocol mainly focused on mobility aware, bandwidth aware, and distance aware route formation to minimize the communication delay, jitter, and energy consumption while improving the PDR and average throughput. The experimental results proved the efficiency of the proposed protocol compared to existing protocols. For future work, we suggest working on security aspects by introducing the different attacks in the network.

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