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IMPROVED-QOS-AODV PROTOCOL PERFORMANCE SIMULATION IN NS-3

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ABSTRACT

In order to effectively alleviate obstacles in mobile ad hoc networks (MANETs) caused by packet loss, congestion management tactics (including routing techniques) and control inflow at the network layer should be combined. The main issue with routing in mobile systems is congestion, which ultimately reduces network performance due to the nature of the wireless network resources' limited accessibility, node mobility, and changing topology of a wireless network. Due to connection failure of mobile node failure, congestion causes packet loss in addition to time and energy waste. A node's mobility, interconnection bandwidth capacity, and location can all be used to detect congestion. We proposed Improved AODV, a novel modified Ad Hoc On-demand Distance Vector, as a conclusion (IAODV). The goal of the IAODV protocol is to identify the multi-objective path that will lessen route congestion and, as a result, packet drops. Numerous trust factors, including the geographical distance to the target node, node velocity, and bandwidth availability, were taken into consideration when developing the route creation algorithm. We determine the integrated ranking for each mobile node while selecting the forwarding relay using dynamic weight-management technique. The I-AODV protocol has a simple layout that lessens the impact of connection issues. The simulation results show how effective the proposed methodology is in comparison to current practises. Due to our measurements, average throughput, the packet delivery ratio (PDR), average end-to-end delay, jitter, & average energy consumption of the proposed protocol and the present protocol.

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

INTRODUCTION

Self-organizing wireless ad hoc networks can be set up without the aid of infrastructure. Mobile Ad hoc Networks (MANETs) constitute autonomous networks of mobile nodes linked together via wireless connections that are independent of the network infrastructure that is currently in place [1–7]. For communication between nodes that are not physically connected by wireless networks, each node functions as both a host and a router, forwarding packets from other nodes. The architecture of ad hoc networks presents a significant challenge for the development of dynamic routing protocols that can efficiently establish pathways between communicating nodes. Due to frequent and unpredictable network topology changes brought on by the high level of node mobility, the routing protocol must be able to keep up [8]. Cooperative communication is a novel area of wireless networking research that has emerged as a result of the interaction between link-quality volatility and the broadcasting nature of wireless channels.

Advantages and Drawbacks

A mobile ad hoc network has some of the following benefits: - Mobile nodes provide access to services and information regardless of their location.

- these networks can readily set up anywhereas well as any time.
- Affordability.
- Development infrastructure requireno any assistance.

The following are few downsides of the MANET network:

- There are lesser Network resources.
- lesser physical security for physical network
- Due to the open nature of MANET, MANET's potential is increased.
- Authorization is not available at present.
- Difficult to detect Malicious due to thevariable network structure.
- Protocols that are used in wired networks arenot applicable in wireless networks.

OBJECTIVE

Particularly on-demand routing systems have drawn a lot of interest because they use less bandwidth over proactive protocols. On-demand Distance Vector (AODV) & Dynamic Source Routing are the two on-demand ad hoc routing systems that have received the most research (DSR). The limitations of the two strategies have been identified by earlier studies. They construct and reliant on a hop-based route for every data session, which is the fundamental cause of this. Both routing protocols must regularly start a route discovery process when a link on the current route fails. The fundamental component of protocols like AODV is route construction. Therefore, the important factors that influence the total network should be taken into consideration when choosing the forwarder node.
Node mobility, bandwidth capacity, and distance to the destination node are examples of performance metrics. Designing the I-AODV protocol to create more dependable routes in MANETs and enhance overall QoS performance is the issue statement for this project.

The following is a list of the main goals of the suggested research on MANETs.

- To simulate and evaluate the effectiveness of the current MANET routing methods.
- To research the various MANET bandwidths-aware routing protocols.
- To suggest a novel route discovery algorithm that uses a trust-based methodology.
- To create the innovative modified routing algorithm for the MANETs utilizing the suggested route discovery algorithm
- To model, simulate, and analyze the efficiency of the suggested protocol.

Review of past work

- By enabling any mobile node to forego packet forwarding or reject RREQ, the authors [53] define the SLA (Simple Load Balancing Technique) approach with the aim of minimising traffic concentration.
- A new approach for determining bandwidth for MANET on-demand routing protocols like AODV was presented by the author of [54] along with yet another innovative load balancing mechanism. In this approach, the destination node selects the most effective path using the path details from the RREQ packet.
- [55] presented a capable routing system for deceitfully managing load balancing and network congestion in MANET. Multiple additional routes between two nodes were found using the suggested strategy. By enabling any mobile node to forego packet forwarding or reject RREQ, the authors [53] define the SLA (Simple Load Balancing Technique) approach with the aim of minimising traffic concentration.
- The cost, stability, and traffic load of the link were calculated based on the available power of the involved nodes. The traffic is divided among different lines when the load on a link hits a predetermined threshold.
- Using bypass route selection, the adaptive reliability and congestion control routing protocol was proposed in [56] to address congestion and route issues in MANETs. The numerous paths are built. Among these, the shortest routes are discovered for efficient data transmission. Congestion is identified based on connection, path, and capacity utilization.
- The authors of [57] proposed the bandwidth aware multipath reactive (BAMR) routing system for mobile ad hoc networks. Ad hoc on demand multipath distance vector (AOMDV) routing protocol was modified for mobile ad hoc networks in the proposed protocol. A proposed protocol called BAMR seeks out routes with enough bandwidth and fewer network failures.
- Congestion control load balancing adaptive routing protocol (CCLBARP) techniques was developed by the authors of [58] to improve network life, latency, and system routing overhead in MANETs.

Summary

This chapter provided an overview of the different facets of MANET routing. Prior to reviewing the QoS-based MANET routing options, we thoroughly examined the AODV and DSR routing schemes.

PROPOSED METHODOLOGY

This chapter describes the architecture and implementation of the I-AODV protocol, which is suggested as a solution to the problems associated with MANET routing while taking mobility and link bandwidth utilisation into account. For reliable routing relay selection in the routing formation algorithm, we have also added the geographic distance parameter in addition to the mobility and bandwidth resources. This section first presents the detailed methodology of I-AODV protocol and then the experimental environment is discussed.

QAODV Protocol

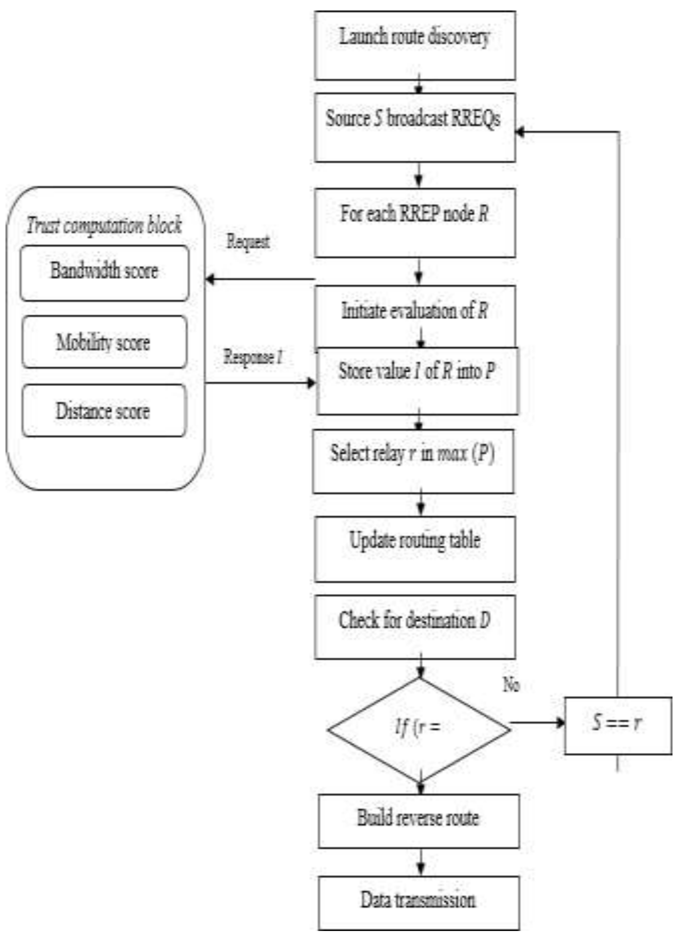


Figure 3.1 Architecture of proposed route discovery algorithm

The proposed protocol's methodology is presented in this section. Figure-3.1 shows the architecture of the reactive routing algorithm in Q-AODV protocol. Each source node in the network periodically starts the route discovery process, as depicted in figure 3.1 and its corresponding algorithm 3.1. The route request messages (RREQ) are therefore broadcast to the closest neighbours. Upon receiving RREP, three parameters, like bandwidth score, mobility score, as well as distance score, are used to analyse each RREP node's behaviours. The evaluation of that specific node is then computed using the integrated trust score. The forwarding relay node will be chosen as the node with the higher score. Until the destination is reached, this process is repeated. The reverse route forms once the destination node is identified, and data transmission then starts.

Notation	**Symbol**
S	Source node
D	Destination node
$RREQ$	Route request
$RREP$	Route response
R	Current node under evaluation
r	Selected relay node
P	Stores the integrated trust value for each R
Q	Computed integrated trust score for R
n	Number of neighbors discovered
$t1$	Trust value for bandwidth factor of R
$t2$	Trust value for mobility factor of R
$t3$	Trust value for distance factor of R

Table-3.1. Symbols used in algorithms.

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 specific amount of time. The current available bandwidth-based trust evaluation of the node R is computed as:

$t1 = 1 - \left(\frac{utilizedBW(R,t)}{maximum\ BW}\right)$ (3.1)

Where, $utilizedBW\ (R, t)$ represents the currently utilized bandwidth of node R at time t. And maximum BW represents the maximum bandwidth set for each node at 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 also the vital as it leads to frequent route operations. Therefore, to build the reliable and stable routes, we need to select the node with minimum mobility speed. We first estimates, the current mobility speed of the node R at current time as:

$speed = getVelocity\ (R,\ t)$ (3.2)

The $getVelocity\ (R, t)$ 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):

$t2 = 1 - \left(\frac{speed}{speed}\right)$ (3.3)

Where, the max speed represents the maximum velocity for each mobile node in the network. In this study, we set 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 related node with minimum geographical distance towards the D. This trust value is computed as given below.

$t3 = 1 - \left(\frac{dist\ (R,D)}{dist}\right)$ (3.4)

Where, the max dist represents the maximum allowable distance for each mobile node in the network. In this study, we set 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 performed as:

$I(R) = w^1 \times t1 + w^2 \times t2 + w^3 \times t3$ (3.5)

Where, $I(R)$ is trust score for node R. The weight components w^1, w^2, and $w^3$are used to covert and normalize the weight of each node in 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 assumptions were taken into account during the research.

- All nodes have equal communication ranges, all links are bidirectional, and all nodes have a perfect communication coverage disc in a two-dimensional space.

- Single-hop communication should be avoided in favour of multihop communication.
- The sensing coverage disc is perfect, and each node has a single mobile.
- Nodes in the network are unaware of their location, orientation, or nearby nodes.
- The first graph, created immediately following deployment using the greatest communication range, is connected.
- It is assumed that each vehicle is aware of it's own direction and moving speed, and that it can locate its position in the network using GPS technology, which is used to calculate the distance parameters.
- Data link layer does not take packet loss into consideration.
- When a node's radio is off, there is a mechanism by which it can be awakened.
- The time units of simulation clock are roughly 1 second, and the network duty cycle is 100%, meaning that the network is constantly active.The Poisson process density, or lambda, is correlated with the network density.
- Two popular propagation models are utilised. two-ray ground propagation model (= 4) and the free space model (= 2).
- The connection between both the nodes is not transitive
- all nodes have equal processing power, transmission range, and other device capabilities
- nodes are identified by fixed IDs.
- Nodes are unrestricted in their movement within the network and are free to leave or join at any time.
- The availability of the routes described in the thesis limits the transmission range of all network nodes from source to destination.
- Because there are no malicious invader nodes, all of the nodes establish mutual trust by using predetermined keys.
- While being transmitted over a wireless network, packets could be lost or harmed.
- The assumption that mobility is low is used to evaluate the routing protocol.
- In order to gain a fundamental understanding of how the load balancing routing protocols behave in various circumstances, a variety of evaluation scenarios will be used.

Simulation Tool

The first section of this section will give an overview of all such networks along with their usage, benefits, and drawbacks of using it. According to the dictionary, the term "simulation" refers to the reproduction of essential functions of something that is aid to learning or training. In order to simulate the work, we must choose one of them, based on their availability and compatibility with the problem.

Table-3.2 Comparison of the network simulators

Simulator	**Free**	**Open Source**	**Program Language**
NS-3	Yes	Yes	C++,TCL
GloMoSim	Limited	Yes	Parse
Opnet	No	No	C

NS 2 is selected because of the following advantages of utilizing it:

1. Open Source & free software for the simulations.
2. Easily available for the download & installation.
3. Programming is done in C++.
4. More features implemented for the simulation.

System Requirements

The system requirements for this work, taking into account the software & hardware components, are, according to the simulation tool chosen:

- Software Requirements
- Ubunto 12.04
- Ns-allinone-3.34
- Virtual machine 8.0
- Bonn Motion [210]
- Hardware Requirements
- 20 GB free space of HDD
- 3 GB of RAM
- Installation Assumptions

A. Windows is installed in C drive

Network Scenarios and Performance Metrics

I've created networks for two different network configurations with varying mobility and density.

The list of model parameters including both scenarios is shown in Tables 3.3 and 3.4.

Table-3.3 Network parameters for mobile nodes densityvariation

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 priqueue
Routing protocols	AODV, COCO [59], and IAODV

Table 3.4. Network parameters for node velocity 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 priqueue
Routing protocols	AODV, COCO [59], and IAODV

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: This measurement works out the all-out number of parcels conveyed each second for example complete number of messages which are conveyed each second. The normal throughput in Kbps is:

$$T = \left(\frac{R}{T^2 - T^1}\right) \times \left(\frac{8}{1000}\right) \tag{3.6}$$

Where R is finished gotten bundles at all objective hubs, T^2 is reproduction stop time & T^1 re-enactment start time.

2. PDR: It is the computation of the proportion of parcel got through the objections which are sent through the different wellsprings of the diverse traffic designs. It is figured as:

$$P = \left(\frac{P_r}{P_g}\right) \times 100 \tag{3.7}$$

Where, P_r are number of received packets & P_g number of generated packets?

3. Average Delay: This measurement works out the normal time between the parcel start time at the all sources & the bundle arriving at time at the all-objective hubs. It is figured as:

$$D = \frac{\sum_{i=1}^{N} \quad d_t^i + d_p^i + d_{pc}^i + d_q^i}{N} \tag{3.8}$$

Where N is number of complete transmission joins, d^i_t is transmission deferral of i^{th}link, d^i_p is proliferation postponement of i^{th}link, d^i_{pc} is handling postponement of i^{th}link, & d^i_q is transmission postponement of i^{th}link.

SIMULATION RESULTS AND DISCUSSIONS

In accordance with the goals of the proposed research, we have simulated, evaluated, and compared the proposed IAODV protocol with two other routing protocols, AODV and COCO [59]. The MANETs that we have created have different mobile nodes and mobility rates. Various network scenarios, such as those with varying mobility speeds and numbers of mobile nodes, have been prepared to assess the dependability and effectiveness of the suggested routing methods, as was discussed in chapter 3. Before presenting the graphical results, we first discuss the visual results.

Visual Results

We utilised the NS3 visualizer model for network visualisation. The visualisation snapshots are displayed in the figures below from 4.1 to 4.2. The system model depicted in Figure 4.1 is one in which 50 mobile nodes are dispersed at random over a 1000x1000 network area. Within this space, the mobile nodes are sporadically moving with respect to time. As soon as the simulation begins, the network's mobile nodes begin sensing their own frequencies and, as a result, their nearby mobile nodes. Figure 4.2 depicts this process. According to a MANET property, every mobile node senses the mobile nodes of its neighbours for communication purposes. Figure 4.3 shows two examples: the route request broadcasting process and congestion indication. The green lines represent the typical packets that are broadcast among the nodes to choose the routing path. The red lines represent the effects of network congestion and packet drops.

Figure 4.4, similarly shows data communication via the selected paths (green lines) & packet loss (red lines) because of the presence of congestion in the network.

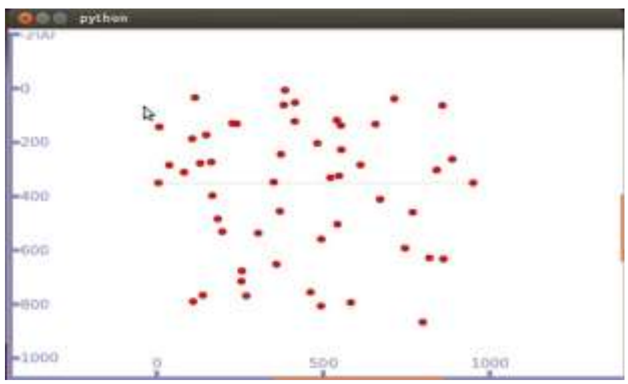


Figure 4.1-MANET of 50 Mobile Nodes

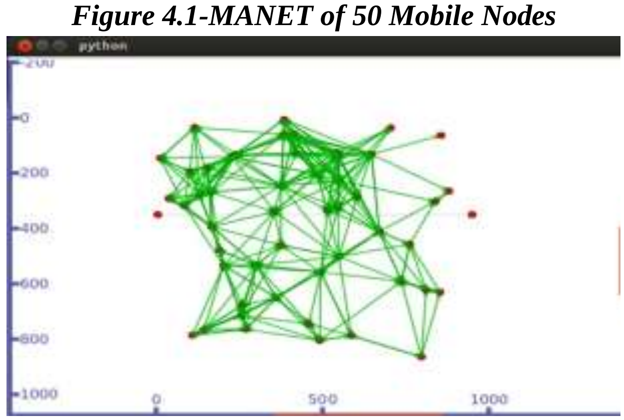


Figure 4.2-Network Sensing

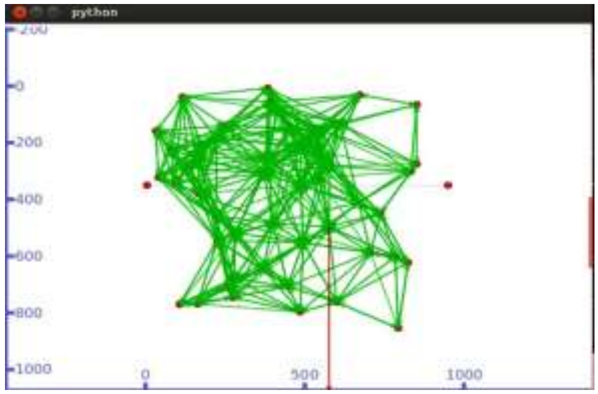


Figure 4.3-Route Request Broadcasting

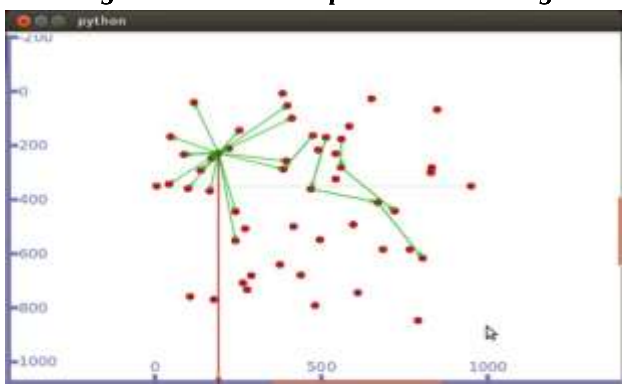


Figure 4.4-Data Transmission and Packet Droppingin Presence of Malicious Attacker

Nothing can be interpreted as performance metrics from the standpoint of visualization. As a result, the scope of visualization for any research project is very constrained; instead, performance parameter measurement using simulation traces is the main focus. The results for each contribution are shown in the following section using various performance metrics.

Comparative Analysis

This section discusses the comparative resultsof the density scenario & mobility scenario.

Density Analysis

The second scenario involved varying numbers of mobile nodes to demonstrate the proposed routing protocol's scalability. To test AODV, COCO, and the proposed I-AODV routing protocols, such as 50, 100, 150, 200, and 250, we created five different MANET networks. The throughput performance for every network scenario using this routing protocol is displayed in Figure 4.5. The proposed IAODV demonstrates an increase in throughput when compared to cutting-edge routing protocols. The PDR performance for each network scenario using each routing protocol is shown in Figure 4.6. When compared to cutting-edge routing protocols, the proposed IAODV shows an improvement in

PDR. The delay performance for each network scenario using each routing protocol is shown in Figure 4.7. The proposed I-AODV demonstrates that the delay is reduced when compared to cutting-edge routing protocols. Jitter is a parameter for evaluation that is equally important to delay. The jitter performance for each network scenario using this routing protocol is shown in Figure 4.8. The suggested I-AODV demonstrates that jitter is reduced when compared to cutting-edge routing protocols. The energy usage of the mobile devices was examined in figure 4.9, where the average energy consumed by each routing protocol was determined. It demonstrates that the proposed I-AODV protocol used less energy than the AODV and COCO protocols. These performances are enhanced by the fact that the proposed I-AODV protocol incorporates the route formation algorithm by using three different trust parameters, such as mobility, proximity, and bandwidth availability, to get around the shortcomings of the basic AODV protocol. Only congestion parameters were taken into account when developing the COCO protocol's routes, which is insufficient for MANETs' need for reliable, effective routes.

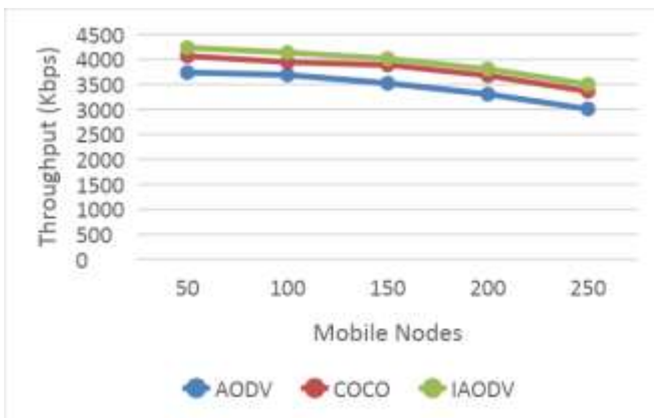


Figure 4.5-Average throughput analysis for density scenario

Figure 4.6- PDR analysis for density scenario

Figure 4.7-Average delay analysis for density scenario

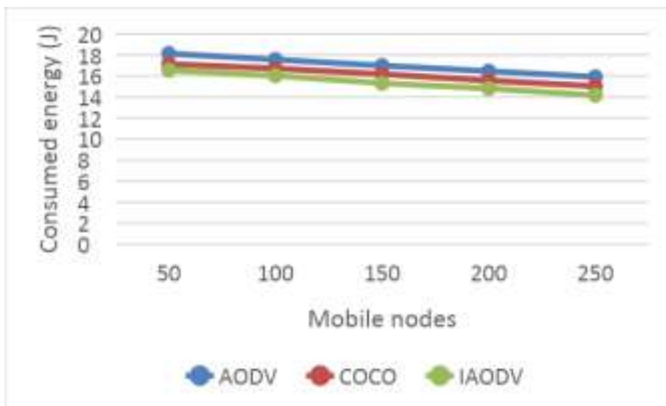


Figure 4.8- Jitter analysis for density scenario

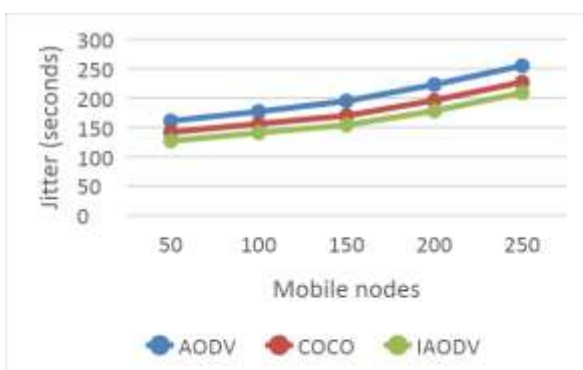


Figure 4.9-Average energy consumption analysis

Mobility Analysis

The comparative analysis for the various mobility scenarios is presented in this section. With 100 mobile nodes operating at the same time, we have changed the mobility speed from 15 m/s to 45 m/s. The results for the average throughput, PDR, delay, jitter, and energy consumption parameters are shown in Figures 4.10–4.14 in that order. These findings demonstrate that the proposed I-AODV protocol significantly outperforms the AODV and COCO protocols.

In terms of average throughput, Figure 4.10 compares the performance of the AODV and COCO methods to the suggested I-AODV routing protocol. Throughput determines the quality of service and data rate performance for wireless networks. When compared to AODV, the COCO method exhibits better throughput performance. In every case of mobility speed, the proposed I-AODV routing protocol performs better than both COCO and AODV routing protocols. The findings also show that throughput performances decrease as mobility speed increases.

The performance for PDR & delay across all routing protocols is shown in Figures 4.11 and 4.12. By maintaining a ratio of 100 mobile nodes per mobility speed, we were able to vary the mobility speed of the nodes. When compared to other protocols, the I-AODV protocol performs better in terms of QoS effectiveness. When compared to AODV, I-performance AODV's only slightly outperforms it in scenarios with varying mobility speeds, by about 20 to 30%. Similar circumstances are depicted in jitter performance figure 4.13. Additionally, the warning about growing jitter and delay as mobility speed increases. This shows that mobility causes frequent route interruptions, which lowers performance.

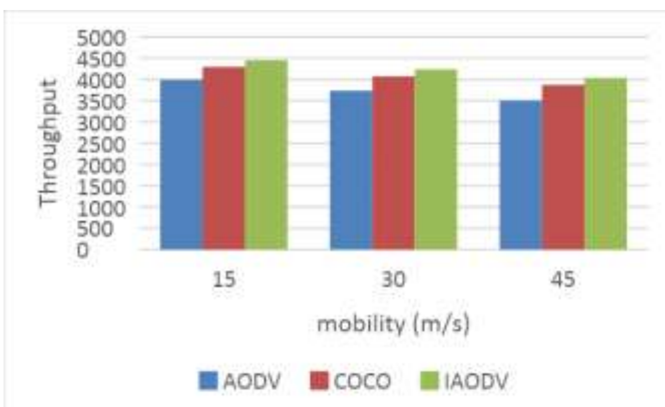


Figure 4.10 Average throughput analysis for mobility scenario

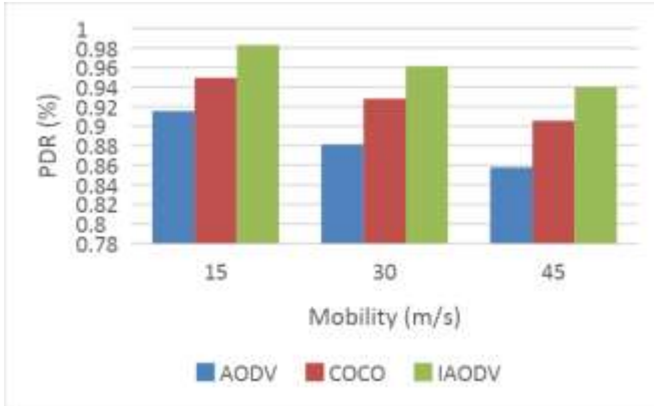


Figure 4.11-PDR analysis for mobility scenario

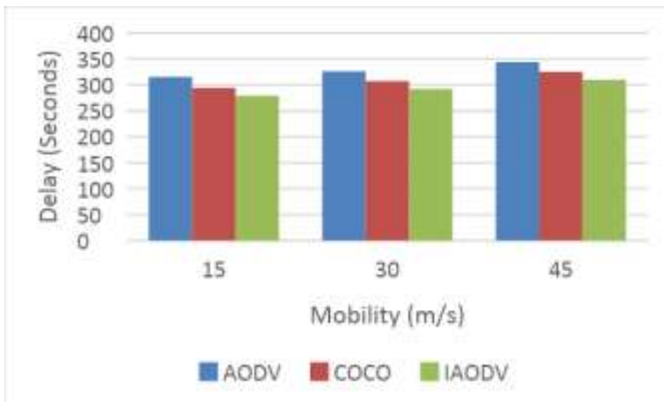


Figure 4.12-Average delay analysis for mobility scenario

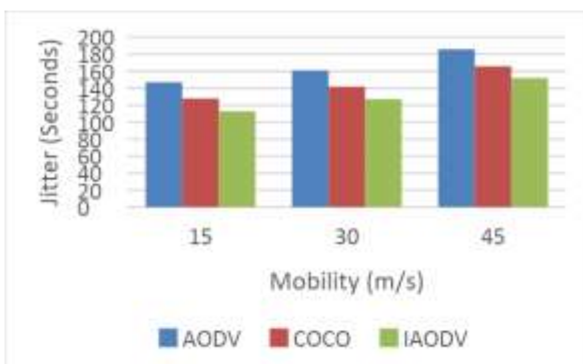
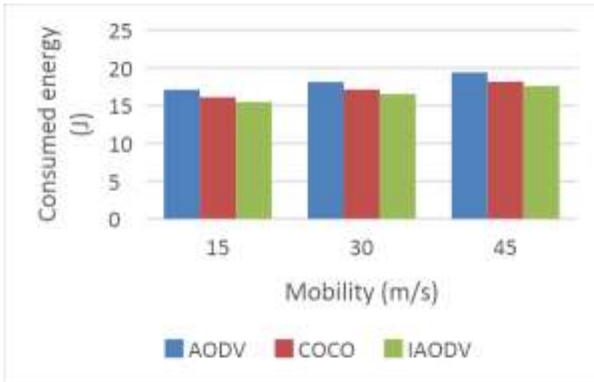


Figure 4.13-Jitter analysis for mobility scenario

Figure 4.14, which analyses the average performance of energy consumption, demonstrates that as mobility speed has increased, so has energy consumption. This is because the high mobility speed leads to a higher rate of retransmissions. Since then I-AODV protocol was created with the mobility parameter in mind, it consumed less energy than other protocols.



CONCLUSION AND FUTURE WORKS

A MANET's ability to communicate more effectively depends on effective path selection. Traditional MANET routing techniques suffer from increased routing overhead and a lower packet delivery ratio due to the frequent route breakdowns in MANET communications. In our initial contribution to this research, we presented an original path selection routing method based on an optimization technique. We provided a thorough analysis of the literature on MANET route optimization in terms of a number of factors, including mobility speed, energy consumption, load, and other factors. The majority of QoS improvement strategies rely on algorithms built on top of routing protocols.

In order to enhance QoS, we started by talking about congestion-based routing strategies for MANET and other wireless networks. In this report, we suggest a modified AODV protocol called IAODV. To reduce communication delay, jitter, and energy consumption while increasing PDR and average throughput, the protocol primarily focused on mobility aware, bandwidth aware, and distance aware route formation. The effectiveness of the proposed protocol in comparison to other protocols was demonstrated by the experimental results. We advise focusing on security issues in subsequent work by introducing various network attacks.

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