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An Approach for Scaling Down the Control Packet Load of AODV Routing by Adopting WRS Model for MANETs

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Abstract

Background/Objectives: A MANET is collection of mobile hosts that often change paths. AODV routing is best for establishing route. There are issues with broadcast storm like contention, collision and interference. They deteriorate performance of QoS. For setting a path, it is necessary to broadcast RRPs, which lead to consumption of bandwidth, congestion and contention. The aim of broadcasting is to decrease flooding. MANETs have limited bandwidth hence necessary to decrease the amount of flooding. **Methods:** AODV transmits RRPs to adjacent nodes for setting up a route and thus enhances the consumption of network bandwidth. Our approach uses weights assigned to nodes depending on the set of rules framed for determining an appropriate path. The proposal is integrated with AODV with information about 2-hop neighbors. This helps in establishing efficient forward path, thus reducing redundancy. **Findings:** The limited availability of bandwidth in MANETs, it's necessary to reduce control packets and considered many parameters for simulation. The outcome of proposed approach is compared with RS-AODV considering conditions like collisions, broken links, energy consumption end-to-end delay and RRPs. Ad hoc networks are found to be constant for a specific period of time and this helps in collecting neighbor node information. This determines an efficient path has been established, thus reducing the packets being broadcasted. **Novelty:** WRS mechanism is discussed in this paper for reducing the packets being transmitted in the prevailing AODV routing. The simulation exhibits that WRS-AODV approach is 3% energy efficient, throughput achieved with 20.4% enhancement and 65% reduction in the packets being transferred. A mathematical approach for addressing uncertainty and ambiguity, which also takes into consideration the importance of object, is WRS theory. NS-2 used shows to be effective for the proposed model in terms of performance for parameters like throughput, broken links, collisions, end-to-end delay, RRPs and energy consumption.

Keywords: Broadcasting; Flooding; MANET; Weighted Rough Set; AODV; Neighbor Coverage

1 Introduction

A collection of mobile wireless devices that work together in transmitting packets on another's behalf constitute a Mobile Ad hoc Network (MANET). This does not necessitate any kind centralized management or stable infrastructure. This exclusively repairs itself, however. The use of MANETs has wide range possibilities for applications, including military communications, rescue services and meetings. Mobile communications have grown increasingly popular, and there have been significant developments in the field of mobile technology. Because of this, during the past few years, MANETs have become significantly more important in society. Every node operates as either a host or a router, so that it may receive a packet and send information to every node in the topology. With increase in the usage of mobile devices, adequate utilization bandwidth is considered a difficult task. Most of the existing routing techniques discussed in the research, didn't focus on the effective utilization of bandwidth in real-time usage. Blind flooding is a simple technique of broadcasting packets. Every node is required to retransmit packet whenever it receives a new packet. It ends up with transmitting multiple redundant packets. This causes broadcast storming issue. Contention problem arises with broadcast storming and leads to collision issues. Researchers have proposed variety of solutions for resolving broadcast issues which include selective forwarding, Location-Aided Routing, and PANDA. Most researchers further discovered a variety of heuristic techniques that were primarily based on counters, probabilities, and functions. In a selective forwarding strategy, 1-hop neighbors are chosen arbitrarily in order to ensure they cover all of the 2-hop neighbors. Majority of the available protocols are split in two categories namely proactive or reactive protocols. Reactive or on-demand protocols require the route to be discovered only when it is required/needed. Flooding mechanism requires the route request packets to be broadcasted throughout the mobile network. In contrast, proactive protocols need to periodically exchange routing information and every node needs to maintain complete knowledge of the network. DSR and AODV algorithms employ flooding-based mechanism with a query-reply approach for searching new routes. It is considered that LAR is best when compared to DSR and AODV. In contrast to DSR and AODV, Location Aided Routing (LAR) offers improvement. LAR approach decreases the load on flooding, by simply making use of the information about the position of a node.

PANDA is an approach that intends at determining the positional information for delay in rebroadcast. According to this technique, a node locates the best candidate nodes making use of the parameters like velocity and location. The paper discusses about WRS. It is a mathematical construct that is used to classify the nodes which employ neighbor knowledge-based approach much effectively and efficiently. Weighted Rough Set (WRS) method is proposed protocol in our paper. This technique is proposed to decrease the amount of flooding that prevails in AODV routing. The candidate node set identified by this approach after evaluating the correlation between one-hop and two-hop neighbors. The Weighted Rough Set model (WRS-AODV) produced better results than the Rough Set model (RS-AODV), by considering the importance of each node in the network. The results obtained were compared with the proposed WRS-AODV and RS-AODV and demonstrated that it performed better than other protocols implemented earlier. The parameters considered for comparison included broken links, energy consumption, and throughput, number of collisions, end-to-end delay and route request packet.

Fundamentally the process for discovering a route in MANETs with reactive protocols is the broadcasting approach. This approach performs broadcasting using blind flooding. The major problem that needs to be dealt with is to decrease the number of rebroadcasts. This also requires that we need to maintain the amount of retransmissions and also consider that the packets are reaching the destination without any delay. It is necessary that we acknowledge that with increase in the number of rebroadcasts, there is a possibility of increase in reachability of the packets to the destination. But we also need to consider about the degradation of the performance of the protocol because of wastage of the bandwidth and increase in the number of collisions. Alternatively, limiting the number of retransmissions would result in decreasing the reachability. This is due to the separation of the retransmission wherein only few nodes will be able to receiving the packets. Thus the problem to be addressed here is about finding a way to decrease the number of rebroadcasts at the same time preserving reasonable bandwidth and delivery of packets to the destination node.

This research paper is conferred regarding our proposal by blending it with traditional AODV protocol by virtue of 2-hop neighbor information. The main objective is to reduce the redundancy in the number of retransmissions of the packets. The remaining paper is organized as various sections. The working of WRS, mechanism for use in MANETs and the mechanism used for WRS approach towards AODV routing is discussed in Section 2. The results and discussion are discussed in Section 3. Section 4 is about the conclusion and discussion about the proposed approach with existing work.

2 Methodology

Rough Set Based [1–4] routing and Fuzzy [5–8] technique were the approaches used by the researchers for MANETs in the past. Most of the existing protocols are based upon the information contained in a node for selecting the next node through which data packets can be transferred namely DSR+, DSR β. RS-AODV routing protocol uses the information of the node for selecting the neighboring nodes in order to transmit control packets for acquiring accurate path towards destination. In order to reduce the amount of flooding in network, limited number of forward nodes is selected. In order to achieve this Neighbor-Knowledge-Based algorithms are used. This set is considered to be Connected Dominating Set [9]. A dominating set is one where either all nodes in the network are in the set or its neighbors are part of it (set). The main purpose for selecting set of forward nodes in the network is to see that a perfect set is formed even in the absence of stable infrastructure. Most of the research and the literature available, it is identified that in order to determine CDS, the researchers used two approaches. One approach called Self Pruning [9] obtained the information of the neighboring nodes by one-hop technique. The other approach called Dominant Pruning [10,11] used two-hop technique.

Neighbor-Knowledge-Based technique is another way of determining the CDS. There are two means of implementing Neighbor-Knowledge-Based approach namely neighbor-designating [12] and self pruning [9]. The status of forwarding the packet for any node is decided by its neighboring nodes and this method is called neighbor-designating. In this method, the sender chooses its one-hop neighboring nodes from the subset as the forwarding nodes so that it can visit all its neighboring two-hop nodes. Every single node in self-pruning approach assesses the status of forwarding information on a local basis and decides whether to forward or not. All or most of the algorithms discussed are established on identical concepts. However, these concepts are acknowledged or considered in depth. Selective broadcasting is among the most preferred routing protocol for ad hoc networks.

Much work related to Dominant Pruning, Partial Dominant Pruning and Total Dominant Pruning algorithms were carried out by researchers. Most of them proposed the use of two-hop neighboring node data for determining the dominating set. Another algorithm APDP which is an enhancement of the PDP analyzes the adjoining and identical nodes in the network.

The proposal in this paper is with regard to establish identical node by the proposed WRS model. This model determines the identical nodes using both one-hop and two-hop neighboring nodes by using equivalence relation. In our proposal, WRS model is employed for determining the RREQ forwarding node which would be the best amidst all the current neighbors in the network [13]. This mechanism involved in WRS model is capable of regulating the excessive usage of Route Request in AODV by excluding all the unnecessary RREQ to receiver node.

2.1 Functioning and Implementation of WRS

Let us observe universal set U consisting of elements. Let the information system be represented by the relation I = (U, A, V, ρ), with A representing attributes consisting of non empty finite set, $V = \cup_a \varepsilon_A V_a$ represents values for the attributes. V_a is considered to be domain for attribute a. A domain is considered to constitute all feasible set of values. $\rho: U \times A \rightarrow V$ represents information function. The information function is represented for any attribute a for any element x in the same way that x ε U, $\rho(x, a)\ \varepsilon\ V_a$.

Decision system is expressed by I = (U, A, V, ρ). For attribute d where d ε A then d is considered as decision attribute. Then we calculate the set of conditional attributes where A - {d} is considered to be a set.

Based upon the definitions stated in Rough Set Information System, the above conditions have been stated. Our proposal adopts the node information system available at every node related to its neighboring nodes. Thus the obtained information is transformed into its equivalent weighted information.

2.2 Model Adopted for WRS

The model of Rough Set is modified to WRS model, where the proposed WRS model deals with scaling down the noise associated with model of Rough Set. The proposed approach also keeps in consideration about the nodes priorities. Every node is assigned with a weighted factor that shows the significance of the node. This is exclusively required to prioritize the rules being formed for actual requirement of the information system. The node information system is used as a record of the information about each node in the network. Among all the recorded information, on record implies a rule that is to be considered. This rule is considered as a condition for transmitting RREQ towards the receiver node. Most of the proposed approaches do not have any specific rule and most of them are expressed by a simple weighted coefficient w.

Let us consider that there are two sets F1 and F2. Also considering that each of these two sets has elements in each and that they reside in Z boundary zone as shown in Figure 1. Let the element in F1 that doesn't reside in Z and the element residing in F2 is a part of Z may contain a noise within. Let's consider Figure 2 where, when noise is decreased F1 falls almost in the positive region of Z and F2 now is almost a part of the negative region of Z.

In an effort for strengthen the accuracy of the proposal; weighted coefficient is adopted in WRS model. The following section discusses about two better approaches for achieving better results.

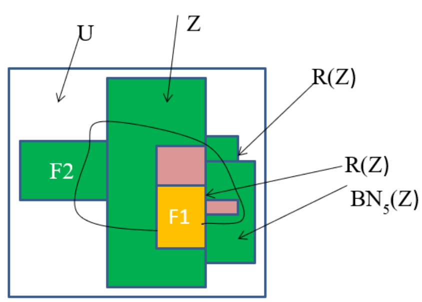

Fig 1. Cause of noise due to the boundary zone

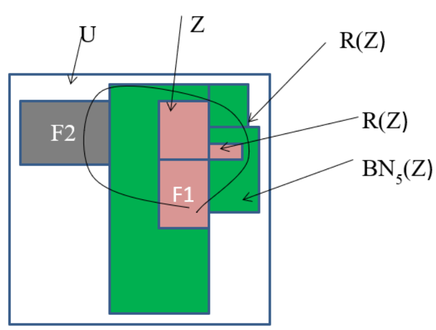

Fig 2. Boundary zone decreased due to elimination of noise

The first approach is to make use of the rules of the current system. Considering that m rules exist for a domain at the same time. Let us take into consideration the i^{th} domain, then

if $T_j(x_i) = 1$, then it indicates that the rule x_i is accepted by the j^{th} expert

if $T_j(x_i) = 0$, then it indicates that the rule x_i is rejected by the j^{th} expert

At the end, the cumulative value of all experts' opinion is considered as

$T_j(x_i)$, $j = 1, 2, 3, \ldots, n$, can be expressed by the equation

$$w(x_i) = \sum_{j=1}^{n} T_j(x_i) \quad (1)$$

The second approach is based on the rule's significance. In this approach, first we have to construct a set of rules for a domain. Let us consider the i^{th} domain. The next step would in accordance to the rules framed. Here, we select a significance factor for all depending on the resources available for each rule.

In our proposal, we use $\mu_j(x_i)$ which denotes the experts assigned rules defined for x_i significance for all $0 < \mu_j(x_i) < 1$. For the stated rule x_i , all the experts opinions are added. With this, for the rule x_i, the significance can be expressed as follows

$$w(x_i) = \sum_{j=1}^{n} \mu_j(x_i) \quad (2)$$

It is observed that both the approaches have the same ability to produce the results. The principle behind the two approaches is to designate similar significance factor for all the rules framed. All the corresponding rules should be verified and the weighted coefficient w should be normalized, as the relative factor is considered as the weighted coefficient.

2.3 Applications of WRS

The operations on data mining, knowledge discovery and decision analysis are the different applications wherein Rough Set can be used efficiently. Based on the previous knowledge, primary intention of data mining, ML, knowledge discovery, pattern recognition is to consolidate the likeliness with regard to targets. The incomplete knowledge is further divided into lower and upper likeliness by the use of the Rough Set Model. The boundary region is one that lies in between the upper and lower likeliness. WRS model is implemented with the intention to diminish the noise as proposed in basic Rough Set approach.

2.4 Formation of the WRS for use in MANETs

Consider a network, where P is defined as a group of mobile hosts. A route is defined by pathway between the all nodes in the network P. The network is considered to have nodes $p_1, p_2, p_3, p_4, \ldots, p_n$, where $p_i \varepsilon$ P and I = 1, 2, 3, 4,…., n. let us consider that $x_1, x_2, x_3, \ldots x_n$ are the set of attributes represented by Q. In order to have an efficient and competent routing, these attributes are formulated. The attributes are based on various factors like pause time, speed location etc for a particular mobile at a given time period. A rule will be formed for every attribute based on a certain threshold value. The threshold levels have been chosen in accordance with the resources that are accessible a given point of time. In this manner, all nodes preserve the neighborhood node information. This is shown in Table 1, considering the notion P x Q $\rightarrow$ V, where V defines a group of conditional values that could be used. The corresponding value for every node I (M, A) would be either 1 or 0 depending on the value of the attribute.

2.4.1 Weighted Information System (WIS)

It is designated by S. S is considered to be an ordered pair consisting of the following attributes.

$$S = < U, A, V, f, w >$$

Where, U is defined as finite set. It is also assumed that U is non-empty set. Let A = $C \cup D$, conditional attribute set is designated by C. D is considered as conclusion attribute set. Assume that C $\cap$ D = ϕ. Let attribute set be denoted by V. Also assume, that arbitrary value is denoted a. Let x_i be considered as an arbitrary object and the function f(x_i , a)denotes the value of the attribute x_i and w is considered as the object's weighted factor.

2.4.2 The Rough Membership

Considering the WIS, X denotes a non-empty subset. This subset is obtained from a finite universe U. The membership for x ε U with reference to X can be calculated using the equation.

$$\mu^R X(x) = \frac{\sum w\ i, xi\ \varepsilon X \cap \lfloor X \rfloor R}{\sum w\ i, xi\ \varepsilon \lfloor X \rfloor R}, x \in U \quad (3)$$

This is possible when w_i = 1. The equation stated in (3) is considered as the basic Rough Membership.

- **Lower Approximations**

It is represented by the equation for M as

$$R_\alpha(X) = \left\{ \left(x \mid \alpha^R X^x\right) \geq 1 - a \right\}, 0 \leq a \leq 0.5 \quad (4)$$

- **Upper Approximations**

It is represented by the equation for M as

$$R_\alpha(X) = \left\{ \left(x \mid \alpha^R X^x\right) a \right\}, 0 \leq a \leq 0.5 \quad (5)$$

In accordance to the proposed technique, an association amidst one-hop and two-hop nodes has been employed to split the neighboring nodes into lower approximate set and upper approximate sets for the given nodes. Multiple steps can be employed in order to classify the process for establishing the lower and upper estimates. Establishing the rules is chosen as the first step. The rules' constructed values have been assigned with significance value during the second stage. Upon extraction of the rules, they are tested using an algorithm.

With the help of the Weighted Rough Set, the relationship between the inputs and the outputs is given by the relation$y = f(G, N, R)$, the output represented by y. The input is fragmented in terms of weight and represented by G. N represents the complete list of rules. R represents agreed upon rules. The following algorithm describes the use of rules in the proposed approach.

If the node is having battery power >= 200
Assign the weight w1; otherwise assign 0
If node is having a traffic <= 1500
Assign the weight w2; otherwise assign 0
If the node is having pause time >= 50
Assign the weight as w3; otherwise assign 0
If the nodes relative distance is <= 30
Assign the weight w4; otherwise assign 0

2.5 WRS Design

The Weighted Rough Set transforms the present neighboring nodes in these two subsets. The control packets are forwarded from either sender or intermediate node to lower approximate nodes. From among lower and upper approximate nodes, the lower approximate nodes are considered as the best choice.

The strategy proposed in our model uses the two-hop neighborhood information for calculating the lower and upper approximations. As stated in equation 1, the WRS model separates approximates depending on the weight assigned to the node. Based on information obtained from the node's two-hop neighborhood, weight of node is normalized between the values 0 and 1. Based upon the equations stated in 2 and 3, nodes are categorized into upper and lower approximations.

Let us look into an example considering an ad hic network with 12 nodes as depicted in Figure 3. Every node in the network has a set of neighboring nodes. Let us consider node 6 which is identified by the neighborhood nodes with 2, 5, 9 and 7.

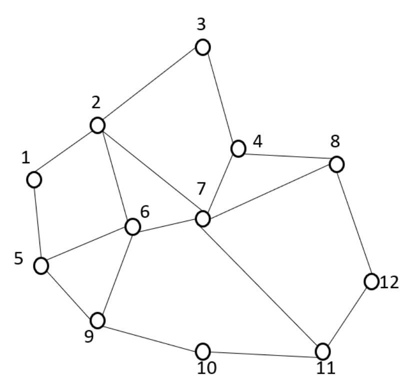

Fig 3. An ad hoc network comprising 12 nodes

Table 1 shows various node attribute parameters like pause time, battery power, traffic, the relative distance between destination and its different neighboring nodes. In accordance with the rough set mechanism rules, the values considered in Table 1 are reconstructed to Rough Set information. A predefined weight is assigned for every rule. As mentioned in equation 1, the corresponding measures are evaluated for each of the one-hop and two-hop neighbors. These measures are used to identify the approximations of the lower and upper values. This is done considering the equations stated in equation 2 and 3.

Table 1. Neighbor node information with one-hop and two-hop neighbors for node 6

Node number	Pause time in seconds	Traffic in bits / seconds	Relative Distance ΔR_t (M)	Power of the battery in Watts
2	10	1000	10	100
5	20	1500	20	200
9	30	2500	5	500
7	40	2000	40	100
1	11	2000	30	600
3	20	9000	40	700
4	30	2000	23	100
6	40	1002	45	200
8	50	3000	45	300
10	60	2003	24	400
11	20	1000	100	500

Table 2. Rough Set Node Information System

Node number	Pause time in seconds	Traffic in bits / seconds	Relative Distance ΔR_t (M)	Power of the battery in Watts
2	0	0.5	0.75	1
5	0.25	0	0.75	1
9	0.25	0	0.75	1
7	0.25	0	0.75	1
1	0.25	0.5	0.75	1
3	0.25	0.5	0.75	1
4	0.25	0.5	0.75	1
6	0.25	0.5	0.75	1
8	0.25	0.5	0.75	1
10	0.25	0.5	0.75	1
11	0.25	0.5	0.75	1

2.6 Routing Based on the Weighted Rough Set

The neighborhood node information is employed to construct a route based on the proposed routing protocol. Furthermore, the node information gets modified every time the topology is reconstructed. Every node makes use of the neighborhood node information before delivering any control data to its subsequent node. The neighborhood nodes are split into lower and upper approximation nodes based on the concept of Weighted Rough Set model. The lower approximation set of nodes are identified to transfer the control information.

2.6.1 Implementation of the Weighted Rough Set Model for AODV

Use of the proposed strategy aims is to decrease the redundancy in flooding observed in the Route Request Phase (RREQ) of AODV. Several approaches are used to determine the connection between the existing nodes in the normal AODV protocol. This includes a technique where hello messages are sent as local broadcast.

Our strategy uses a method which sends a distinct hello packet whenever it identifies a change in the network topology. This packet while traversing the network carries within it the current status of the neighborhood node and transmits the

Table 3. The neighborhood node information for every node with a two-hop

V	N(v)	N(N(v))
1	1, 2, 5	1, 2, 3, 5, 6, 7, 9
2	1, 2, 3, 6, 7	1, 2, 3, 4, 5, 6, 7, 8 , 9, 11
3	2, 3, 4	1, 2, 3, 4, 6, 7, 8
4	3, 4, 7, 8	2, 3, 4, 6, 7, 8, 11, 12
5	1, 5, 6, 9	1, 2, 5, 6, 7, 9, 10
6	2, 5, 6, 7, 9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
7	2, 4, 6, 7, 8, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
8	4, 7, 8, 12	2, 3, 4, 6, 7, 8, 11, 12
9	5, 6, 9, 10	1, 2, 5, 6, 7, 9, 10, 11
10	9, 10, 11	5, 6, 7, 9, 10, 11, 12
11	7, 10, 11, 12	2, 4, 6, 7, 8, 9, 10, 11, 12
12	8, 11, 12	4, 7, 8, 10, 11, 12

information to the neighboring nodes. All the neighbor nodes maintain a routing table within it for improving the response time in transmitting the packets and further to produce quick responses for establishing a new node connection.

In addition to the current node information present in the routing table, relative information about the node is also appended to the routing table. Along with the essential goal of the AODV protocol which are very efficient, if we include our proposal it works more effectively. The discovery packets are transmitted or broadcasted only if necessary. In our approach, the local connectivity information and topology maintenance are distinguished. Any changes in the local connectivity are propagated to the neighborhood nodes that need the information.

- **Discovering the Route**

Whenever the source node wants information to be sent to its neighborhood nodes which may not contain the routing information available in its table, then there is a need to initiate the route discovery process. All nodes in the topology need to maintain two important data (1) the sequence number (2) the broadcast-id. RREQ packets are transmitted to selected neighbors whenever the source node wants to discover a route or path. All nodes in the network are assigned the primary task of preserving the neighborhood nodes information in a table within it. Every node in the network has to maintain a table containing the neighboring nodes information. The find a route or path, the selected node has to obtain the neighboring nodes information through the table associated with each node.

Every node that receives RREQ packet from its neighboring node has to transform the stored information within to lower and upper approximations. This is possible by using the rules established by the WRS. As mentioned in the previous sections, every rule framed is designated with a calculated value depending upon available resources in topology. This assists in transmitting the RREQ packets from any node. This is continued until RREQ packet is timed out. This process is for selected nodes. If the node that initiated the RREQ is unable to reach the destination then it will initiate again by sending RREQ packets to all its neighboring nodes. In such cases, it is necessary that all nodes in the network have to maintain additional information about its neighboring nodes. This approach may includes excessive overhead on the nodes, but it is necessary in transmissions that include multimedia or video transferring because the network is considered to be stable only for a limited time period as the network is considered to change the topology at frequent intervals. Situations like this can be overcome by keeping the information about the neighboring nodes for a longer time period which helps in establishing a reliable route.

- **Creating a set up for Reverse Path**

There are sender sequence number and receiver sequence number in traditional AODV protocol. The protocol even maintains broadcast-id. The reverse route information towards the sender is stored in the sender sequence number. The sender nodes task is to maintain nodes updated information for reaching the receiver node. Before the sender node could accept any information, the primary task of the receiver sequence number is to describe how updated the information is about the route. Whenever RREQ packet traverses from the sender to all possible receivers, a backward route is set up and the same is intimated to sender node. Whenever a node receives first copy of the RREQ from its neighboring nodes, it keeps the address information for establishing the reverse path to it. This helps intermediate nodes in establishing a reverse path to the sender.

- **Creating a set up for Forward Path**

The RREQ handles the setting up of the forward path with the help of the neighbor node table information. All the nodes receiving the RREQ packet first check whether it was received from any other node. Every node that receives RREQ initially verifies if there is path from itself to the receiver node or not. This verification by performed by examining the sender sequence number is similar to what is present in RREQ. RREQ packets will be retransmitted to the neighboring node, if it is determined that the node receiving the RREQ has receiver sequence number greater than the one it contains. Since it has received a receiver sequence number which is greater, it will not use this for setting up a route. If receiver sequence numbers of RREQ and an intermediate node are satisfying the condition where the number is either higher or equal to the one present RREQ, then only the node sends a reply message, otherwise it retransmits the packet. The node receiving RREQ packet, initially checks whether there is any route to the destination or not. It also verifies whether RREQ packet has been received earlier by the node. Then only, it sends back message to the node via RREP packet back to the node from which it received RREQ.

An RREP comprises information about address of the sender node, address of the receiver node, receiver sequence number; number of hop counts and lifetime of RREP.

The following are the steps for the modification done to the existing AODV RREQ phase

- All the nodes in the topology gather the attribute values for their respective neighboring nodes both for one-hop and two-hop and check for their availability at a given point of time
- Based upon the set of rules, Rough Set information is framed.
- Using equation 1, node weight is calculated with respect to the rough membership

Every time a source node wants to establish route towards the destination node, it initiates a RREQ packet. The RREQ includes information regarding address of sender node, address of receiver node, sender sequence number, receiver sequence number, broadcast-id and hop count. The said parameters are stated by the source node. After initializing parameters, the sender node forwards RREQ packet to nodes that have been selected in the network, rather than forwarding the packet to all neighboring nodes.

- **Forwarding Node Selection Process**

There are two ways of selecting a node for forwarding the RREQ packet in a network. It depends whether the node initiating the forwarding is a sender or an intermediate node. Steps involved in selection process.

- **Process of selecting a node at Sender node**

When the sender node wants to transmit RREQ, it checks whether the neighboring node is a receiver node. If the neighboring node is the receiver, RREQ packet will be transmitted directly to that node. Otherwise, RREQ packet will be forwarded to the next approximate node available.

- **Process of selecting a node at intermediate node**

The intermediate node first checks whether the RREQ packet is an old packet or not. Old packet is detected by examining the packets information. If it finds it as an old packet, it will simply discard the packet. If the RREQ packet is a new one and its neighboring node is the receiver, then RREQ packet will be transmitted to that node. Otherwise, the packet will be forwarded to nodes that have been selected on the rules framed.

The process of selecting a node continues until the receiver node is identified or before the timer expires for that request.

2.7 Constructing the Neighborhood Table and Managing the Routing Table

- **Neighborhood Table**

A mobile node needs to maintain both one-hop and two-hop neighbor node information table as proposed in our protocol. Each neighbor needs to maintain a table with information of

- Its neighboring node
- Pause time of the node
- Node battery power
- Traffic in neighbor node

• Relative distance between the destination node

All nodes need to determine these values and record in their neighborhood table. When RREQ reaches a particular node, the relative distance parameter is calculated. The neighborhood table keeps on modifying itself each time there is modification in the network topology.

- **Managing the Routing Table**

The information for parameters stated below is maintained by mobile nodes for all destinations in the network topology.

• Destination address
• Information of the next hop
• Number of hops required
• Sequence number for destination node
• The neighbors that are existing for the destination node
• Expiry time of the entry of routing table information

Whenever there is a transmission from sender to the receiver, it is necessary to reset the route entry information. At the time of transmission route table entry is fixed to present time along with active-timeout of the route. When the mobile node finds a new route towards the receiver, it examines the new path id detected for transmission and first correlates the receiver sequence number assigned in the new path with that of the current path. A choice is made by the node depending on the receiver sequence number it read and selects the path having a greater sequence number. The new path obtained is chosen if both the sequence numbers are similar but that which has small metrics towards the destination.

- **Setup for Reverse and Forward Path**

While RREP packet takes the reverse path towards the destination, all the intermediate nodes that receive the RREP constructs a link to the node from whom the packet was received. It also upgrades the nodes timeout period for the routes that move towards the source node.

Table 4. Parameters used for simulation

Name of the Parameter	Value	Description
Total number of nodes	50	Total Number of Simulation nodes
Range of x	2000 meters	X – Dimension
Range of y	2000 meters	Y – Dimension
Range of battery power	250 meters	Power Range of the Nodes
Name of the used MAC Protocol	IEEE 802.11	MAC Layer Protocol
Used Network Protocol for implementation	AODV and Rough AODV	Network Layer
Used Transport Layer Protocol	UDP	Transport Layer
Propagation Function used	Free Space	Propagation Function
Node Replacement	Random	All the nodes are distributed in random manner
Simulation Time	20 Minutes	Depending on simulation clock
Interval of Mobility	15 – 30 Seconds	Pause time of a node
Radio Frequency used	$2.4e^9$	Radio layer setting
Network Bandwidth	2 Mbits / second	Nodes bandwidth

The simulation is executed by using the parameter node pause time by differing time from 15 seconds to 30 seconds with time interval of 5 seconds. The simulation is run four times with different time intervals.

3 Results and Discussion

3.1 Simulation Parameters

Glomosim simulator was used for simulation. The simulator parameters are specified in Table 4. According to the simulator clock, the simulation time was 20 minutes. The network was defined using 50 nodes and they were located randomly in the area specified by the parameters mentioned in Table 4. The power range for every node in the network is 250m.

3.2 Metrics used for Evaluating Performance

For evaluating the performance of the proposal, metrics used are

- Number of collisions – Total packets lost because of the channel being accessed by more than one node at a particular point of time. These collisions occur in the MAC layer
- Number of route requests – Total packets produced during the entire simulation
- Throughput or Packet Delivery Ratio – It is the percentage of packets that have been sent by the sender to the packets that have been received by the receiver
- Energy Consumption – Total energy consumed by all transmissions during the simulation time.

3.3 Simulation Results

The simulation results depicted in Figure 4 exhibit the reduction in the number of link breakages. This is because of the increase in the number of nodes in the network. There has been substantial decrease in the number of broken links by approximately 40%.

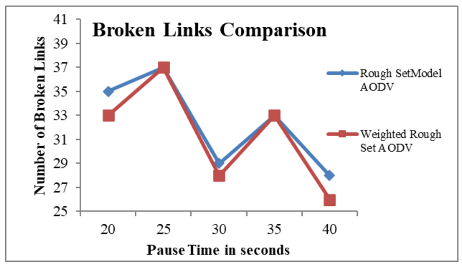

Fig 4. Broken links comparison

The simulation results exhibited in Figure 5 depict that WRS-AODV uses minimum power when compared to RS-AODV. The consumption of energy in WRS-AODV in comparison to RS-AODV improves with increase in the number of nodes. It is observed that both the approaches yield similar results when the size of the network is small.

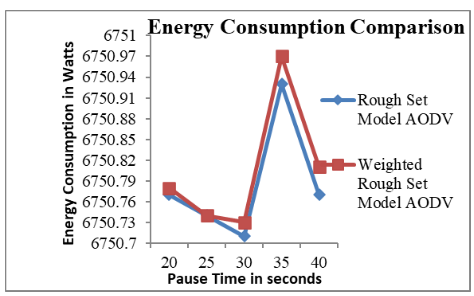

Fig 5. Energy Consumption Comparison

The simulation results demonstrated in Figure 6 indicates throughput for WRS-AODV and RS-AODV protocols. The results obtained shows that the efficiency of throughput is minimized for every increase in speed in transmission. The results obtained clearly indicate that WRS-AODV is dominant when compared to RS-AODV. The throughput is more because of the decrease in the number of collisions and also because of the reduction in the number of broken links.

The simulation results of WRS-AODV when compared to RS-AODV exhibit the mobility of nodes for the protocols on collision of packets. The Figure 7 shows that the collision rates increase because of the quick rise in the transmission rate. The redundancy of the transmissions is decreased because of the effective mechanism of WRS-AODV. The proposed approach eliminates the problem of collisions by 33%.

The simulation result shown in Figure 8 depicts the delay in performance of the proposed approach WRS-AODV with respect to time. There is a rise in delay with increase in node mobility. The delay increases by 24% for every increase in speed. There are different factors that lead to this namely time assigned for queuing packets, propagation time, time required for compilation of

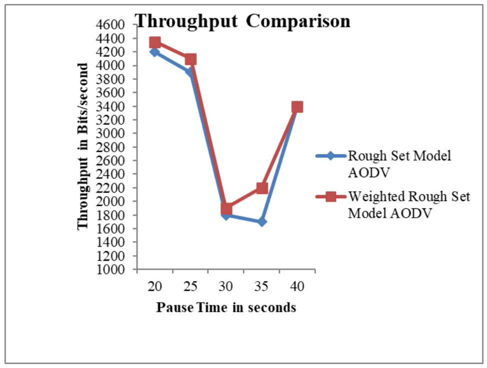

Fig 6. Throughput comparison

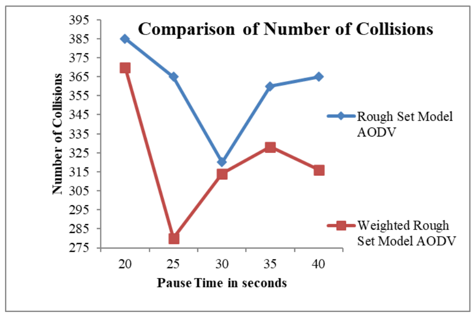

Fig 7. Number of collisions comparison

paths. With the increase in node speed, the nodes proceed faster towards the destination, hence decreasing the length of the routes from intermediate nodes. The proposed approach is better than RS-AODV by approximately 35%.

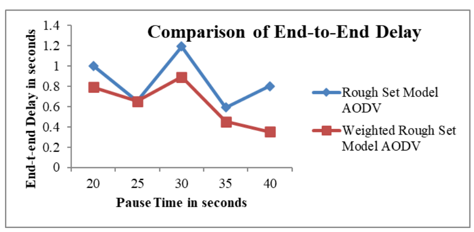

Fig 8. End-to-end delay in seconds

The simulation results depict that for a network with many nodes, more number of messages are required to be generated. The results show that there is decrease in the number of packets being transmitted in the network. The proposed approach shows that the total number of messages retransmitted is reduced to approximately 65% of RS-AODV approach.

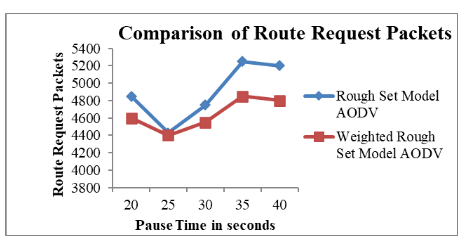

Fig 9. Route request packet comparison

4 Conclusion

Thorough simulations were carried out for examining the approaches of Rough Set AODV and WRS-AODV using Glomosim simulator under numerous network scenarios such as collisions, route request packets, end-to-end delay, throughput, energy consumption and number of broken links. This study models an approach that unifies the information about its neighboring nodes with the help of weighted information. It aims to avoid the traditional method of determining the route as implemented in AODV.

There has an outstanding decrease in RREQ packets being transmitted along with improvement in the number of collisions during broadcasting. In order to achieve the above results, we have used some strategies. Among them the important one deals with the assessment of delaying a repetition of a node. Another strategy is with gathering the information about the neighboring nodes and how many hops are required to reach the destination via that node. It has been examined through simulations that under all network conditions, WRS-AODV has shown preeminence over RS-AODV. WRS-AODV has minimized the broadcast storm issue. This approach has simulated that the outcome achieved has been able to reduce the number of redundant packets being transmitted along with improvement in throughput, number of collisions, number of link breakages, reducing the end-to-end delay and improving energy consumption.

There has a decrease in the number of route request packets using WRS-AODV which resulted in 3% deduction of energy consumption and up to 65% deduction in the number of packets being dropped because of the reduction in collision and increase in throughput. Due to the reduction in collision, the number of broken links in the network also decreased up to 40%.

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