

Flooding Based Route Discovery in Mobile Ad-Hoc Networks using Weighted Rough Set (WRS) Model

Dr. Nithya Rekha Sivakumar¹

¹(Department of Computer Science & Engineering, College of Computer, Qassim Private Colleges, KSA)

Abstract: A mobile Ad-hoc networks consists of wireless hosts that may move often, movement of host results changes in path. The well known Fisheye State routing (FSR) protocol determines a route when no route exists or route breaks. To establish new path from source to destination, it broadcast control packets (route request packets), which increases the network bandwidth consumption and to reduce flooding. As mobile Ad-hoc networks have limited bandwidth, it is important to reduce the flooding. This paper provides a protocol which uses the weighted Rough set model to control the route request packets in the existing FSR protocol in GRID. Weighted Rough set theory is a mathematical tool to deal with vagueness, uncertainty and it also considers the importance of the objects (nodes).

Keywords: MANET; Grid Fisheye State Routing Protocol (GFSR); NS2; Weighted Rough Set Model

I. Introduction

Mobile Ad-hoc Network (MANET) consists of a set of wireless devices that are capable of moving around freely and cooperate in relaying packets on behalf of one another. It does not require any static infrastructure or centralized administration. Instead, it is completely self-healing. MANET's have many potential applications in a variety of fields like military tactical communications, disaster rescue operations, recovery and collaborative group meetings. Recently, there have been rapid developments in mobile devices and growing interest in mobile communications. Due to this, MANET's have been gaining a great significance in the society during the past few years. Each node acts as both router and host as well (i.e., a node can receive the packet and can forward it to other nodes in the network). Due to increasing demand of mobile devices, effective use of available bandwidth has been a challenging problem. Several existing routing algorithms available in the literature are not zeroing in on the effective bandwidth usage. A straightforward approach for broadcasting is blind flooding in which each node will be obligated to rebroadcast the packet whenever it receives the same for the first time. Blind flooding will generate many redundant transmissions and broadcast storm problem in which these packets cause contention and collision. To avoid Broadcast storm problem several approaches were introduced by researchers such as selective forwarding, LAR and PANDA. Also several heuristic approaches were discovered by researchers which are mainly counter based, probability based and function based. In selective forwarding method, 1-hop neighbours are selected in such a way that it covers all its 2-hop neighbours in a heuristic manner. Most of these existing protocol proposals can be classified into two main categories: proactive protocols and reactive.

1.1 Proactive Routing Protocols

In proactive routing protocols each node keeps the routing information in a number of tables. This information is exchanged with other nodes periodically and or when there is a change occurs in the network topology. A number of proactive routing protocols have been proposed. Some of these protocols are DSDV, WRP, GSR, HSR, FSR, OLSR, CGSR, etc. among which FSR and OLSR scale very well in large and highly mobile network.

1.2 Positional Attribute Based Next-Hop Determination Approach (Panda)

Positional Attribute Based Next-hop Determination Approach (PANDA) attempts to utilize positional information to determine the rebroadcast delay. In this approach, a node can find the candidate nodes based on velocity and location information. We tried to design a model to find the candidate nodes among the neighbours based on WRS model which is a mathematical concept effectively used for classification of objects (nodes) which use the neighbour knowledge-based methods more effectively.

In this proposed novel protocol, we tried to reduce the existing flooding in Fisheye State Routing Protocol in Grid by applying Weighted Rough Set (WRS) model. This model finds the candidate node set by finding the similarity relation among the 1-hop and 2-hop neighbours. Weighted rough set model considers the object (node) importance also and this model gives better results compared with FSR in Grid.

The results of Weighted Rough Set model in Grid Fisheye State Routing (FSR) protocol are compared with Flooding by Propagating Neighbourhood Information Algorithm Study and Probabilistic Broadcasting Algorithm. It is found that our WRS model shown improved performance in several important parameters like throughput, energy consumption, Packet delivery Ratio, Delay, Overhead and Normalized overhead. The paper structure follows: Section 2 is the related work. Section 3 comprises WRS mechanism for MANETs. Section 4 deals with WRS model approach Fisheye State Routing (FSR) in Grid, section 5 presents Simulation results of this method, and section 6 presents conclusions and future scope.

II. Related Work

In (Shivanajay A., Dipti Srinivasan M., Chen K., and Althanasios V ,et al .,2008), have just started to develop Fuzzy and Rough set based routing algorithms for MANETs. (Nagaraju Aitha and Ramachandram Srinadas et al., 2011), proposed that in the existing protocols like Dynamic Source Routing + (DSR +), Dynamic Source Routing β (DSR β) and are using the node information to select the next hop to transfer the data packets and Fisheye State Routing (FSR) Protocol is using the node information to select the neighbour nodes to forward the control packets to search the path to the destination.

Neighbour-knowledge-based algorithms are based on the following idea to avoid flooding the whole network; a small set of forward node is selected. Basically, the forward node set forms a Connected Dominating Set (CDS). A node set is a dominating set if every node in the network is either in the set or the neighbour of a node in the set. The challenge is to select a small set of forward nodes in the absence of global network information. In the literature researchers attempted to find CDS using two ways one is using 1-hop neighbourhood information and the other is using 2-hop neighbour information these are called as self pruning and dominant pruning. Neighbour-knowledge-based algorithms can be further divided into neighbour-designating methods and self-pruning methods. In neighbour-designating methods the forwarding status of each node is determined by its neighbours. Basically, the source node selects subset of 1-hop neighbours as forward nodes to cover its 2-hop neighbours. In self-pruning methods each node makes its local decision on forwarding status whether to forward or not to forward. Although these algorithms are based on similar ideas, this similarity is not recognized or discussed in depth.

Selective broadcasting in ad hoc networks has been extensively studied. In (Wei L. and Jie W et. al., 2002) proposed Dominant Pruning (DP) algorithm, Partial Dominant Pruning (PDP) and Total Dominant Pruning (TDP). These algorithms use the 2-hop neighbourhood information to find the dominating set. Adaptive Partial Dominant Pruning (APDP) is an extension of PDP which identifies the adjacent and equivalent nodes. In this particular work equivalent nodes are identified using WRS model among the 1-hop and 2-hop neighbours by establishing an equivalence relation. In our proposed method, we apply WRS model to identify the best RREQ forwarding nodes among the existing neighbours. This kind of WRS mechanism controls the overhead of Route Request Phase (RREQ) of FSR in Grid by eliminating the redundant RREQ forwarding towards the destination.

III. Research Methodology

3.1 Weighted Rough Set Mechanism

3.1.1 Rough Set Mechanism

Consider a universe U of elements. An information system. I is defined as $I = (U, A, V, \rho)$ where A is a non empty finite set of attributes; $V = \cup_{a \in A} V_a$ is the set of attribute values of all attributes, where V_a is the domain (the set of possible values) of attribute a ; $\rho : U \times A \rightarrow V$ is an information function such that for every element $x \in U$, $\rho(x, a) \in V_a$ and is the value of attribute a for element x . $I = (U, A, V, \rho)$ is known as a decision system, when an attribute $d \in A$ is specified as the decision attribute. Then $A - \{d\}$ is known as the set of condition attributes. These definitions are based on the definition of Rough Set Information System . In this proposed method we are using node information system at each node of its neighbour nodes and it is converted into weighted information.

3.2 Weighted Rough Set Model

WRS model is an advancement to rough set model, WRS not only considers noise reducing capability of rough set model it also considers the significance of objects (nodes). Object significance can be considered as object weighted factor. This idea is to suit for actual requirement, especially to prioritize the rules. The object information system can be regarded as a record. One record is a rule which is a condition to forward the control information (i.e., RREQ) towards the destination in the proposed protocol. It is depend on the application. In the existing information system there are no parameters to indicate rule' s significance and it is characterized by weighted coefficient w .

In the Figure (1) two sets E1 and E2 have elements in each and these are belonging to X' s boundary region. Though the element in E1 that not belonging to X and the element in E2 that belong to X may be noise. In Figure (2) after reducing noise E1 is belongs to X' s positive region approximately and E2 is belongs to X' s negative region approximately. Thus the X' s boundary region is reducing and vagueness is decreasing. To improve the accuracy of the approximation in WRS model using weighted coefficient defined in two ways described in the following.

The first one is decided by times of the rule existing information system. Suppose there are n rules for a same domain (for example ith domain) in the same time. If $T_j(x_i) = 1$, means rule x_i is accepted by the jth expert. If $T_j(x_i) = 0$, means rule x_i is refused by jth expert. At last, we sum up all experts opinion $T_j(x_i)$, $j = 1, 2, 3, \dots, n$ defined as follows:

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

The second one decided by rule' s significance. First let us frame all rules for same domain (for example ith domain). Secondly, according to these rules, assign a relative significance factor for every rule based on available resources. We use $\mu_j(x_i)$ to denote experts assigned rules of x_i 's significance for $0 < \mu_j(x_i) < 1$. For rule x_i , we sum up all experts opinions. Rule x_i ' s significance can be defined as

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

Figure 1. Noise is caused by boundary region

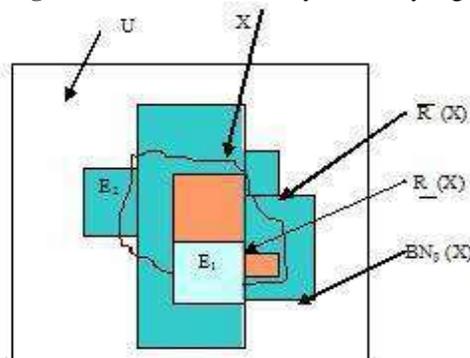
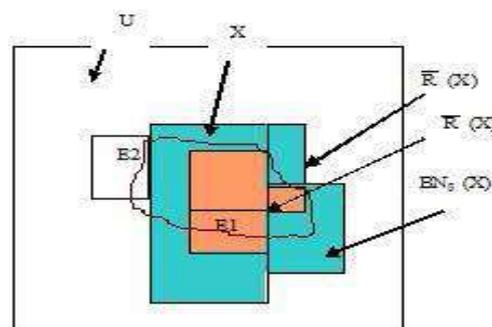


Figure 2. Elimination of noise decreased the boundary



The effectiveness of these two ways is same. Their essence is to assign a relative significance factor for every rule. Every rule should be checked and w should be normalized since weighted coefficient is relative factor.

3.3 Weighted Rough Set Formulation For MANET

Let M be the set of mobile nodes. A route is a path through mobile nodes in M. It is denoted as sequence of mobile nodes $m_1, m_2, m_3, \dots, m_k$, $m_i \in M$, $i = 1, 2, 3, \dots, k$ and let A be the set of attributes denoted by x_1, x_2, \dots, x_p . These attributes are framed for effective routing mechanism. The attributes are like locations, pause time, speed...etc., of a mobile node. Every attribute will form a rule based on predefined threshold value. The threshold values are identified based on the available resources at a particular time.

Thus every node maintains the neighbour node information table: $M \times A \rightarrow V$, where V is the set of all possible conditional values. The value of (m, a) is either 0 or 1 based on the attribute values.

Definition 1: Weighted Information System

Weighted information system S is an ordered pair $S = \langle U, A, V, f, w \rangle$, in which U is a non-empty and finite set. $A = C \cup D$, where C is a condition attribute set, D is a conclusion attribute set, $C \cap D = \phi$. V is the attribute's values set, a is an arbitrary attribute, x_i is an arbitrary object, $f(x_i, a)$ is attribute value of x_i and w is object's weighted factor.

Definition 2: Rough Membership

In WRS, let X be a non-empty subset of a finite universe U . The measure of the relative membership of $x \in U$ with respect to X is defined as:

$$\mu^R X(x) = \frac{\sum_{w_i, x_i} \sum_{X \cap [X]} X \cap [X]}{\sum_{w_i, x_i \in [X]R} R}, x \in U \quad \dots\dots\dots (3)$$

When $w_i = 1$, The above formula becomes the basic Rough membership.

Definition 3: Lower approximations

The lower approximation of M is defined as

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

Definition 4: Upper approximations

The upper approximation of μ is defined as

$$R_\alpha(X) = \{ x \mid \mu^R X(x) \geq \alpha \} \quad 0 \leq \alpha \leq 0.5 \quad \dots\dots\dots (5)$$

In this proposed method, the set of neighbour nodes divided into lower and approximation set of nodes based on the relationship between the 1-hop and 2-hop nodes. The process of finding lower and upper approximations can be categorized into different stages. The first stage would be to select the rules. The second stage is to assign the significance values to the constructed rules. Once the rules are extracted, they can be presented in if CONDITION(S)-then DECISION format. Using WRS the equation representing the mapping between the inputs and the output can be written as $y = f(G, N, R)$ where y is the output, G is the granulization of the input space into weight N is the number of rules and R is the set of rules defined as follows:

```
If battery power > battery threshold
return w1
If traffic <= traffic threshold
return w2
If pause-time > pause-time threshold
return w3
If relative distance <= distance threshold
return w4
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3.4 WRS Construction

WRS model converts the existing neighbour nodes into two subsets, called lower and upper approximations. The source or intermediate node will forward the control packets to lower approximation nodes. The lower approximation nodes are the best candidate nodes compared to upper approximation set of nodes. In our proposed model, lower and upper approximations are constructed using the 2-hop neighbour information. The lower and upper approximations are separated depending on the node weight as shown in equation 1 calculated by WRS model. The node weight is normalized between 0 and 1 based on 2-hop neighbourhood information. The classification of nodes as lower and upper approximation is based on equations 2 and 3.

The Algorithm of the **Modified FSR in Grid RREQ** Phase is as follows:

1. All nodes maintain own incoming and outgoing flow information, speed, pause time, and battery power.
2. All nodes periodically exchange "hello" message to its entire neighbour.
3. Neighbour Nodes receive hello message and store the node information in neighbour table along with traffic, pause time and speed.
4. While transmitting hello message, node send message with 1 hop neighbour information which called Special Hello message.
5. Neighbour nodes store info about 1 hop neighbour of source node in neighbour table.
6. Whenever source node wants to transmit data packet then it initiates path discovery by sending RREQ to selective neighbours.

7. If destination to packet is in first hop then source send RREQ msg. directly without broadcasting.
8. If destination is not found in neighbour than it choose selective neighbour from neighbour table and broadcast packet.
9. It selects the neighbour nodes by applying approximation using WRS with defined rules.

IV. Proposed Research

4 Weighted Rough Set Based Routing

In the proposed routing protocol a route is established using the neighbour node information. Also it is updated whenever a change takes place in the topology. When a node is required to send any control information to the next node it uses the neighbour node information. Accordingly, neighbour nodes are categorized into lower and upper approximation nodes using the mathematical tool WRS model WRS. Then the control information is sent to lower approximation set of nodes.

4.1 Weighted Rough Set FSR in Grid

The proposed protocol zeroes in on reduction of the redundant flooding in Route Request Phase (RREQ) of FSR. In the existing FSR protocol local connectivity of the mobile node is identified by use of several techniques including local broadcast known as hello messages. Here, we introduced a special hello packet when there is a change in the topology. It carries not only the existing status of the neighbour node but also sends neighbour node attributes. The routing tables within the neighbourhood of a node are organized to optimize response time to local movements and to provide quick response time for establishment of new routes. In the present work node relative information is additionally added to the existing routing table. The primary objectives in the existing FSR algorithm are more effectively utilized in the present work as follows. The broadcast of discovery packets takes place only when necessary. Local connectivity management and general topology maintenance are distinguished. Information about changes in local connectivity is disseminated to neighbouring mobile nodes which may likely to seek information.

4.1.1 Path Discovery

The path discovery process is initiated whenever a source node needs to send information to another node for which it has no routing information in its table. Every node maintains two counters: a node sequence number and broadcast id. The source node initiates path discovery by sending the RREQ packet to selective neighbours. To find selective neighbours each node will maintain the neighbour information in the form of a table. When source node or intermediate node gets the RREQ packet it converts the stored information into lower and upper approximation using WRS with the help of framed rules. Here each rule is assigned a predefined significance value based on the resources available in the network. These approximations are helpful to send RREQ packet from source or intermediate node.

This process will repeat itself in a stipulated number of RREQ retires. If source is not able to get the destination then it will try to send the RREQ to every node in all the neighbour nodes. To achieve this, each and every node additionally has to maintain the neighbour node's attribute information. Even though this is an overhead, in some situations like multimedia application and video conferences ad-hoc network is stable for some considerable period of time. In this situation collected neighbour node attribute information will sustain for a long time and this information is helpful to establish reliable path.

4.1.2 Reverse Path Setup

FSR maintains two sequence numbers apart from broadcast_id. These are the source sequence number and the destination sequence number known to the source. The source sequence number is used to maintain freshness information about the reverse route to the source, and the destination sequence number specifies how fresh a route to the destination must be before it can be accepted by the source. A reverse path from all the nodes to the source is automatically established during when the RREQ travels from a source to various destinations. In order to establish a reverse path a node records the address of the neighbour from which it receives the first copy of the RREQ. These reverse time for the RREQ to traverse the network and produce a reply to the sender.

4.1.3 Forward Path Setup

Forward path setup is handled by RREQ phase along with neighbour table information. The receiving node first checks whether the RREQ was received over bidirectional link. If the intermediate node has a route entry for the desired destination, it determines whether the routing is current by comparing the destination sequence number in its own route entry to the destination sequence number in the RREQ. If the RREQ's sequence number for the destination is greater than recorded one by the intermediate node, then the intermediate node rebroadcasts RREQ instead of using it. The intermediate node can reply only when it has a route with sequence number that is greater than or equal to the contained one in the RREQ. If it has not any current route to

the destination and the RREQ has not been processed previously the node then unicasts a RREP back to its neighbour from which it receives the RREQ. A RREP contains the following information.

1. Source Address.
2. Destination Address.
3. Destination Sequence Number.
4. Hop count.
5. Lifetime.

4.1.4 Algorithm for Relative Weight Calculation:

1. Based on rules relative membership measure is identified by adding all weight.
2. While sending RREQ message, source node intermediate broadcast id and route sequence number.
3. If received sequence number is greater than recorded on than intermediate nodes rebroadcast the RREQ.
4. If current node contains route to destination or current node is destination then it generates repeated message.
5. Node generate repetitive message and unicast to source through intermediate node and it establish forward pointer to source node & records the destination sequence.
6. If current node receives more than one repeated message then it validates for greater sequence number and forwards.
7. All other repeated nodes are discarded. After establishing path source, send packet to established path and update route by sending Special Hello message periodically for route maintenance.

Selection Process at Source node

If (Source node of any of the neighbour is destination) then directly RREQ packet is forwarded to destination node.

Else

RREQ is forwarded to one set of approximation nodes

Selection Process at Intermediate node

If the RREQ packet is old then packet will be discarded

Else

If the packet is new and its neighbour is destination then RREQ will be broadcasted to destination node

Else Then RREQ packet will be forwarded to selected nodes.

This process will continue till the destination node is found in stipulated route request retries.

4.5 Neighbour Table And Routing Table Management

4.5.1 Neighbour Table

In the proposed protocol a mobile node maintains the 1-hop and 2-hop neighbour table to identify the selective nodes. The neighbour table contains the following information.

- Neighbour node.
- Node pause time.
- Node battery power.
- Traffic along the neighbour node.
- Relative distance with respect to destination.

The above values are identified and stored in the neighbour table. The relative distance parameter is evaluated when a RREQ is reached to a particular node. The neighbour table is modified whenever there is a change in the topology.

4.5.2 Routing Table Management

Mobile node which maintains the routing table entry for each destination consists the following entries.

- Destination
- Next Hop
- Number of hops
- Sequence number for the destination
- Active neighbours for this destination.
- Expiration time for the route table entry.

Each time a route entry is used to transmit data from source toward a destination, the timeout for the entry is reset to the current time plus active_route_timeout. If a new route is offered to a mobile node it then compares the destination sequence number of the new route to that of the current route. The route with greater sequence

number is chosen. If the sequence numbers are the same then the new route only which has smaller metric to the destination is selected.

4.6 Reverse And Forward Path Setup

As the RREP travels back to the source, each node along the path sets up a forward pointer to the node from which the RREP came updates its timeout information for route entries to the source and destination and records the latest destination sequence number for requested destination.

A node receiving a RREP propagates the first RREP for a given node towards that source. If it receives further RREPs, it updates its routing information and propagates the RREP only if the RREP contains either greater destination sequence number than the previous RREP or the same destination sequence number with the previous RREP, or the same destination sequence number with a smaller hop count. It discards all other RREPs it receives. We ran each simulation four times with different node pause time varying from 15 to 30sec with a step interval of 5 sec. The graphs are presented in results section.

V. Simulation Results

The Simulation is investigated with the Network simulator 2. The simulation time was 15 minutes according to simulator clock. A total of 45 nodes were randomly placed in field of 2000 X 2000 m². Power range of each node is 250m.

5.1 The Performance Measures

The performance of proposed protocol is evaluated using the following metrics:

5.1.1 Average Consumed Energy

Average Consumed Energy is the energy consumed between nodes. In Figure.3 is stable with respect to pause time as the energy consumed is less.

5.1.2 Total Consumed Energy

Total Consumed Energy is the energy consumed through the entire network (whole network). Figure. 4 explains that the energy consumed is less with respect to pause time in the whole network.

5.1.3 Packet Delivery Ratio

Packet delivery fraction is the ratio between the number of packets originated by the application layer CBR sources and the number of packets received by the CBR sinks at the final destinations. Figure. 5 shows that packet delivery is efficient in Weighted rough set routing.

5.1.4 Throughput

Throughput is the average rate of successful message delivery over a communication channel. The throughput is defined as the total amount of data a receiver R receives from the sender divided by the times it takes for R to get the last packet. The throughput is measured in bits per second (bit/s or bps). The throughput is shown in Figure.6 with respect to pause time. According to our simulation results, it has stable performance as it delivers data packets at higher rate.

5.1.5 Overhead

Network Control overhead (NCO) is used to show the efficiency of the MANET's routing protocol scheme. It is defined, as the ratio of the number of control messages (the number of routing packets, Address Resolution Protocol (ARP), and control packets e.g., RTS, CTS and ACK) propagated by each node throughout the network and the number of the data packets received by the destinations. Figure.7 shows with high performance at 15sec. Pause time, but constantly decreased finally.

5.1.6 Normalized Overhead

The graphs in Figure.8, illustrate the Normalized routing overhead experienced in the 2000 m X 2000 m boundary. As Figure clearly explains that in Weighted Rough set routing is comparatively reduced. In our simulation, the maximum update interval for the intrascope and interscope is set to be half. The routes produced would have been less accurate which may have result in a drop in throughput. This means that accuracy of the routes will be high during high mobility where nodes are more likely to migrate more frequently and experience topology changes, and when mobility is low, less updates are sent. From the result shown in Figure 8, it can be seen that Weighted Rough set routing produced less overhead gradually, across all different level of node density and pause time.

Figure 3. Average consumed energy in Weighted Rough set Routing

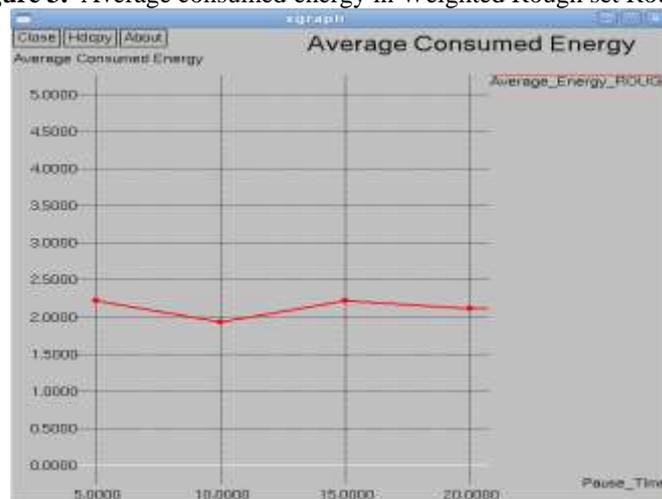


Figure 4. Total consumed energy in Weighted Rough set Routing



Figure 5. PDR in Weighted Rough set Routing



Figure 6. Throughput in Weighted Rough set Routing

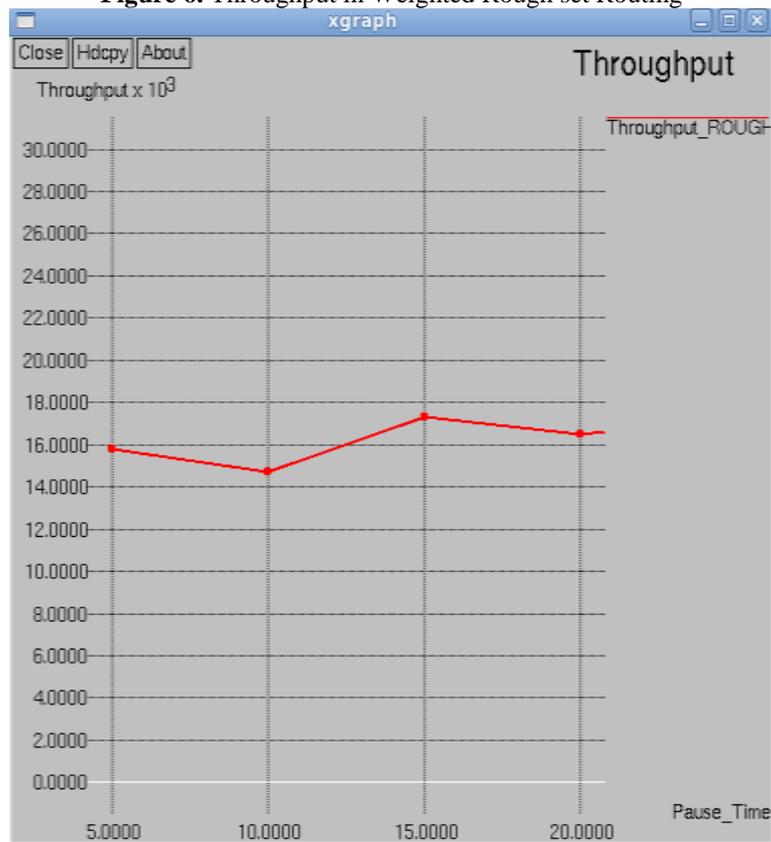


Figure 7. Overhead in Weighted Rough set Routing

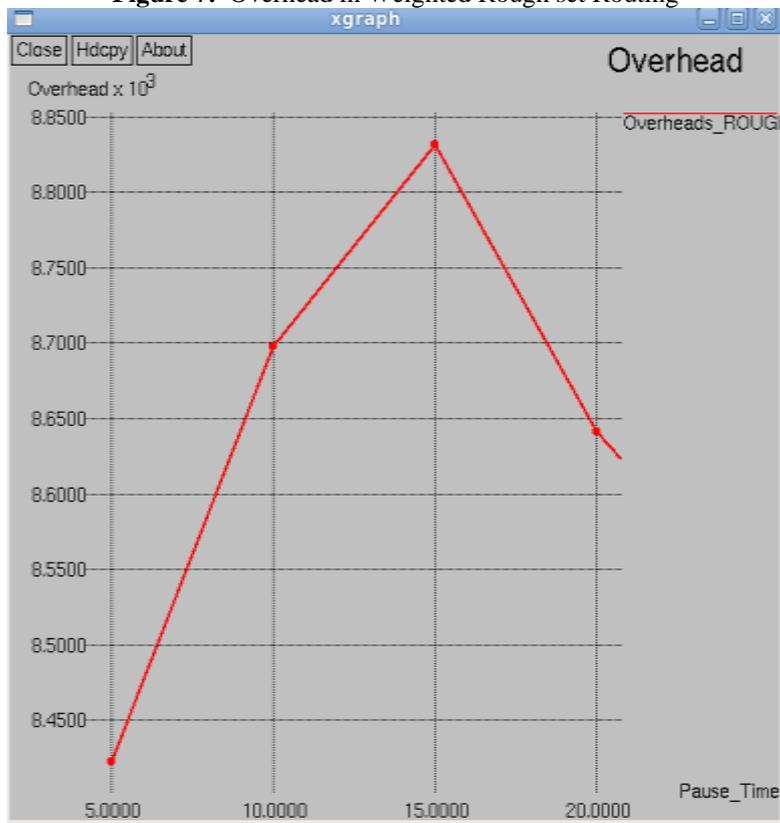
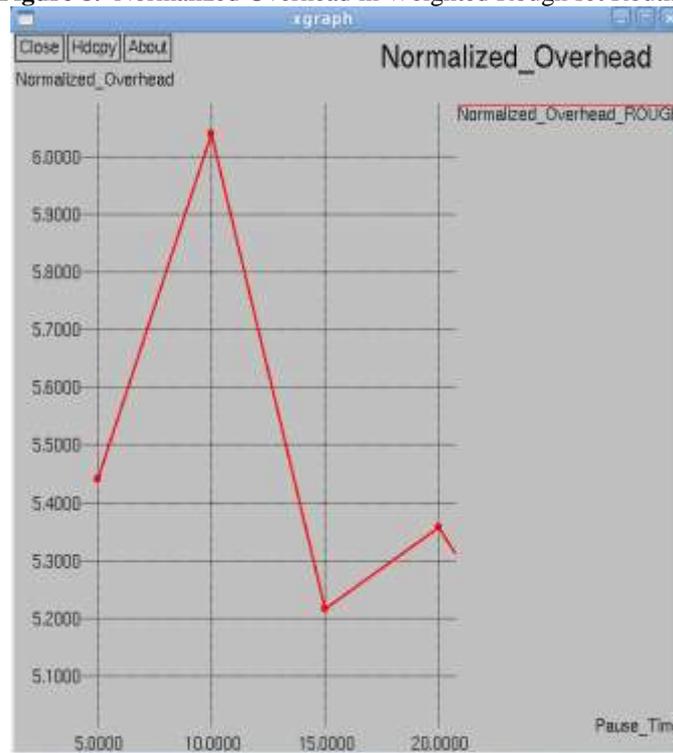


Figure 8. Normalized Overhead in Weighted Rough set Routing



VI. Conclusions And Future Work

In this paper we discussed a method to reduce the redundant broadcasting. In a particular situation ad-hoc networks are stable for a short stipulated time interval and this stability is made use to collect the neighbour node information which is kept with each node. This shows that WRS Model have efficient path by reducing flooding from source to destination with best Quality of service. A node needs to find the destination from the source then the collected node information will be helpful to establish a long term valid path. This long term valid path in turn to reduce the number of unnecessary Route Request control packets. The future scope is to discretize the collected node information. Also the comparative study between Propagating Neighbourhood Information Algorithm, Probabilistic Broadcasting Algorithm and Weighted Rough Set Model with FSR Protocol in Grid using MANET is in progress.

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