CHAPTER 6

A NOVEL APPROACH TO REDUCE FLOODING OF FSR PROTOCOL IN GRID USING WEIGHTED ROUGH SET MODEL

6.1 Introduction

A mobile Adhoc network consists of wireless hosts that may move often, movement of host result changes in path. The well known Fisheye State routing (FSR) protocol in Grid 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 Adhoc networks have limited Bandwidth, it is important to reduce the flooding. This research provides a protocol which uses the Weighted Rough set (WRS) 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).

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. In [127, 138], blind flooding have generated many redundant transmissions and broadcast storm problem is existed in which these packets cause contention and collision. To avoid Broadcast storm problem several approaches were introduced by researchers in [125], 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 neighbors are selected in such a way that it covers all its 2-hop neighbors in a heuristic manner.

The rest of the research is organized as follows. Section 6.2 comprises related work with PANDA algorithm, section 6.3 describes the WRS mechanism the work proposed for MANET’s. Section 6.4 deals with WRS model approach with Fisheye State Routing (FSR) in Grid, section 6.5 presents Simulation results of this method, and section 6.6 presents the conclusions.

6.2 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. It has been tried to design a model to find the candidate nodes among the neighbors based on WRS model which is a mathematical concept effectively used for classification of objects (nodes) which use the neighbor knowledge-based methods more effectively.

Neighbor-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 neighbors 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 neighborhood information and the other is using 2-hop neighbors information; these are called as self pruning and dominant pruning. Neighbors-knowledge-based algorithms can be further divided into neighbors-designating methods and self-pruning methods. In neighbors-designating methods the forwarding status of each node is determined by its neighbors. Basically, the source node selects subset of 1-hop neighbors as forward nodes to cover its 2-hop neighbors. 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.

In [137, 140], Selective broadcasting in adhoc networks has been extensively studied. In [139], the authors proposed Dominant Pruning (DP) algorithm, Partial Dominant Pruning (PDP) and Total Dominant Pruning (TDP). These algorithms use the 2-hop neighborhood 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 neighbors by establishing an equivalence relation.

In this proposed novel protocol, here it is 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 neighbors. Weighted Rough set model considers the object (node) importance also and this model gives better results compared with FSR in Grid. In this proposed method, WRS model is applied to identify the best RREQ forwarding nodes.
among the existing neighbors. 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.

The proposed work was compared with the results of Weighted Rough Set model in Grid Fisheye State Routing (FSR) protocol with Flooding by Propagating Neighborhood Information Algorithm Study and Probabilistic Broadcasting Algorithm. It is found that WRS model has shown improved performance in several important parameters like Throughput, Energy consumption, Packet Delivery Ratio, Delay, Overhead and Normalized Overhead.

### 6.3 Weighted Rough Set Mechanism

#### Rough Set Mechanism

Consider a universe U of elements. An information system I is defined as I = (U, A, V, ρ) where A is a non empty finite set of attributes; V = ∪ a∈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; ρ: U × A → V is an information function such that for every element x ∈ U, ρ(x, a) ∈ V_a and is the value of a attribute for element x. I = (U, A, V, ρ) is known as a decision system, when an attribute d ∈ 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 by using node information system at each node of its neighbor’s nodes and it is converted into weighted information.
6.3.1 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 depends 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 6.1 Two sets E1 and E2 have elements in each and they belong to X’s boundary region. Though the element in E1 that do not belong to X and the element in E2 that belong to X may be noisy. In Figure 6.2 after reducing noise E1 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 i\textsuperscript{th} domain) in the same time. If \( T_j(x_i) = 1 \), means rule \( x_i \) is accepted by the \( j \text{'th} \) expert. If \( T_j(x_i) = 0 \), means rule \( x_i \) is refused by \( j \text{'th} \) expert. At last, all experts opinion \( T_j(x_i) \), \( j = 1, 2, 3, \ldots n \) are defined as follows:
\[ w(x_i) = \sum_{j=1}^{n} T_j(x_i) \] 

The second one decided by rule’s significance. First frame all rules for same domain (for example \(i^{th}\) domain). Secondly, according to these rules, assign a relative significance factor for every rule based on available resources. Then \(\mu_j(x_i)\) is used to denote experts assigned rules of \(x_i\)'s significance for \(0 < \mu_j(x_i) < 1\). For rule \(x_i\), summarize all experts’ opinions. Rule \(x_i\)'s significance can be defined as,

\[ w(x_i) = \sum_{j=1}^{n} \mu_j(x_i) \]
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 a relative factor.

6.3.2 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...m_k, m_i ∈ M, i = 1, 2, 3, …, k and let A be the set of attributes denoted by x_1, x_2,….. x_p. These attributes are framed for effective routing mechanism. The attributes are like locations, Pause-Time, Mobility 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 neighbor’s node information table: M × A → 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 $S = < U, A, V, f, w >$, 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, $C \cap D = \emptyset$. $V$ 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 $w_i$ 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:

$$
\mu^R_X(x) = \sum_{x_i} \sum_{x \in [X]_R} \frac{\cap [X]}{x \in J} 
$$

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

**Definition 3:**

**Lower approximations**

The lower approximation of $\mu$ is defined as

$$\bar{R}_X = \{ x | \mu^R_X(x) \geq 1 - a \}, 0 \leq a \leq 0.5$$

**Definition 4:**

**Upper approximations**

The upper approximation of $\mu$ is defined as

$$\overline{R}_X = \{ x | \mu^R_X(x) \geq a \}, 0 \leq a \leq 0.5$$
In this proposed method, the set of neighbor nodes is 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 significant values to the constructed rules. Once the rules are extracted, it 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:

\[
\begin{align*}
\text{If } &\text{ battery power } > \text{ battery threshold } \\
&\text{return } w1 \\
\text{If } &\text{ traffic } \leq \text{ traffic threshold} \\
&\text{return } w2 \\
\text{If } &\text{ Pause-time } > \text{ Pause-time threshold} \\
&\text{return } w3 \\
\text{If } &\text{ relative distance } \leq \text{ distance threshold} \\
&\text{return } w4
\end{align*}
\]

6.4 WRS Construction

WRS model converts the existing neighbor 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 neighbor 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 neighborhood information. The classification of nodes as lower and upper approximation is based on equations 2 and 3.

### 6.4.1 Proposed WRS Model

<table>
<thead>
<tr>
<th>Algorithm of the Modified FSR in Grid RREQ Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All nodes maintain own incoming and outgoing flow information, speed, Pause-time, and battery power.</td>
</tr>
<tr>
<td>2. All nodes periodically exchange “hello” message to its entire neighbor.</td>
</tr>
<tr>
<td>3. Neighbor Nodes receive hello message and store the node information in neighbor table along with traffic, Pause-time and speed.</td>
</tr>
<tr>
<td>4. While transmitting hello message, node send message with 1 hop neighbor information which called Special Hello message.</td>
</tr>
<tr>
<td>5. Neighbor nodes store information about 1 hop neighbor of source node in neighbor table.</td>
</tr>
<tr>
<td>6. Whenever source node wants to transmit data packet then it initiates path discovery by sending RREQ to selective neighbors.</td>
</tr>
<tr>
<td>7. If destination to packet is in first hop then source send RREQ message directly without broadcasting.</td>
</tr>
<tr>
<td>8. If destination is not found in neighbor then it choose selective neighbor from neighbor table and broadcast packet.</td>
</tr>
<tr>
<td>9. It selects the neighbor nodes by applying approximation using WRS with defined rules.</td>
</tr>
</tbody>
</table>
6.4.2 Weighted Rough Set Based Routing

In the proposed routing protocol a route is established using the neighbor 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 neighbor node information. Accordingly, neighbor’s nodes are categorized into lower and upper approximation nodes using the mathematical tool WRS model. Then the control information is sent to lower approximation set of nodes.

6.4.3 Weighted Rough Set FSR in Grid

The proposed protocol zeroes in 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, special hello packet is introduced when there is a change in the topology. It carries not only the existing status of the neighbor node but also sends neighbors node attributes. The routing tables within the neighborhood 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 research 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 take place only when necessary. Local connectivity management and general topology maintenance are distinguished. Information about changes in local connectivity is disseminated to neighboring mobile nodes which may likely to seek information.
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 with a node sequence number and broadcast id. The source node initiates path discovery by sending the RREQ packet to selective neighbors. To find selective neighbors, each node will maintain the neighbor 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 neighbor nodes. To achieve this, each and every node additionally has to maintain the neighbor node’s attribute information. Even though this is an over head, in some situations like multimedia application and video conferences adhoc network is stable for some considerable period of time. In this situation collected neighbor node attribute information will sustain for a long time and this information is helpful to establish reliable path.

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 neighbor 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.

**Forward Path Setup**

Forward path setup is handled by RREQ phase along with neighbor 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 the 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 neighbor from which it receives the RREQ. A RREP contains the following information.

- Source Address.
- Destination Address.
• Destination Sequence Number.
• Hop count.
• Lifetime.

### 6.4.4 Proposed Algorithm for Relative Weight Calculation

**Algorithm: 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 neighbors 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 neighbors 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.

6.4.5 Neighbor Table and Routing Table Management

Neighbor Table
In this proposed protocol a mobile node maintains the 1-hop and 2-hop neighbors table to identify the selective nodes. The neighbors table contains the following information.
- Neighbor node.
- Node Pause-time.
- Node battery power.
- Traffic along the neighbor node.
- Relative distance with respect to destination.

The above values are identified and stored in the neighbors table. The relative distance parameter is evaluated when a RREQ is reached to a particular node. The neighbors table is modified whenever there is a change in the topology.
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 neighbors 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 Time-out for the entry is reset to the current time plus active_route_Time-out. 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.

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 Time-out 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. Each simulation is run four times with different node
Pause-time varying from 15 to 20 seconds with a step interval of 5 seconds.
The graphs are presented in Simulation results section.

6.5 Simulation Results

The Network simulator 2.34 is used to run the Simulation. The simulation
time was 15 minutes according to simulator clock. A total of 45 nodes were
randomly placed in field of 600 X 600 m². Power range of each node is 250 m.

6.5.1 The Performance Measures

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

Average Consumed Energy
Average Consumed Energy is the energy consumed between nodes. In
Fig.6.3 is stable with respect to Pause-time as the energy consumed is less.

Total Consumed Energy
Total Consumed Energy is the energy consumed through the entire network
(whole network). Fig.6.4 explains that the energy consumed is less with
respect to Pause-time in the whole network.
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. Fig. 6.5 shows that packet delivery is efficient in 15 seconds Pause-time and gradually increasing the performance after 20 seconds with WRS routing. Thus when Pause-time is increased PDR is efficient in WRS model.

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 Fig.6.6 with respect to Pause-time. According to our simulation results, it has stable performance as it delivers data packets at higher rate.

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. Fig.6.7 shows with high performance at 15sec. Pause-time, but constantly decreased finally when Pause-time is increased.
Normalized Overhead

The graphs in Fig. 6.8, illustrate the Normalized routing overhead experienced in the 600 X 600 m² boundary. As Figure 6.8 clearly explains that in Weighted Rough set routing is comparatively reduced. In this 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 Fig. 6.8, it can be seen that Weighted Rough set routing produced less overhead gradually, across all different level of Node Density and Pause-time.

![Average Consumed Energy](image)

*Figure 6.3: Average consumed energy in Weighted Rough Set Routing*
Figure 6.4: Total consumed energy in Weighted Rough Set Routing

Figure 6.5: PDR in Weighted Rough Set Routing
Figure 6.6: Throughput in Weighted Rough Set Routing

Figure 6.7: Overhead in Weighted Rough Set Routing
6.6 Summary

In this chapter, the basic idea is discussed with a new method called Weighted Rough Set Model (WRS) to reduce the redundant broadcasting to reduce flooding. In a particular situation, adhoc networks are stable for a short stipulated time interval and this stability is made use to collect the neighbors node information which is kept with each node. 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 reduces the number of unnecessary Route Request packets. Hence sum of weighted co-efficient such as w1, w2, w3 and w4 is calculated for Grid FSR to assume the best route for path selection.