Enhancing routing Performance by Using Neighbor Coverage Knowledge and Energy Aware Metric in Mobile Adhoc Networks

**Abstract:** A mobile adhoc network is an independent collection of mobile nodes without having the fixed infrastructure. In the mobile adhoc networks, because of the high mobility of the nodes there is frequent link breakage that causes frequent path failure and route discoveries. A mobile node instinctively rebroadcasts the route request packets and it causes the broadcast storm problem. Because of the high dynamic networks, there is routing overhead so that it consumes high network resource. So, in order to conquer this problem, a neighbor coverage-based probabilistic rebroadcast protocol is used to reduce routing overhead. Also a rebroadcast delay is used to determine rebroadcast order and then to attain additional coverage ratio by sensing neighbor coverage knowledge. By using this method, the numbers of retransmissions is decreased, reduction in routing overhead and to improve the routing performance. But the limitation is the link stability is not considered. To improve the performance the link stability and path stability is an important conception among the nodes. In addition to that energy is an important resource that needs to be preserved in order to extend the lifetime of the network. Actually, in the wireless sensor network different nodes take different amount of energy for transmitting the same data packets. Based on this energy metric the path has to be chosen. Due to the energy drain rate, improve the energy saving. So, in this manuscript to compute the link stability metric and energy metric. Based on this the path is to be chosen. An experimental result shows that when compared to the existing system in the proposed method to achieve high packet delivery ratio, low delay and less energy consumption.

**Keywords:** Mobile ad hoc networks, neighbour coverage, probabilistic rebroadcast, routing overhead, link stability, energy aware metric
1. Introduction:

A collection of mobile nodes is a mobile adhoc network which has no fixed infrastructure. Mobile adhoc network is inherently different from conventional networks. Routing in a MANET depends on the many factors which includes topology, router selection, and initiation of request to identify the path quickly and efficiently. The Adhoc On-demand vector Routing (AODV) protocol and Dynamic Source Routing (DSR) have been proposed for improving the performance. These two protocols are on-demand routing protocols and improve there is improvement in scalability. On the other hand, because of the high mobility of the nodes in mobile adhoc networks, there is a frequent link breakage that leads to frequent path failures so that increase in packet drops and end-to-end delay.

In the traditional on-demand routing protocols, flooding is used to find a route. A route request (RREQ) packet is broadcasted throughout the network and the broadcasting causes excessive redundant transmissions of RREQ packet and the broadcast storm problem occurs. The protocols for broadcasting are categorized into four types: Simple flooding method, Probability based methods, area based methods and neighbor knowledge methods. In these broadcasting protocols if there is an increase in the number of odes in a static network will humiliate the performance of the probability-based and area-based methods.

To diminish the routing overhead and to develop the routing performance neighbor coverage based probabilistic rebroadcast protocol is used. A rebroadcast delay is required to effectually develop the neighbor coverage knowledge and using this rebroadcast orders is determined. After that to combine the additional coverage ratio and connectivity factor the rebroadcast probability is determined that can be utilized to reduce the number of rebroadcasts of the RREQ packet and to enhance the routing performance. Additionally, the link stability and the energy aware metric are significant to enhance the network performance. To improve the lifetime of the network, energy is an important resource in the mobile adhoc networks. The main objective of this work is to minimize the energy consumption of the mobile nodes and to maximize the link stability of the transmissions.

2. Literature Review:

David B. Johnson et.al suggested dynamic source routing protocol especially for multi-hop wireless adhoc networks [1]. This protocol permits the network to be totally self-managing.
and self-configuring without the necessity of permanent infrastructure. This protocol is composed of two methods one is route discovery and another one is route maintenance. These methods work together which permits nodes to find and preserve source routes to random destinations in the ad hoc network. But the disadvantage of this method is there is less packet reception ratio.

Xianren Wu et.al suggested a mathematical framework for reducing routing overhead in mobile adhoc networks [2]. A framework is presented to model the overhead as a function of stability of topology and systematically differentiate the statistical distribution of topology evolutions. Additionally, the practical view on optimized link state routing (OLSR) protocol under the general framework with the understanding of the importance and practicalness of the optimized link state routing protocol. But the drawback of this method is if there is increase in control traffic that leads to reduction in packet delivery ratio and increases the delay.

Yu-Chee Tseng et.al suggested a scheme for reducing redundant rebroadcasts in the mobile adhoc networks [3]. To diminish the broadcast storm problem, a numerous schemes called probabilistic based method, counter-based method, distance-based method, location-based method and cluster-based schemes are proposed to decrease the broadcast storm problem. A counter-based method eliminates the rebroadcast problem if there is more traffic. If location information is obtainable through devices like GPS receivers, the location-based scheme is the better choice to reduce the redundant traffic. But the drawback of this method is the reliability of the packet reception ratio is less.

Brad Williams’s et.al proposed different broadcasting approaches in mobile adhoc networks. The probabilistic scheme is same as flooding in which nodes only rebroadcast with predetermined probability [4]. After that, a counter-based scheme shows that the affiliation between the number of times a packet is received at a node and the probability of that node being able to reach additional area on a rebroadcast. If each redundant packet received, the counter value is incremented by one. If the counter is less than a threshold value when the Random Assessment Delay expires, the packet is rebroadcast. Otherwise, it is simply dropped. In the Distance-Based Scheme a node compares the distance between itself and each neighbor node that has previously rebroadcast a given packet. But the disadvantage of this method is high expensive and high computation.
Jae-soo Kim et.al suggested a probabilistic broadcasting method according to the coverage and neighbor confirmation in mobile adhoc networks [5]. When a node is located in close to the sender, that means small additional coverage and rebroadcast from this node can reach less additional nodes, so the rebroadcast probability will be set lesser. However, if a mobile node is situated far away from the sender, the additional coverage from this node is large and its rebroadcast probability is higher. The estimation of coverage area is the distance between the sender and receiver and the distance can be computed by signal strength. But the drawback of this method is it causes unneeded packet retransmissions, required high network bandwidth, and collision.

Joseph Y. Halpern et.al suggested gossip based method in which every node sends a message with some probability for decreasing the overhead of the routing protocols [6]. This scheme exhibits bimodal behavior in insufficiently large networks: in some executions, the gossip dies out rapidly and barely any node gets the message; in the residual executions, a considerable fraction of the nodes gets the message. But the disadvantage of this method is there is occurrence in unnecessary routing messages.

Wei Peng et.al suggested a new broadcast method is proposed which effectually diminish the broadcast redundancy in mobile wireless networks [7]. It uses only local topology information and statistical information of duplicate messages to evade redundant rebroadcasts. There are some postulations for broadcast algorithm. The first one is an Omni-directional antenna is used and there is similar transmission range for all mobile nodes. The wireless channel is shared by all nodes and that can be accessed by any node at random time interval. But the main limitation of this method is there is less packet delivery ratio and high energy consumption.

Vinay Ribeiro et.al suggested a deterministic timer based schemes is proposed to avoid the packet losses [8]. In this work, firstly to introduce two novel deterministic timer-based schemes: One is Dynamic Reflector Broadcast (DRB) and another one is Dynamic Connector-Connector Broadcast (DCCB). Both of the schemes possess effectiveness within a feature of the optimum, a property that other deterministic timer-based schemes do not share and this can be analyzed. The novelty of the proposed scheme is hybrid backbone that includes a static Dominating set (DS) and a set of connecting nodes are computed in a dynamic manner. The disadvantage of this method is there is increase in the number of transmissions that impacts high power consumption and high latency.
Feng Xue et.al suggested a number of neighbors required for connectivity in wireless networks. Wireless networks do not have static links [9]. The links are formed by nodes and select the power levels to transmit the data. So, the problem is the quantity of neighbors needed to connect the overall network. All nodes assist in routing each other’s packets, so that packets are elated in a multi-hop fashion from source to destination.

John Heidemann et.al suggested a Robust Broadcast Propagation protocol to increase the reliability in wireless networks [10]. Robust Broadcast Propagation protocol exploits two observations: Firstly, the level of reliability needed of a broadcast is dependent on the local network density. Secondly, sometimes network topologies consist of well-connected components combined by significant links; discovering and increasing the reliability of these links is important to provide both high reliability and efficiency. But the disadvantage is high packet loss and high delay.

3. Neighbor Coverage Based Probabilistic Rebroadcast Protocol:

Neighbor coverage based probabilistic rebroadcast protocol is used in the mobile adhoc networks to diminish the retransmissions. To utilize the knowledge of neighbor coverage in an effectual manner a novel rebroadcast is required to determine the rebroadcast order and then attain a more accurate additional coverage ratio. Connectivity metric is one more parameter to choose the number of neighbors should obtain RREQ packet to overcome the trouble of redundant retransmissions. A node that has more number of common neighbors with prior node has lower delay. If this node rebroadcasts a packet, more number of neighbors will know this detail. So, the main purpose of the rebroadcast delay is nodes that have transmitted the packet spread to more neighbors. After that the determination of rebroadcast probability is takes place. This scheme taken into account of the uncovered neighbors, connectivity metric and density of the node. In the rebroadcast probability there are two metrics: The first metric is called additional coverage ratio and the second metric is called the connectivity factor. The additional coverage ratio is defined as the ratio of the number of nodes should be covered and the total number of neighbors. The connectivity factor is defined as an association of network connectivity and the number of neighbors of a given node.
3.1. **Determine The Uncovered Neighbor Set:**

The RREQ packet is received by node $n_i$ that can be broadcasted from node s. By using the neighbor list in RREQ packet, to estimate number of neighbor nodes have not been covered by RREQ packet. Suppose, node $n_i$ has larger number of uncovered neighbors by the RREQ packet from s, whereas if node $n_i$ rebroadcasts the RREQ packet so that more number of additional neighbor nodes have been covered. Now we define the uncovered neighbor set $U(n_i)$ of $n_i$,

$$U(n_i) = N(n_i) - [N(n_i) \cap N(s)] - \{s\}$$

Where $N(s)$ and $N(n_i)$ are the neighbors sets of node s and $n_i$, correspondingly. s is the node which sends an RREQ packet to node $n_i$. From this we obtain the initial UCN set.

3.2. **Rebroadcast Delay Determination:**

Actually, to find the route between the source and destination the RREQ packet is broadcasted. Because of the broadcast nature of an RREQ packet, node $n_i$ may be receive duplicate RREQ packet from its neighbors. By utilizing the knowledge of neighbor coverage node $n_i$ further adjust the $U(n_i)$. In order to adequately exploit the neighbor knowledge and to restrict collisions every node should set a rebroadcast delay. The definition of the rebroadcast delay $T_d(n_i)$ is determined by,

$$T_k(n_i) = \frac{1 - |N(S) \cap N(n_i)|}{|N(S)|}$$

$$T_d(n_i) = MaxDelay \times T_k(n_i)$$

In which $T_k(n_i)$ is the delay ratio of node $n_i$, and MaxDelay is a small constant delay. |.| is the number of elements in a set. The rebroadcast delay is defined as: Firstly, the delay time is used to decide the node transmission order. To exploit the neighbor coverage knowledge in a sufficient manner, it should be distributed as rapidly as possible. If node s sends an RREQ packet, the whole neighbors of $n_i, i = 1,2, \ldots, |N(s)|$ receive and process the RREQ packet. Assume that node $n_k$ has the largest number of common neighbors with node s, node $n_k$ has the lowest delay.
3.3. **Rebroadcast Probability Determination:**

In the rebroadcast probability determination, when node \( n_i \) receives a duplicate RREQ packet from its neighbor node \( n_j \), it knows that how many of its neighbors have been covered by the RREQ packet from \( n_j \). Based on the neighbor list in the RREQ packet, the node \( n_i \) could further regulate its UCN set. Then, the \( U(n_i) \) can be adjusted as:

\[
U(n_i) = [U(n_i) \cap N(n_j)]
\]

After adjust the \( U(n_i) \), the packet received from \( n_j \) is discarded. If the timer of rebroadcast delay of \( n_i \) expires the node attains the final UCN set.

3.4. **Additional Coverage Ratio:**

The additional coverage ratio \( (R_a(n_i)) \) of node \( n_i \) is defined as,

\[
R_a(n_i) = \frac{|U(n_i)|}{|N(n_i)|}
\]

\( R_a(n_i) \) denotes the ratio of the number of nodes that are additionally covered to the total number of neighbors. The nodes which are additionally covered necessitate to receive and process the RREQ packet. As \( R_a \) becomes larger, more nodes will be covered by this rebroadcast, and more nodes necessitate to obtain and process the RREQ packet, and, thus, the rebroadcast probability should be set to be higher.

3.5. **Connectivity Factor:**

The connectivity factor \( F_c(n_i) \) is defined as,

\[
F_c(n_i) = \frac{N_c}{|N(n_i)|}
\]

In this equation, \( N_c = 5.1774 \log n \), and \( n \) indicates the number of nodes in the network. If the value \( |N(n_i)| \) is larger than \( N_c \), the value of \( F_c(n_i) \) is less than 1. If the value of \( N(n_i) \) is less than \( N_c \), the \( F_c(n_i) \) is greater than 1. The additional coverage ratio and the connectivity factor are combined so that the rebroadcast probability \( Pre(n_i) \) of node \( n_i \) is computed as,

\[
Pre(n_i) = F_c(n_i). R_a(n_i)
\]

In this equation, if the \( Pre(n_i) \) is larger than 1, to set the \( Pre(n_i) \) to 1.
Algorithm: NCPR

\( RREQ_v: \) RREQ packet received from node \( v. \)

\( R_v.id: \) The unique identifier (id) of \( RREQ_v \)

\( N(u): \) Neighbor set of node \( u \)

\( U(u, x): \) Uncovered neighbors set of node \( u \) for RREQ whose id is \( x. \)

The timer node \( u \) for RREQ packet is \( \text{Timer}(x,u) \) the id is \( x. \)

1. If \( n_i \) receives a new \( RREQ_s \) packet from \( s \) then

2. \{ Compute initial uncovered neighbors set \( U(n_i, R_s.id) \) for \( RREQ_s \) \}

3. \( U(n_i, R_s.id) = N(n_i) - \{N(n_i) \cap N(S)\} - \{s\} \)

4. \{Compute the rebroadcast delay \( T_d(n_i) \) \}

5. \( T_k(n_i) = \frac{1-|N(S)\cap N(n_i)|}{|N(S)|} \)

6. \( T_d(n_i) = \text{Maxdelay} \times T_k(n_i) \)

7. Set a Timer( \( n_i, R_s.id \) ) according to \( T_d(n_i) \)

8. End if

9. While \( n_i \) receives a duplicate \( RREQ_j \) from \( n_j \) before \( \text{Timer}(n_i, R_s.id) \) expires do

10. \{ Adjust \( U(n_i, R_s.id) \) \}

11. \( U(n_i, R_s.id) = U(n_i, R_s.id) - \{U(n_i, R_s.id) \cap N_j\} \)

12. Discard \( (RREQ_j) \)

13. End while

14. If \( \text{Timer}(n_i, R_s.id) \) expires then

15. \{Compute the rebroadcast probability \( \text{Pre}(n_i): \} \)

16. \( R_d(n_i) = \frac{|U(n_j)|}{|N(n_i)|} \)
17. $F_c(n_i) = \frac{N_c}{|N(n_i)|}$

18. $Pre(n_i) = F_c(n_i) \cdot R_d(n_i)$.

19. If $\text{Random}(0,1) \leq P_{re}(n_i)$ then

20. Broadcast ($RREQ_s$)

21. Else

22. Discard ($RREQ_s$)

23. End if

24. End if

4. Link Stability And Energy-Aware Metric:

In the mobile adhoc networks, the link stability is a significant metric and also energy is a limited resource. In order to recover better packet delivery ratio and to decrease the energy consumption a link-stability metric and the energy-aware metric is to be calculated. Using stable links is critical for providing stable paths between the connection peers. The link stability is estimated by computing the residual lifetime of the links. Additionally, the higher residual lifetime of a link indicates the higher reliability of the link. If the distance between the nodes is too larger if their distance exceeds the radius of the transmission, the link breakup occurs. On the other hand, energy is an important resource in the mobile adhoc networks. Actually, in the mobile adhoc networks, different nodes take different amount of energy to transmit and receive the data packets. The path is to be chosen based on the link stability and the energy-aware metrics. Due to the energy drain rate, improve the energy saving.

4.1. Link Stability Metric:

In the link-stability metric, a statistical-based approach has been accepted in order to differentiate among several links which are more stable, meaning they are the most likely of all to stay obtainable for some periods of time, without precisely predicting the residual link lifetime of each link. Resulting that, this analysis produces an assessment of the link residual
lifetime of the link, while the stability of a link is specified by its probability of persisting for a certain time span. The residual lifetime denotes the remaining time which the link can exist before flouting. The expected residual lifetime \( R_{i,j}(a_{i,j}) \) of a link \((i, j)\) of age \(a_{i,j}\) is determined from the gathered statistical data as follows:

\[
R_{i,j}(a_{i,j}) = \frac{\sum_{a=a_{i,j}}^{a_{\text{max}}} a.d[a]}{\sum_{a=a_{i,j}}^{a_{\text{max}}} d[a]} - a_{i,j} \quad \forall \ (i,j) \in A,
\]

In this equation, \(a_{\text{max}}\) denotes the maximum observed age of the links and \(d\) is an array of length \(a_{\text{max}} + 1\) used to store the observed data. Particularly, \(d\) is decided through a sampling of the link ages every fixed time interval and its general component \(d[a]\) denotes the number of links with age equal to \(a\).

### 4.2. Energy-Aware Metric:

Each node in a mobile adhoc network has ability to forward an incoming packet to one of its neighboring nodes and to receive information from a transmitting node. Additionally, every node is able to identify all its neighbors by protocol messages. In the mobile adhoc networks, every node takes different amount of energy for transmitting and receiving the data packets. If the energy consumption decreases, then the lifetime of the nodes is increased. So, by using this energy metric the node has to be selected for data transmission and reception.

The energy needed to transmit a packet from node \(i\),

\[
E_{tx}(p, i) = I \cdot v \cdot t_b \text{ Joules}
\]

Where, \(I\) is current in ampere

\(V\) voltage in volts

\(t_b\) is time taken to transmit a packet

The energy \(E(p, i)\) taken to transmit a packet from node \(I\) to node \(j\) is given by,

\[
E(p, i) = E_{tx}(p, i) + E_{rx}(p, j)
\]

Each node computes the energy level for data transmission and reception overhearing activities and computes the residual energy level.
Each node \( i \) monitors its energy consumption caused by the transmission, reception and overhearing activities and computes the energy drain rate, denoted by \( DR_i \), for every \( T \) seconds sampling interval by averaging the amount of energy consumption and estimating the energy dissipation per second during the past \( T \) seconds. The actual value of \( DR_i \) is calculated by utilizing the well-known exponential weighted moving average method applied to the drain rate values \( DR_i(t-1) \) and \( DR_{\text{curr},i} \) which represent the previous and the newly calculated values:

\[
DR_{\text{curr},i} = DR_i(t),
\]

\[
DR_i(t) = DR_i(t-1) + (1-\alpha).DR_{\text{curr},i}.
\]

5. Experimental Results:

In the experimental results the existing and the proposed system is to be compared. To evaluate the performance of the system we use NS-2 simulator. Broadcasting is an effectual method for data dissemination in mobile adhoc network. The simulation parameters are taken as follows: The radio channel model utilizes a Lucent’s WaveLAN with 2 Mbps bit rate and 250 meters transmission range. Also to consider constant bit rate data traffic and arbitrarily select different source-destination connections. Each and every source sends four constant bit error rate packets whose size is 512 bytes per second. The mobility model is based on the random waypoint in a field of 1000*1000m. The existing and the proposed methods are to compared in terms of packet delivery ratio, Normalized routing overhead, energy consumption.

5.1. Packet Delivery Ratio:

Packet delivery ratio is defined as number of data packets which successfully delivered by the constant bit rate (CBR) destinations to the number of data packets generated by the CBR sources.
5.2. Average End-To-End Delay:

Average End-to-end delay is defined as the average delay of successfully received CBR packets from source to destination node. It contains all possible delays from the CBR sources to destinations.

Figure 2. evaluates the average end-to-end delay of CBR packets received at the destinations with increasing traffic load. When compared to the Neighbor coverage based probabilistic method, the link stabilization and energy aware method achieves less delay.

5.3. Normalized Routing Overhead:

The normalized routing overhead is defined as the ratio of the total packet size of control packets to the total size of data packets delivered to the destinations.
Figure 3. Shows that the Normalized Routing Overhead. In the existing method has high network overhead if the traffic load is high. If the network density increases the normalized routing overhead decreases in the link stabilization and energy aware method.

5.4. Energy Consumption:

Energy consumption is defined as the amount of energy used for the communication and processing the data.

Figure 4. Shows that the average energy consumption. In the existing Neighbor coverage based probabilistic rebroadcast method high energy consumption when compared to the proposed method.

6. Conclusion And Future Work:

To diminish the routing overhead in the mobile adhoc networks, a neighbor coverage-based probabilistic rebroadcast protocol is used. Because of the arbitrary movement of the nodes in the mobile adhoc networks, leads to frequent link breakage, path failure and route
discoveries. So, by using neighbor coverage knowledge, a novel rebroadcast delay is proposed to establish the rebroadcast order and rebroadcast probability. The rebroadcast probability is estimated by the two metrics: one is called connectivity factor metric and the another one is called additional coverage ratio. By using this method, effectually decrease the number of retransmissions so as to reduce routing overhead and to improve the routing performance. Furthermore, to decrease the energy consumption and increase the packet delivery ratio the link stability metric and energy-aware metric is calculated.

For future work, we monitoring the links lifetime of the mobile nodes in the wireless network, in the past and in the present, to predict its behavior, in the future without considering directly parameters depending by underlying mobility model such as node speed or direction.
References:


