ISSN 2321-807X
Volume 13 Number10
Journal of Advances in chemistry

Design and Development of Network Reliability based Secure Multicast Routing Protocol for MANET

[1]Dr. N. Suma, [2]Dr.S.Gopinath
[1]SNS College of Engineering, Coimbatore, Tamilnadu, India
E-mail : kalai_suma@yahoo.com
[2]Karpagam Institute of Technology, Coimbatore, Tamilnadu, India
E-mail : drgopiphd1985@gmail.com

ABSTRACT

In Mobile Ad hoc network (MANET), link quality and stability of links as well as nodes play a major role. In ad hoc network, links are often changing which could affect the node mobility and integrity of data packets. In this research work, Network Reliability based Secure Multicast Routing Protocol (NRSMRP) is proposed to achieve network reliability by means of creation of reliable multicast tree. This multicast tree is constructed based on link quality and reliability trust metric. In first phase, node categorization and reliability metric calculation are implemented with the help of link quality. In second phase, reliable multicast tree is formed based on parent node and child node. Parent node must have god capacity and signal strength to communicate with child node. In last phase, authentication based multicast routes are established based on the calculation of direct reputation of mobile nodes. From the results, proposed protocol achieves better performance than existing schemes.

KEY WORDS

MANET, multicast tree, link quality, reliability trust metric, stability metric, parent node and child node.

1. INTRODUCTION

Reliability in Mobile Ad hoc Networks (MANET) is major issue to achieve network performance. Mobile node consists of wireless link which they communicate in the absence of infrastructure. Network reliability is influenced by means of attackers. Attackers are divided into two types i.e. active and passive attackers. It is vulnerable to network which may damage the entire network connectivity. It should be reduced by means of secure routing protocol. Mesh based routing protocols plays a major role to increase the network lifetime compared to tree based routing.

In [1], authors surveyed the mesh based and hybrid multicast routing protocol for MANET. The basic components of multicast routing protocol are analyzed and provided separate mechanisms for energy, security and location aware. In existing schemes, routes are formed with minimum hop count but not considering link quality. The transmission capacity of the wireless network will be influenced by throughput, and it is obvious that it will affect the whole reliability of MANET. Including this, the congestion of wireless network also needs to be taken into account in ad hoc networks. Congestion means that an excessive amount of packets arriving at a network bottleneck which leads to a many packet drops. The capacity is limited and network reliability will be affected due to congestion. So it is impractical to set all mobile nodes with the same reliability in MANET. In order to compute the network reliability in a more realistic way, the proposed work focus on the node reliability model with fuzzy interference system on the basis of analysis of wireless devices.

The paper is organized into five chapters. Chapter 1 provides the introduction about MANET and reliability. Chapter 2 discuss the reliability based stable multicast routing protocols, power aware multicast routing and authentication based schemes which are relevant to proposed protocol. Chapter 3 provides the implementation of proposed protocol and Chapter 4 discuss the simulation results. Last chapter concludes the proposed model.

2. RELATED WORK

In [2] a Reliable and Energy Efficient Protocol Depending on Distance and Remaining Energy (REEDDRE) was proposed to provide better energy efficiency on Medium Access Control (MAC) layer. Cluster region is formed based on distance between neighbor nodes and residual energy. Some adjustments were made in multicast flow with the addition of unicast links with clusters. In [3], fuzzy cost based Multi Constrained Quality of Service Routing was proposed for optimal path selection based on bandwidth, end to end delay and number of intermediate hops. The path with maximum lifetime and minimum fuzzy cost was considered for best transmission. There was no stability of link present in this work. Reliability based performance metrics were not focused in this work. In [4], a new stability protocol called link stability to achieve reliable routes in multicast routing. In this protocol, link quality is estimated to achieve balanced route. In some cases, the link is not in a good quality such as network connection and link quality. In [5], energy consumption is reduced with Fuzzy Based Energy Efficient Multicast Routing (FREEMR). This protocol was utilized for better path selection and minimum energy consumption based on the implementation of fuzzy logic concept. The network lifetime was extended with respect to energy efficient multicast routing. In [6], a stable backbone-based multipath routing protocol (SBMRP) was constructed for more residual power and stable path foundation. If any nodes having this quality, it is considered as stable nodes. Multipath routing is established between origin and sink node through stable nodes. Alternate path is established if any route failure or link quality failure happens. In [7], Intelligent Energy efficient routing protocol was introduced for biological agents. A coordination technique is integrated for multi-hop ad hoc network. It reduces the power consumption without affecting the connectivity and network availability. Adaptive Fuzzy Logic Based Security Level Routing [8] was a secure end to end protocol to discover the secure multicast route. Only secure routes were focused. There is need to

DOI : 10.24297/jac.v13i10.5769
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focus on stability with reliable multicast route. In [9], an enhancement of On demand Routing Protocol was developed to achieve stability and Quality of Service. The basic structure and design of multicast algorithm was modified with network connectivity and link quality. In [10] multi-path unicast routing algorithm was introduced based on mobile agents. The network delay and overhead are reduced using mobile agents. Maximum Link Expiration Time (LET) is achieved by means of stronger routing stability and low probability of link failure. The time consumption for rerouting was totally reduced. In [11], a novel protocol called as The Efficient continuous path Multicast Protocol (ECPM) was introduced for choosing best intermediate nodes between source and destination for packet forwarding. The concept of Virtual Symmetry structure is used to find optimal path and high successful rate with more packet delivery ratio. In [12], authors proposed Trust Value based Energy Efficient Routing to increase network reliability based on energy consumption. Each node calculates trust value before packet forwarding. The reliability metric was used to create better routes for successful transmission. In [13], an Adaptive Energy Efficient and Reliable Gossip Routing (AEERG) Protocol was proposed to achieve energy efficiency and reliability. A counter value was set to present neighbor node in active state. The counter value was adjusted based on delivery rate. In [14], a multipath route discovery algorithm was designed for link quality. The secondary route was chosen in the absence of fresh route discovery process. The network communication was increased based on the network performance.

3. IMPLEMENTATION OF NETWORK RELIABILITY SECURE MULTICAST ROUTING PROTOCOL

The main aim of this proposed protocol is to establish reliable multicast tree that should balance both residual power and authentication. In this protocol, there are three major steps to achieve the balancing between data integrity and power. Signal strength is measured before the route establishment starts. Parent node is chosen as strong node which is having more energy and more integrity of packets. Child node is acting as either strong or weak node based on the situation arises. If any parent node expires before its validity of lifetime, the child node which is having more packet integrity, it will act as parent node. Stability metric, reliability trust metric and direct reputation of node are computed to discover the secure multicast tree. Once the tree is formed, the network will be more secure and produce more packet delivery rate.

The following assumptions are made while calculating reliability as follows:

i. Number of multi-hop neighbour nodes is limited to overcome failures of links.

ii. Multipath routing must be discovered with minimum source and destination nodes, and maximum neighbour nodes.

iii. Each neighbour node must communicate through shortest paths.

iv. Packet loss rate must be estimated once the first route discovery process is completed.

v. Link capacity and reliability will be calculated through Quality of Service (QoS) and Signal to Noise Ratio (SNR) estimation.

vi. Remaining energy must be estimated and kept more after route maintenance.

Determination of Reliability link factor

To define the reliability factor of all links reside in the network region, it is required to identify the link forwarding capacity. The link forwarding capacity can be estimated based on the number of packets successfully forwarded. In this connection, packets are flooded from source to destination in the presence of mobility environment. Mobile nodes are having routing table which consists of identity of all neighbors. If any one of the neighbour does not follow the rules and regulations of network cluster head, it will be automatically removed and isolated from the network. In order to choose the reliability trust metric, it is desired to characterize the reliable cooperative node. These nodes are roaming inside and outside the network in the absence of access point. Reliability trust metric (R_{tm}) is estimated as,

$$R_{tm} = W\left(P_k^{res} * C_k^{ss}\right)$$

Where W is the weight of signal strength $\left(C_k^{ss}\right)$ and residual power $\left(P_k^{res}\right)$. The residual power is the difference between power consumed $P_k^{con}(\tau - 1)$ during final transmission and power status $P_k^{res}(\tau - 1)$ of final transmission.

$$P_k^{res} = P_k^{res}(\tau - 1) - P_k^{con}(\tau - 1)$$

The signal strength $\left(C_k^{ss}\right)$ can be measured based on signal to noise ratio and transmission power.

From the reliability factor, the stability metric (S_{kl}) can be calculated as,

$$S_{kl} = \frac{R_{tm}}{Q_l}$$

Where Q_l is the quality of links.

Selection of Reliable and Unreliable nodes

Mobile nodes are categorized into two types.i.e. reliable and unreliable nodes. The following steps are used to select nodes.

Step 1: Neighbor node transmits hello packets with maximum signal strength in the network periodically.

Step2: Once hello packets received by neighbour nodes, signal strength, reliability trust metric and stability metric can be measured.

Step 3: Each node has reliability trust metric and stability metric and check with threshold value.

Step 4: If the metrics are below the trust threshold value, it is considered as reliable nodes otherwise unreliable nodes.

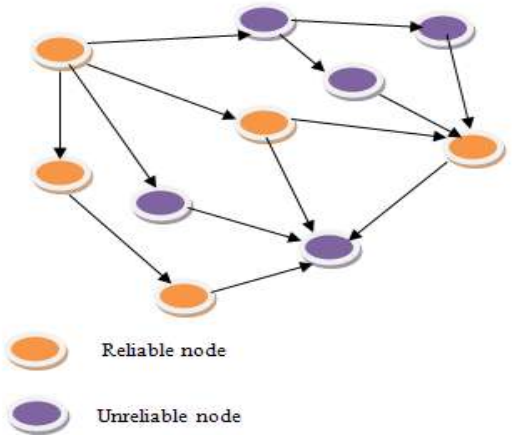

Figure 1. Selection of reliable and unreliable nodes

Figure 1 shows the selection of reliable and unreliable nodes based on stability metric and reliability trust metric. Reliable nodes are strong nodes and remaining nodes are called as weak nodes.

Reliable Multicast Tree construction

Reliable multicast tree is formed based on child node and parent node with reputation metrics. There are major three phases in the construction of reliable multicast tree.

Phase 1:

Each neighbour node sends Multicast Joint Request (MJREQ) to each reliable node stored in neighbour table. Once request message received, reliable node send reply message. For every unreliable or weak node, there will be atleast one parent node i.e. strong node. All the details stored in neighbour table.

Phase 2:

Neighbor node or child node periodically sends Join_Multicast Tree message to strong parent node. Source node S constructs a multicast tree consisting of number of paths. There is only one path exists from source node.

Phase 3:

Only reliable and unreliable nodes are participating in the multicast tree construction. If any third party nodes involved in the multicast tree construction, it will be removed from neighbour routing table.

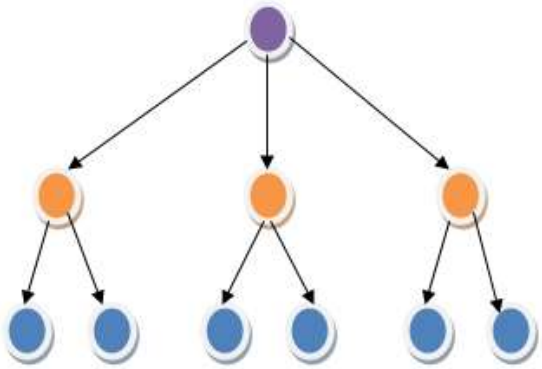

Figure 2. Multicast tree construction

Authentication based Multicast Communication

In this phase, node follows direct reputation value to forward packets to reach destination with more integrity. Integrity of packets is a major issue and it should be maintained throughout the network. Including this, a re-establishment key process is implemented in each and every data packets.

In this phase, direct reputation of node is calculated as,

$$R_{direct} = R_{sm}.*X + R_{si}*(1-X)$$

X is the confidence level constant metric. R_{sm} is the stability metric value of reputation. R_{si} is the reputation satisfaction index value. The subgroup key is estimated from the elliptical curve cryptography technique.

iii. Determination of network reliability using the concept of fuzzy decision mechanism

The concept of fuzzy logic is implemented in this protocol to decide the network reliability. The model used in the fuzzy logic is mamdani fuzzy model. Uncertainties may arise in the link or node. It may be good or false. From the model, an user can decide about the decision of uncertainties. Fuzzy interference system is integrated with fuzzification and defuzzification to decide the optimal system behaviour. Fuzzification is input system which accepts two parameters i.e. reliability trust metric and direct reputation of node. Defuzzification is a output module that produces network reliability.

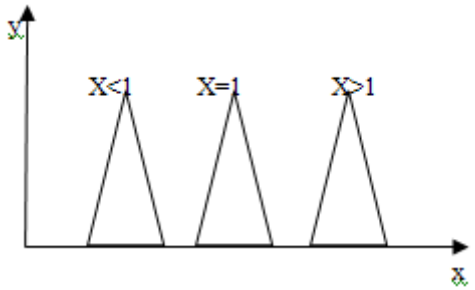

Figure 3. Fuzzy decision rule

If either reliability metric or node reputation is low or medium, network reliability value from defuzzification will be either low or medium. If network reliability is ensured at defuzzification, integrity and residual power will be improved.

4. PERFORMANCE EVALUATION

The proposed protocol is evaluated with the help of network simulator (NS2.34). The simulation settings and parameters are summarized in table 1.

Table 1. Simulation and Settings parameters of NRSMRP

No. of Nodes	120
Area Size	2000 x 2000 m^2
Mac	802.15
Radio Range	200 m
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	80 bytes
Mobility Model	Random Walk
Initial energy	90 Joules
Transmitted power	0.934 watts
Received Power	0.084 watts

Performance Metrics

The following metrics are used to evaluate the performance of protocol.

Packet Loss Rate: It defines the packet lost during transmission phase.

Network Reliability Rate: It defines how much packets delivered with maximum link quality and high reliability trust metric.

Packet Delivery Ratio: It defines packets delivered on the successful transmission after route maintenance phase.

Overhead: Number of routing control packets normalized by total packets.

End-to-end delay: It depends on the routing discovery latency, additional delays at each hop and number of hops. It is normalized by means of control packets.

Results

Figure 4 shows the result of simulation time Vs Packet Delivery Ratio. From the results the proposed protocol

NRSMRP achieves better performance than existing schemes.

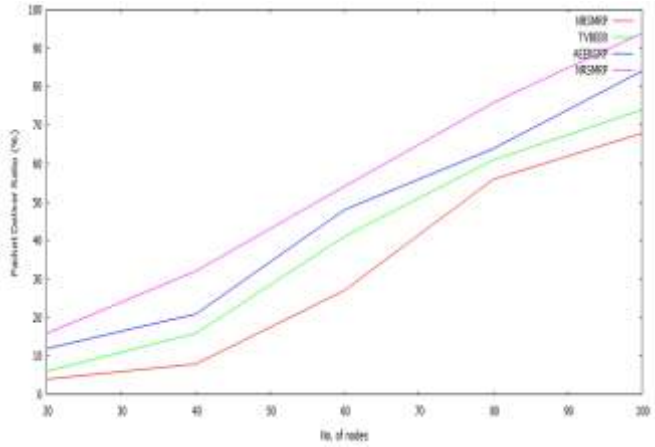

Figure 4. Packet Delivery Ratio Vs Number of Nodes

In Figure 5, end to end delay is varied in terms of speed. From the results, NRSMRP achieves less delay than existing schemes and protocols.

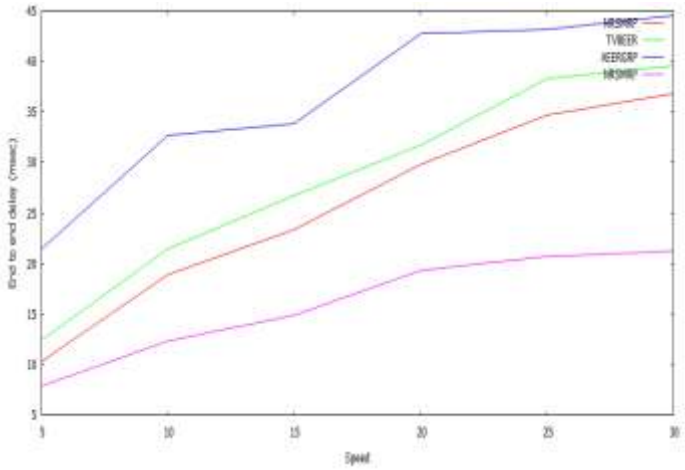

Figure 5. End to end delay Vs Speed

In Figure 6, 7& 8, the network reliability rate, overhead and packet loss rate. From the results, NRSMRP achieves less overhead and packet loss rate and high network reliability rate. It is because of reliable multicast tree formation and authentication based message transformation.

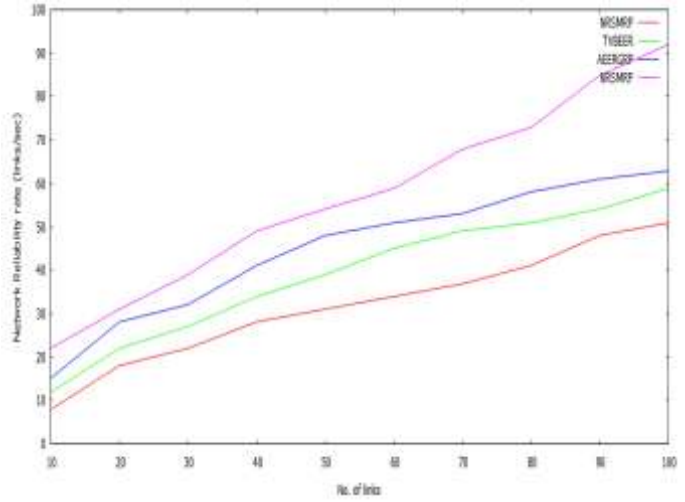

Figure 6. Network Reliability Rate Vs No. of Links

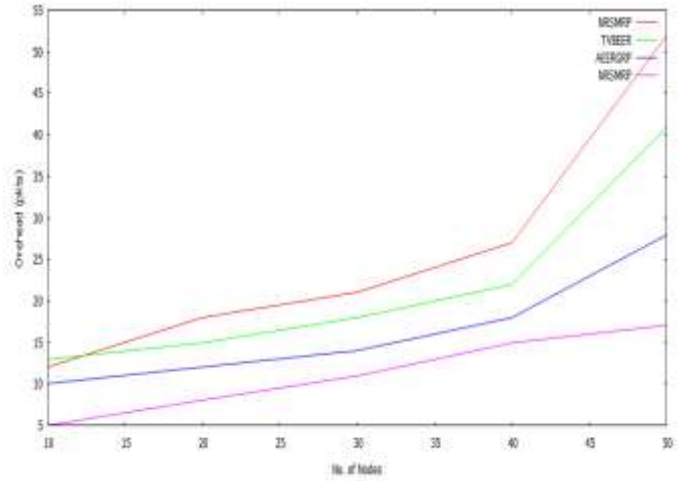

Figure 6. Overhead Vs No. of node

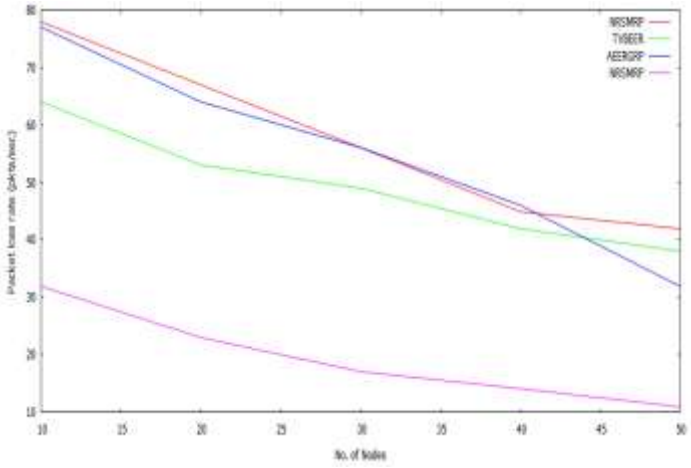

Figure 7. Packet Loss Rate Vs No. of Nodes

5. CONCLUSION

In this research work, network reliability based secure multicast routing protocol is developed to balance the integrity of packets and power of nodes. In multicast tree establishment phase, routes are formed based on link quality and stability metric. Stability metric is calculated based on reliability trust metric and signal to noise ratio. Reliability trust metric is estimated based on signal strength and residual power. Residual power is increased by means of proper selection of nodes i.e. parent node and child node as well as routers. Security is also enhanced with the proposed protocol to provide data integrity based on the estimation of node reputation metric. In future, it is planned to implement secure symmetric authentication approach to make network more secure.

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DOI : 10.24297/jac.v13i10.5769
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