Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

Fuzzy based Fault Tolerant Routing Protocol for Node Reliability in MANET

S. Pragadeswaran[1*], Dr. N. Suma[2], Ms. S. Madhumitha[3], Dr. S. Gopinath[4]
[1,2,3,4]Karpagam Institute of Technology, Coimbatore, India
[1]praga1994@gmail.com

ABSTRACT

Mobile ad hoc network (MANET) is one of the popular and challenging networks which consist of random mobile nodes with low mobility. Achieving fault tolerance and more reliability are the biggest tasks in the network. In existing works, it was failed to balance link tolerance and node reliability during route maintenance process. In this research, Fuzzy based Fault Tolerant Routing Protocol (FFTRP) is proposed to produce more tolerability and high network lifetime. In first module, network model is designed to support mobility function and scalability. In second module, a multicast routing is established based on path reliability. In third phase, fault tolerant calculation is done and integrated with multicast routing. The proposed work is simulated using network simulation tool in terms of node reliability rate, node stability ratio, end to end delay and control overhead.

Keywords: Fault tolerant, node reliability, multicast routing, scalability and network connectivity.

Introduction

Mobile Ad hoc Networks is one of the type of ad hoc network where nodes are communicated without access point. It is a flexible region where the nodes can be added or removed from the network at any time and it will also support the mobility of nodes efficiently [1]. For packet forwarding, data can be transmitted through mobile nodes by discovering routes to sink node. The mobile nodes can join or leave the network due to dynamic topology. Whenever the nodes want to join the network, its identification must be checked by the head to participate in the network. MANETs are deployed to support numerous applications such as military operations, video conferencing and disaster applications and so on. When a user wants to send his data to more number of receivers, there multicasting can be used [2,3].

Group connectivity is supported by multicast routes and it is very useful for improving the efficiency of routes while multiple copy of messages can be transferred in broadcast nature. Multicasting is one of biggest challenge in MANET where it provides group communication whereas multiple sink nodes are connected to single source node. The routing protocols are classified into two types i.e. mesh based routing protocols [4] and tree based routing protocols [5]. By adopting multicast communication, network can produce low delay, less bandwidth consumption, minimum overhead and high packet delivery rate at the end of packet transmission.

In general, MANET routing protocols focus on link reliability and fault tolerant capacity in the network without considering the network resources to meet the requirements of quality and deliverability. Fault tolerant routing is difficult to achieve in MAENT. In this research work, link reliability is determined based on packet loss, energy loss and retransmission of packets. It is maintained as threshold value to reduce the packet loss and to improve the network lifetime. Fuzzy decision model is enhanced to obtain the desired number of fault routes from the total number of routes based on crisp values. The FFTRP is evaluated using network simulation tool with existing schemes.

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

The paper is framed with 5 sections. In first section, MANET overview and use of multicast routing is discussed. In second section, the protocols, schemes, methods related to proposed protocol are analysed and identified the drawbacks. In third section, working and implementation of proposed protocol are given. In fourth section, results were compared with proposed work based on simulation. Last section concludes the work and future scope of the work.

Literature Review

Lorem ipsum dolor sit amet, alii idque ea usu. Causae perfecto et nec, etiam scriptorem quo ut. Before Kulwinder Kaur and Kamaljit Kaur [6] have reviewed and presented different fault tolerant routing algorithms and protocols for ad hoc wireless networks. Various handling problems like node failures, link failures, and transmission power and energy dissipation were analyzed and solutions were given to those issues. The overall performance based on throughput, reliability and network lifetime was recorded in the presence of fault tolerant routing schemes.

Ravichandra and Chandrasekar Reddy [7] presented Fault tolerant QoS Routing Protocol (FTQRP) to attain high tolerant route in the presence of mobile environment. Alternate routes are discovered if the route breaks occurs. Packets are sent through alternative routes to achieve more packet delivery ratio. Mobile nodes are randomly moving inside and outside the network. In previous work of this protocol, genetic algorithm was implemented to address routing with the help of network redundancies. In this QoS protocol, more fault tolerant rate has been improved than genetic algorithm.

Senthil et.al [8] introduced energy efficient QoS routing to estimate parameters of link reliability with the help of fuzzy logic technique. While adopting this approach, routing layer will be more robust. From the OSI architecture, link layer, routing and physical layer performs better. The Signal to Interference plus noise ratio can be calculated using physical layer. The neighbor status and back off time can be estimated for link layer. Data rate and data count information were calculated to decide the packet transmission status.

Nisha Chaudhary et.al [9] have made an analysis on fault tolerant methodologies to route packets along the optimized paths. All the paths have threshold signal strength to achieve more energy efficiency. Route discovery and route maintenance are continuously monitored to avoid packet loss in the presence of link mobility.

Fatemeh Tavakoli et.al [10] proposed efficient fault-tolerant routing algorithm for MANET. Network fault tolerance and natural redundancy was successfully improved using this algorithm. Initially, selection f backup routes and nodes were chosen by predicting reputation parameters. Fault tolerant routing will be initiated once the selection of backup of nodes was over. The primary route between pair of source and destination was estimated.

The new reliable protocol called Mobile Agent based Energy Efficient Reliable routing protocol to improve the link cost metrics i.e network load and link availability. All the mobile agents are randomly deployed and packets are transferred in a hop by hop manner once it reaches the destination [11]. From this traversal, node agents can collect the combine link cost metrics and source agents may able to select the optimal path.

Received 15 December 2020; Accepted 05 January 2021.

The link optimization procedure to extract the bandwidth efficiency using window channel. It was considered that previous obstacles and solutions were found to improve the energy efficiency [12]. The optimal network path was established from source to destination by considering link cost metrics and node trust parameters.

The topology transparent routing to achieve the improvement in network performance. There are three different network scenarios adopted to attain more gain. Network was kept as static and dynamic [13]. Energy estimation was done in the last scenario. Routing steps were modified according to the energy level of mobile nodes. The concept of shortest path mechanism was established to achieve high energy efficiency.

The fault tolerant routing for selecting cluster head with maximum energy efficiency. The link failure was mitigated by deploying local repair method. This method was utilized for avoiding link breakages [14]. However, this routing suffered from excessive routing overhead and more delay.

An effective and secured message broadcasting model to achieve better results over authentication with least energy consumption [15]. The secure broadcast model was used to minimize overhead based on the evaluation of confidentiality and authentication through source node. The confidence correlation measure was calculated to find the authenticated route between source and neighbor nodes.

Gaurav singal et.al [16] introduced a multi-constraints integrated link based multicast routing protocol while considering Quality of Service (QoS) metric to improve throughput, and improve bandwidth efficiency of MANET. The link stability factor was calculated to determine the number of stable links in the network. The authors used the concept of mesh based routing to support mesh communication while reducing link failures.

The main of this research work is to achieve the balancing between route tolerance and network reliability using multicast mechanism.

Methods

In this research work, it is proposed that Fuzzy based Fault tolerant routing protocol to balance the reliability and route tolerant in the presence of mobility of nodes.

Network Model

In this phase, the topology of MANET is derived as T(N,R). Where N is number of nodes and R is the number of routes. Both are connected by the devices i.e. edges. The reliability of link is expressed as l_r and residual energy of node is expressed as E_r.

Multicast Route Establishment based on Path reliability

In this phase, multicast route is established based on embedding reliable information in every packets. In general, multiple routes are discovered and they can compensate for dynamic environment but it is unpredictable to identify the attackers inside the network zone. In the proposed multipath route establishment phase, reliable information about paths are integrated in each and every packets moving towards the destination node. Here paths are considered as disjoint one. Nodes on disjoint paths are not unique. In this phase, cluster is formed and cluster

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

head is chosen based on received signal strength and residual energy. Based on mesh based multicast routing, CH broadcasts the group of messages to multiple destinations via multiple paths. Once the CH received the joint reply packets from destination and intermediate nodes, multicast connection will be established based on link reliability and residual energy of nodes. The Multicast Route request packet contains source id, sink id, sequence number id (to check link activeness), link reliability, and residual energy. After receiving the route request packets from the source node, intermediate node checks the path reliability metric. This metric is determined from the link reliability (l_r), residual energy (E_r), delay (d) and bandwidth (BW). The link reliability is estimated as,

$$l_r = \frac{P_d - P_l}{P_T} - E_w$$

Where P_d is the packets successfully delivered at the destination, P_l is the number of packets loss, P_T is the total number of packets and E_w is the energy wastage on packet loss and retransmission of packets. During bandwidth estimation, the channel capacity and periods of sleep node and active node during packet transmission are considered. In energy model, initial energy is E_i and transmission energy is E_t. The transmission energy is estimated based on packet transmission N_t and reception N_r with respect to constant parameter (μ, ν) and it is derived as,

$$E_t = N_t * \mu + N_r * \nu$$

The delay is measured from the propagation delay, processing delay and queuing delay. It is given as,

$$d = d_p + d_{pg} + d_q$$

The path reliability metric (P_k) is measured as,

$$P_k = P_1 * \left(\frac{BW_s}{BW_T}\right) + P_2 * \left(\frac{E_t}{E_i}\right) + P_3 * \left(\frac{d}{T_{\max}}\right) + P_4 * \left(\frac{l_r}{l_n}\right)$$

Where $P_1 + P_2 + P_3 + P_4 = 1$, T_{max} is the maximum time for synchronization, l_n is the number of links available in the network.

Neighbor node check the reliability of paths and hop count value and forward it to destination node. If the Sequence Number of the node is not matched, neighbor node will resend the RRREQ packets to source node. If it is matched, the message will be broadcasted to destination node. The destination node sends the reply packets containing path reliability count. CH chooses maximum reliability count and check the fault tolerability of the paths. The optimized fault tolerant route is discovered with having least energy nodes on active route inside the network region. Route error (RERR) message will be received if the energy of node falls below the threshold value. Here the maximum transmission energy is 0.879 Joules as fixed in the simulation setup. CH creates and chooses alternative path to the destination.

Determination of Fault tolerable routes

Once the alternative paths are setup towards the destination node, neighbor node discovers the optimal paths based on the link quality estimation. The link quality can be calculated by estimating the Expected Transmission Period (ETP). This metric is used to find link capacity (*lc*) and packet size (*ps*). This ETP value will be stored in all mobile nodes including source and destination. It is given as,

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

$$ETP_k = ETC_k * \left(lc / ps \right)$$

Where *ETC* is the expected transmission count for packets.
Fault Tolerable Routes (FTR) can be found as the sum of metrics of link, remaining energy, hop distance, and ETP. It is estimated as,

$$FTR = \left(\varepsilon * re_k + \phi * \frac{1}{d_{jk}} + \gamma * \frac{1}{ETP_k} + p\_reliability \right)$$ where $\varepsilon, \phi, \gamma$ are the coefficients related to remaining energy, distance between two mobile nodes and expected transmission period. Source node chooses path with maximum FTR. Source node sends RRREQ message towards the next hop. Once it is confirmed, it is able to identify the presence of destination node. The flag will be set if the destination address matches with address in the header field of RRREQ. If not, the optimal route will be constructed towards the destination node.

Fuzzy decision model for Fault tolerant

Fuzzy decision mechanism is used using Mamdani Fuzzy model. The inputs to the fuzzification are path reliability and expected transmission count. It is converted as crisp values and given to fuzzy inference engine. The values are processed and given to defuzzification. The values are converted into single output i.e network lifetime. If both crisp values are high, network lifetime will be high. Figure 1 shows the illustration of fuzzy decision mechanism.

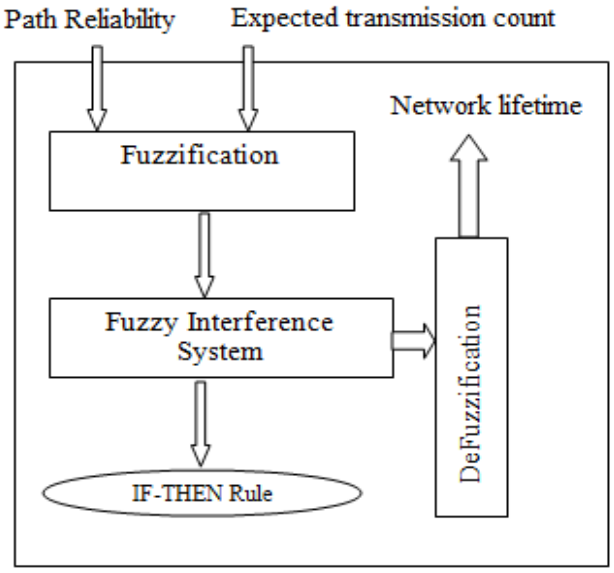

Figure 1. Fuzzy decision model

Results

The FFTRP is simulated with network simulation tool in the simulation area of 1200 x 1200 sq.m. The routing protocol used here is on demand multicast routing protocol (ODMRP). The traffic adopted here is constant bit rate. The simulation settings and parameters are tabulated in Table 1.

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

Table1. Simulation and Settings parameters of FLRMRP

Mobility model	**Random walk**
Received power	**0.0789 watts**
Transmitted power	**0.967 watts**
Simulation area	**1200 x 1200 sq.m**
No. of Nodes	**200**
Traffic	**Constant Bit Rate**
Routing Protocol	**On demand Multicast Routing Protocol**

Performance Metrics

The following metrics are used to analyze the performance of proposed protocol and existing schemes. .

Node Reliability Rate: It is the rate at which number of reliable nodes with respect to packet transmission per sec.

Packet Arrival Ratio: It is the ratio of packets received at the sink node to packet sent successfully.

Control Overhead: It is excess of control packets regularized by the total packets which blocks the communications.

Propagation delay: It is the delay consumed by the packets traveling in the link from node to node.

Fault tolerant ratio: It is the ratio of link with more tolerant rate to the total available links.

Results : Figure 2 shows the result of Packet arrival ratio in y axis while varying the simulation tome in x axis. The FFTRP achieves high packet delivery ratio than existing schemes.

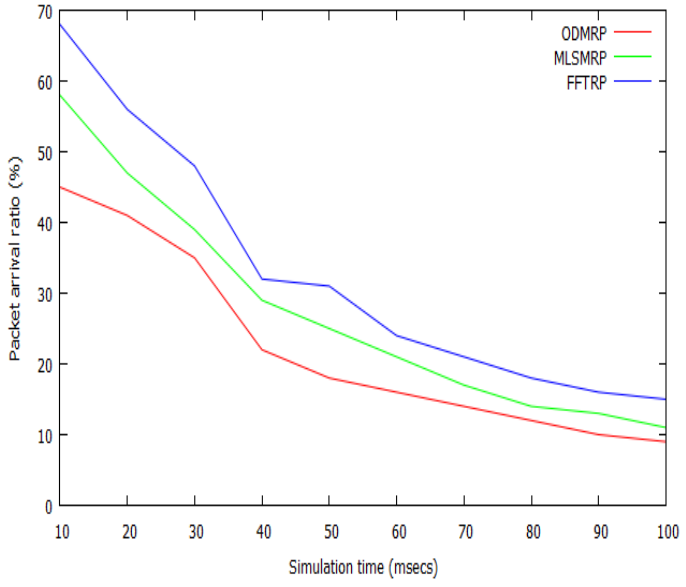

Figure 2. Packet arrival ratio Vs Simulation time

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

In Figure 3, the propagation delay of the proposed protocol is low compared to existing schemes due to the calculation of entire delay. The delay is reduced by finding the fault tolerant routes.

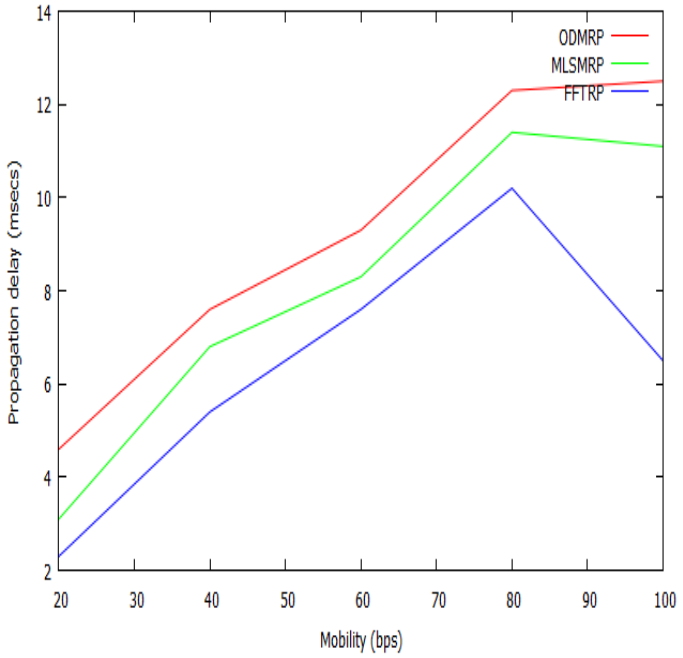

Figure 3. Propagation delay Vs Mobility

In Figure 4, node reliability rate is varied in y axis and no. of nodes is varied in axis. Based on the results, FFTRP produces more reliability rate than existing schemes.

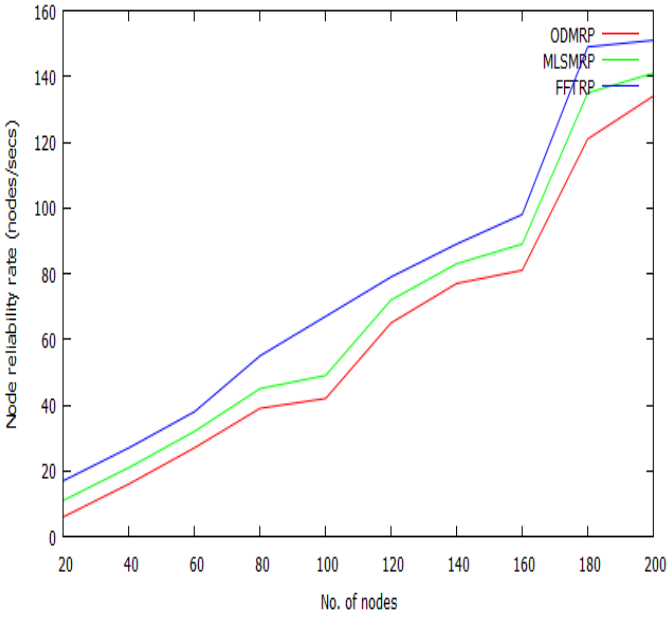

Figure 4. Node Reliability Rate Vs No. of Nodes

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

Figure 5 illustrates the performance of control overhead for proposed scheme and existing schemes. In the simulation output, FFTRP consumes less overhead for packet transmission.
Figure 6 shows the output of fault tolerant ratio while varying the number of links in axis. It is found that FFTRP achieves high tolerant ratio than existing schemes.

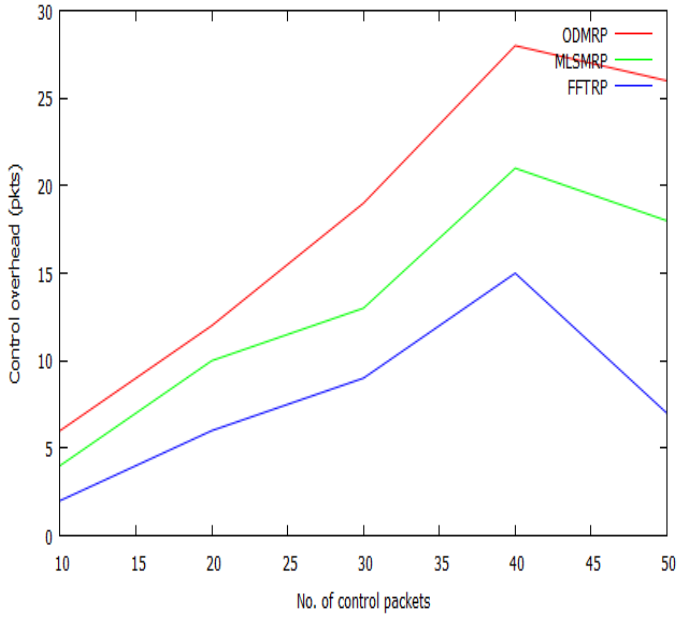

Figure 5. Control Overhead Vs No. of Control packets

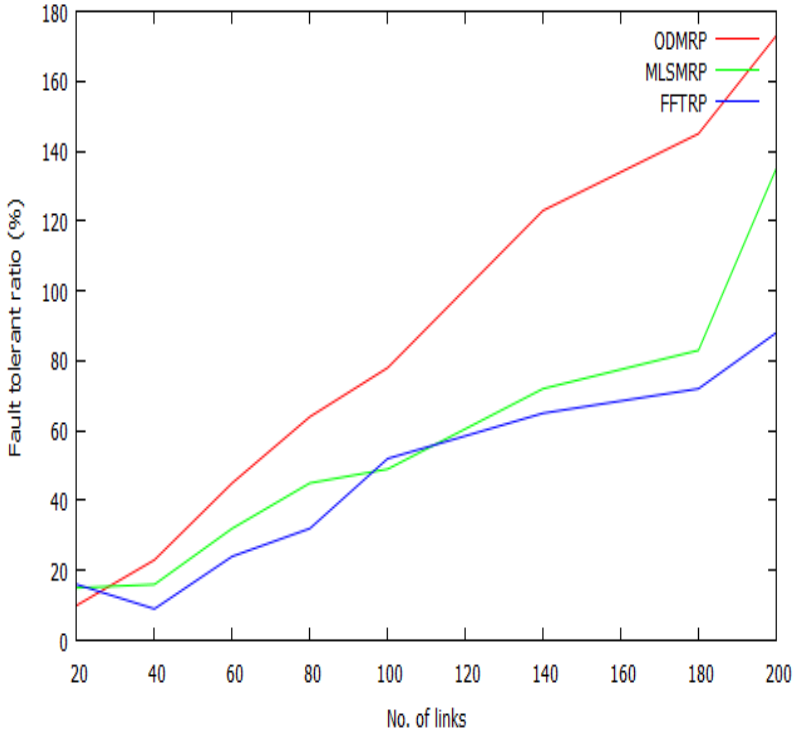

Figure 6. Fault tolerant ratio Vs No. of links

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 1, 2021, Pages. 7223 – 7232

Received 15 December 2020; Accepted 05 January 2021.

Conclusion

MANET is most popular and commercial network where mobile nodes are communicated in the absence of access point. Achieving fault tolerant is major task in ad hoc networks. In this research, Fuzzy based Fault Tolerant Routing Protocol is developed to balance the network lifetime and fault tolerant. Network model is introduced to decide the level of reliability and fault tolerant. Multicast routing is established from source to sink node based on path reliability. Fuzzy decision model is integrated with propose protocol to decide network lifetime. Based on the simulation results, FFTRP produce low control overhead, less delay, high packet arrival ratio, fault tolerant ratio and more node reliability ratio than ODMRP and MLSMRP. In future, it is planned to protect data from the vulnerable attackers from the network using security approaches.

References

[1] Siva Ram Murthy C and Manoj BS (2002), Ad hoc wireless networks: architectures and protocols (Rappaport). *Prentice Hall PTR, USA*, pp.213–245.

[2] Junhai, Lin and Daniye (2008). Research on multicast routing protocols for mobile ad hoc networks. *Computer networks*, 58(1), pp.988–997.

[3] DeepikaVodnala (2019). A Reconfigurable Multicast Routing Protocol for Mobile Ad-Hoc Networks. *International Journal of Innovative Technology and Exploring Engineering*, 8(9), pp.193-198.

[4] Su W, Lee SJ and Gerla M (2002). On-demand multicast routing protocol in multi hop wireless mobile networks (ODMRP). *Mobile Networks and Applications*, 7(1), pp.144-153.

[5] Royer EM and Perkins CE (2000). Multicast adhoc on demand distance vector (MAODV) routing. *Mobile Ad Hoc Networking Working Group, Internet Draft*, pp.21.

[6] Kulwinder Kaur and Kamaljit Kaur (2015). Recent Trends Toward Fault Tolerance Techniques in MANET. *International Journal of Computer Applications*, 10 (22), pp.47-52.

[7] Ravichandra and Chandrasekar Reddy (2016). Fault tolerant QoS Routing Protocol for MANETs. *IEEE International Conference on Advanced Computing*, pp.34-45.

[8] Senthilnathan Palaniappan and Kalaiarasan Chellan (2015). Energy-efficient stable routing using QoS monitoring agents in MANET. *EURASIP Journal on Wireless Communications and Networking*, 13(1), pp.1-11.

[9] Nisha Chaudhary, Er Shiv Kumar Goel, Nitin Goel (2015). A Deep Analysis: Highly Robust Fault Tolerant Secure Optimized Energy Ad-hoc Networks Methodologies for Mobile Nodes. *International Journal of Advanced Research in Computer Science and Software Engineering*, 5(7), pp.540-543.

[10] Fatemeh Tavakoli, Meisam Kamarei, Gholam Reza Asgari (2016). An Efficient Fault-Tolerance Routing Algorithm for Mobile Ad-hoc Networks. *Journal of Advances in Computer Research*, 7(2), pp.23-40.

[11] E.Vishnupriya, T. Jayasankar and P. Maheswara Venkates[h,] "SDAOR: Secure Data Transmission of Optimum Routing Protocol in Wireless Sensor Networks For Surveillance Applications", *ARPN Journal of Engineering and Applied Sciences,* Vol. 10, No.16, Sep 2015, pp 6917-6931

[12] K.Vinoth Kumar, Dr.S.Bhavani, "Trust Based Multipath Authentication Protocol for Mobile Ad Hoc Network" Journal of Computational and Theoretical Nanoscience (CTN), ISSN: 1546-1955

Received 15 December 2020; Accepted 05 January 2021.

(Print): EISSN: 1546-1963 (Online), Volume 12, Number 12, December 2015, pp. 5479-5485(7) DOI:https://doi.org/10.1166/jctn.2015.4552.

[13] K.VinothKumar, T.Jayasankar, M.Prabhakaran and V.Srinivasan, "Fuzzy Logic based Efficient Multipath Routing for Mobile Adhoc Networks", Appl. Math. Inf. Sci. Vol.11, No.2, March 2017,pp.449–455.DOI: http://dx.doi.org/10.18576/amis/110213

[14] D.Anandha Kumar, S.Nyamathulla M. Kirankumar, K.Vinoth Kumar T. Jayasankar "A Hybrid Secure Aware RoutingProtocolforAuthenticationinMANET",InternationalJournalofAdvancedScienceandTechnology,Vol.29, No.3, (2020), pp.8786–8794

[15] S.Pramela Devi, V.Eswaramoorthy, K.Vinoth Kumar and T. Jayasankar, "Likelihood based Node Fitness Evaluation Method for Data Authentication in MANET ", International Journal of Advanced Science and Technology, Vol. 29, No. 3, (2020), pp. 5835 –5842.

[16] M.S. Gaur, Swati Todi, Vijay Rao, Meenakshi Tripathi, Riti Kushwaha (2017). Multi-constraints Link Stable Multicast Routing Protocol in MANETs, *Ad Hoc Networks, DOI*: 10.1016/j.adhoc.2017.05.007.