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Review of Routing Protocols and Associated Challenges in MANETs

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Abstract: ***Mobile Ad Hoc Networks allow us to overcome the obstacle of infrastructure networks. The nodes in such networks communicate with each other directly without the aid of any fixed infrastructure. Each node in such networks can act as a source or a downstream node as well as an intermediate router. Due to dynamic topological structure of these networks, designing optimum routing protocols pose a great challenge. The requirements of route designing can be certain parameters as per the application requirement. Some requirements include lower power consumption, higher data security and option for multicasting which if not optimized can degrade the network performance substantially. This paper mainly focuses on issues with routing protocols in such dynamic environment and prominent challenges faced by MANETs in Quality of Service constrained routing.***

Keywords: Mobile ad hoc network, proactive routing, reactive routing and hybrid routing.

1. Introduction

A MANET is an infrastructure-less wireless network used to connect various mobile devices. The nodes in the network are free to move randomly as long as they are within transmission range of any node comprising the network. Every node in the network works independently and no centralized administration is necessary. This allows such networks to be used in remote areas and disaster stricken areas where little or no infrastructure exists. Several areas where MANETs are used are: Military information networking systems, underwater wireless communication networks and disaster relief operations [1].

Ad hoc networks are robust and so are MANETs. When any intermediate node leaves the network, link breakage takes place. In such a situation, the immediate upstream node or source node itself starts a route discovery and a new route is established [1]. A basic structure of MANETs is shown in Figure 1.

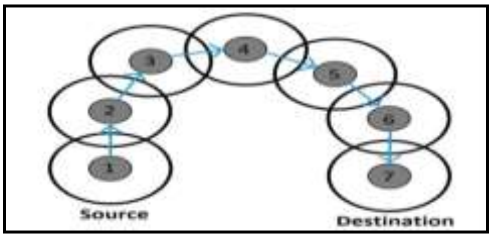

Figure 1: Basic structure of MANETs

An ideal MANET adapts to the traffic and transmission conditions according to the mobility patterns of mobile nodes. The dynamic topology of the MANETs causes the network to undergo occasional disconnections in case of non-ideal MANETs and hence routing protocol optimization becomes an integral part of data transmission [2].

There are several issues with the mobile ad hoc networks such as: Problem of bit error and lower bandwidth capacity due to quality of end to end link paths which are used by several nodes in the network. Ad hoc networks are not very secure and since each node works independently there exist problems of provision of Quality of Service (QoS) parameters such as throughput and end-to-end delay. Since MANETs are infrastructure-less networks without any fixed access point, physical layer complexities pertaining to mobile nodes increase which raises a need to maintain neighbor relationships with all the mobile nodes within the service area. This leads to higher power consumption of battery operated independent mobile nodes [2].

State of the art challenges and a review of the routing protocols along with network performance parameters are being presented in this paper. The network performance parameters are evaluated to gauge the efficiency of a protocol. The challenges discussed pose major issues during implementation and operations in MANETs.

Rest of the paper is organized as follows. Network performance parameters are discussed in section II. Various challenges faced in MANETs are discussed in section III. A review of some standard routing protocols is presented in section IV. The paper is concluded in section V.

2. Network Performance Parameters

Network performance parameters such as throughput, end-to-end delay, jitter and packet delivery ratio are considered in the study of performance evaluation of MANETs. Various issues regarding the network are apprehended by carefully examining these parameters which ultimately testify the QoS of the network [2]. Following are the parameters which have a profound effect on the efficiency of a routing protocol.

2.1 Throughput

Throughput can be defined as the number of data packets which can travel successfully from one location that is source node to the other location that is destination node in a given period of time. This parameter is essential in evaluating the congestion in a route of the network. It is measured in bits per second [3].

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2.2 End-to-End Delay

End-to-End delay is a one directional delay which is a measure of the amount of time taken by a data packet to travel from source node to destination node. It is essential in the evaluation of link failure and congestion in the paths between the nodes in a network. It is typically represented in milliseconds [4].

2.3 Jitter

Jitter is a variation in the amount of time usually required by data packets to transfer from one position, the source node to another position, the destination node. High amount of jitter is caused due to congestion and route failure related factors in the communication path [5].

2.4 Packet Delivery Ratio

Packet delivery ratio is a measure of the ratio between number of data packets successfully transmitted from source node to destination node to the total number of data packets originally transmitted through the established link between source and destination node [6].

3. Challenges in MANETs

MANETs have a major advantage over other networks i.e. mobility, but mobility of nodes makes such networks unpredictable. Inconsistent and more frequent node movements in MANETs lead to problems such as link failures and network congestion which eventually lead to higher packet drop ratio, higher end to end delay, poor quality of service, poor data security, unstable multicasting and routing challenges while designing efficient, self-organizing routing protocols [8]. Some of the challenges in MANETs have been reviewed in this section.

3.1 Quality of Service

Quality of Service (QoS) provides a set of service requirements to the data flows during data transmission through the network. The increasing use of wireless technologies has elevated QoS for multimedia applications in wireless networks. Therefore, providing QoS in MANETs is more challenging than in fixed and wireless networks. Other challenge while providing QoS to wireless networks is that MANETs have fewer resources as compared to fixed wired networks and resource constraints of the nodes pose a major hindrance. Hence it makes difficult for these networks to provide assured QoS requirements for wireless applications [7].

3.2 Routing

Various table driven and on-demand routing protocols are designed to facilitate route repair and maintenance mechanisms to rescue the network during link failures and congested link scenarios. But these mechanisms do not ensure complete packet security and drop proof transfer. The standard routing protocols are not compatible with the infrastructure-less organization of a MANET network which adversely affects the integrity of the network owing to its dynamic topology. Hence such routing protocols are used which are robust and self-organizing in case of adversities such as a link failure or congestion within the network. However, the dynamic nature of MANETs makes it difficult to design routing protocols with minimum packet drop ratio and higher throughput [8].

3.3 Multicasting

In MANET, multicast services play an important role as the bandwidth and energy can be saved through multicast packets delivery. Through multicasting an information message can be sent to multiple receivers having the same address. Multicast uses tree approach such as group shared tree and source specific tree to achieve its objective. Since MANETs suffer from the problems arising due to its dynamic topology the maintenance of connected multicast routing trees cause large overheads. To overcome such problems a modified mesh approach is used. Meshes support more connectivity than trees hence they are more suitable for MANETs but they are more susceptible to form routing loops [9].

3.4 Security

MANETs are vulnerable to various security threats. Certain factors such as high mobility dynamic topology, resource constraints, limited physical security and no centralized access point or administration center makes it susceptible to two types of security attacks: *active attacks* and *passive attacks*. In passive attacks, confidential information may be eavesdropped. In active attacks, packets are injected to invalid destinations; they can also be deleted, modified and impersonated. There are some other security attacks such as *byzantine* or misbehavior attacks, which are generated by network nodes that do not follow protocol specifications. Byzantine attacks are further classified as blackhole, wormhole, rushing, Sybil, sinkhole, HELLO flooding and selective forwarding attacks. MANET applications suchas sensor networks and applications of ubiquitous computing are in demand for strong protection and security mechanisms which is a subject of further research [10].

3.5 Power Consumption

MANETs have higher physical layer complexity as mobile stations are required to maintain neighbor relationships with all the other mobile stations within the service area this requires more power than the infrastructure based networks. In table driven protocols, routing tables of every nodes are periodically updated which not only creates a network overhead but also drains more power. Since MANETs are mobile and make use of battery operated stations without the access points, the power drainage can often lead to link failures and poor quality of service [11].

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4. A Review of Routing Protocols

There are various standard routing protocols that have been proposed which can also be applied in case of MANETs. This section reviews the most widely used standard routing protocols and the limitations in a dynamic environment as in MANETs [6]. Routing protocols can be classified as: Proactive, Reactive and Hybrid as shown in Figure 2.

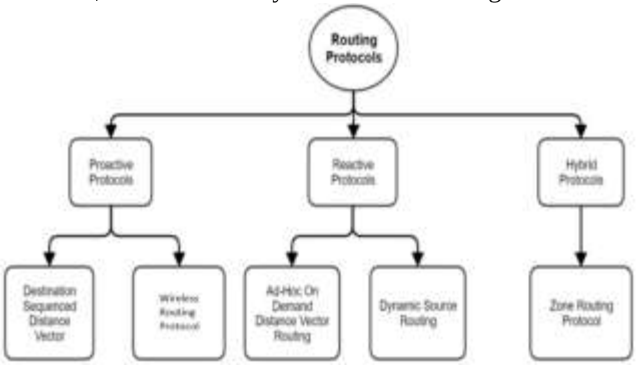

Figure 2: Classification of Routing Protocols

4.1 Proactive Routing Protocols

Proactive routing protocols rely on having complete information for the network. In these protocols, each node contains the routing table of all the nodes of the entire network. Hence they are also known as table-driven routing protocols. The table-driven approach reduces the control traffic overhead generated by proactive routing as each data packet is forwarded immediately by referring to the routing information in the route table which is needed to be updated periodically [11]. Some of the widely used proactive routing protocols are as follows.

4.1.1 Destination-Sequenced Distance-Vector Routing Protocol

Destination-Sequenced Distance-Vector Routing Protocol (DSDV) is a proactive routing protocol which uses the Bellman-Ford algorithm to calculate the number of hops to the destination. Each node contains a routing table which consists of the total number of hops required to reach each possible destination node, destination address and a special sequence number assigned by the destination node. The sequence number is assigned to distinguish between the new and old routes as well as to avoid the formation of loops within the network. In DSDV each node broadcasts and updates its routing table information periodically with the new information. This broadcasted new information consists of the address of the destination node, the number of hops required toreach the destination and the new sequence number assigned by the destination node. This sequence number is incremented whenever a new node is added. The largest sequence number is used for routes to ensure that the most recent data is used [11].

If a routing table is updated with a higher sequence number then the existing route is replaced with the new one to reduce the possibility of routing loops. In case of a major topology change a full routing table dump will be performed, this adds huge amount of routing overheads in a dynamic network situation [12].

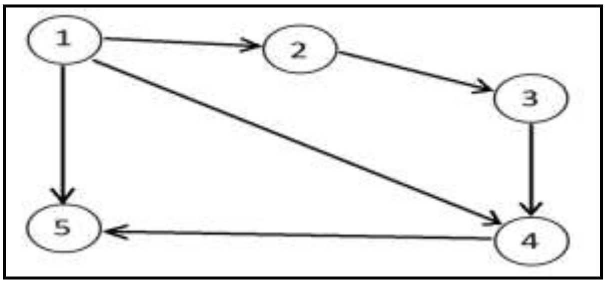

Figure 3: DSDV Network and routing table at source node (1)

Destination	Next Hop	Metric
(2)	(2)	1
(3)	(2)	2
(4)	(4)	1
(5)	(5)	1

In Figure 3, there are 5 nodes connected as shown in the diagram. Node (1) wants to transmit data to node (5). In order to do this, it will first look at its own routing table. According to its routing table, there are 3 paths to node (5). One, node (5) is 4 hops away and the first hop should be to node (2). Second, node (4) is 2 hops away from node (5) and the first hop would be to node (4). Lastly, direct from node (1) to node (5). So, the data is transmitted to node (2). Once (2) receives the data, it will also look at its routing table and forward the data accordingly. This process continues till the destination is reached.

DSDV maintains a fewest hop path without any routing loops for all the destination nodes. DSDV protocol is mainly used for small ad hoc networks because in large ad hoc networks the overhead of control messages increases with increase in number of nodes. Hence, when the number of nodes increases the size of the routing table also increases which eventually consumes a large bandwidth when being transmitted over a network [11].

4.1.2 Wireless Routing Protocol

Wireless Routing Protocol (WRP) is also based on the Bellman-Ford algorithm. It is a unicast proactive link state routing protocol in which each node contains the information of the entire topology of the network [13]. The nodes are responsible for maintaining four tables: Distance table, Routing table, Link-cost table and Message Retransmission List (MRL) table [14].

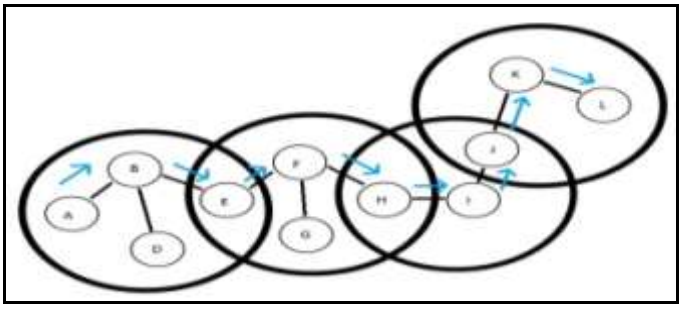

Figure 4: WRP Network of nodes

Each entry of the MRL consists of the following: the sequence number of the update message, a retransmission counter, an acknowledgment flag vector, and a list of updates

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sent through the update message. The Message Retransmission List ensures that which updates in an update message are needed to be retransmitted and which neighbours should acknowledge the retransmission [13].

Distance table of a node stores the distance of each destination node via each neighbor of the node in consideration [13].

Routing table of a node contains the distance of each destination node from that node. It also contains a flag or an identifier to check if the entry in the table is a simple path or a loop [13].

Link-cost table provides the link metric to each of the neighboring nodes. It also provides the number of update periods elapsed since the node received any error-free message from it [14].

4.2 Reactive Routing Protocols

Reactive routing protocols are on demand protocols where routes are discovered only when required. Reactive protocols do not need to maintain a route between all pairs of network nodes continuously and thus it does not need to maintain a routing table.The route discovery procedure takes place only when a source wants to send data to find a destination node and the route is maintained through the route maintenance procedure until the route is no longer needed. In this manner, communication overhead is reduced and battery power is conserved as compared to proactive routing protocols [21]. Some of the routing protocols using this approach are:

4.2.1 Ad hoc On demand Distance Vector

Ad hoc On demand Distance Vector (AODV) is implemented as an improved version of DSDV. The aim of AODV is to reduce the number of broadcast messages sent throughout the network by discovering routes on-demand instead of keeping complete up to date route information. It provides loop free routing by using destination sequence number, generated by the destination itself. If two similar routes to a destination exist then the node chooses the one with the highest sequence number [15].

In DSDV each node used to check its routing table to find a valid route to the destination node. If a valid route is found, the data packet is forwarded directly. If a valid route is not found then the route discovery process of AODV comes into the forefront. During the route discovery process a source node broadcasts a Route Request Packet (RREQ) to all of its neighboring nodes which further broadcast it to their respective neighbors until the packet reaches the destination node. The RREQ packet consists of IP address of the source node, current sequence number assigned by the destination node, IP address of the destination node and the last assigned sequence number. The intermediate nodes record the address of the neighbor from which the first copy of the packet has come in their route tables and forward route request packets to other neighbors. This aids in tracking the reverse path for the Route Reply Packet (RREP) from the destination node.The intermediate nodes forward the RREP coming from the destination node along the established reverse path and store the forward route information in their respective route table. A route discovery process is successful only when the RREP is received by the source node within stipulated time duration or else the RREP is rejected and a new route discovery process is initiated [16].

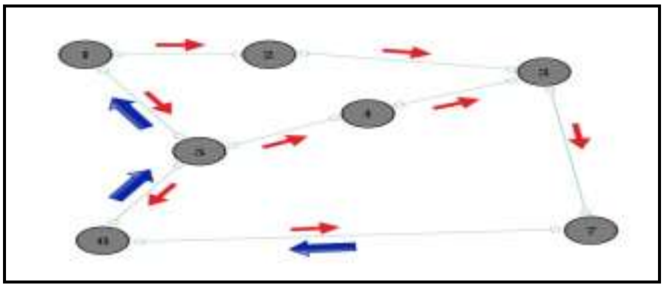

Figure 5: Structure of an AODV Network

In Figure 5, node (1) sends a RREQ for node (7). The RREQ packet travels through multiple paths and a RREP packet is returned to node (1). Once the path is discovered, (1) can start transmitting data to (7).

Dynamic topology of the MANETs is mainly responsible for network issues such as link failure and network congestion. These issues lead to route failure. If a source node moves away from the coverage area, it reinitiates the route discovery process with the other set of neighboring nodes. When the destination or intermediate nodes are dislocated from the coverage area a special RREP containing the updated sequence number and the information regarding the link failures is sent to the affected source nodes, which can thence start a new route discovery process [15].

4.2.2 Dynamic Source Routing

Dynamic Source Routing (DSR) protocol is the most widely used reactive or on-demand routing protocols. The protocol quickly adapts to routing changes in highly frequent node mobility environment, yet requires little or no overhead during periods in which node mobility is less frequent.DSR is based on the link-state routing algorithm and it supports loop-free routing.DSR uses source routing.The advantage of source routing is that its intermediate nodesdo not require up to date routing information, because a packet encapsulates all the necessary routing information. It requires higher memory than others, the memory stored on each node for maintaining node route caches can be quite large. It has two phases: route discovery and route maintenance [17].

In DSR the route discovery process although similar to AODV is slightly deviated in the later stages. The source node broadcasts RREQ packets to each of the neighboring nodes until the RREQ reaches the destination node. Each node adds its own node id to the packet as the packet progresses from one node to the other in the network. In this approach each node contains its route cache which consists of the every possible number of routes available to the destination node. This route cache enables the DSR to reduce the routing overhead generated by the route discovery phase. Each node first checks its cache for a route to the destination. If a route is found in the cache itself, then this intermediate node itself sends the RREP to the source node instead of further broadcasting the RREQ. DSR assumes that

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the path obtained is the shortest since the first packet that arrives at the destination node is only considered [18].

Route Maintenance involves identification of route link to determine its capability and reliability to check if it can carry packet or not. Two types of packets are used: *route error packets* and *acknowledgement*. DSR checks the validity of the existing routes in the network by surveying the acknowledgments received from the neighboring nodes which indicate that data packets have been transferred to the next hop. A node fails to receive acknowledgments from the neighboring nodes if a link error exists. If any error occurs in the link then route error packet is generated and sent to source node to initiate a new route discovery phase [19].

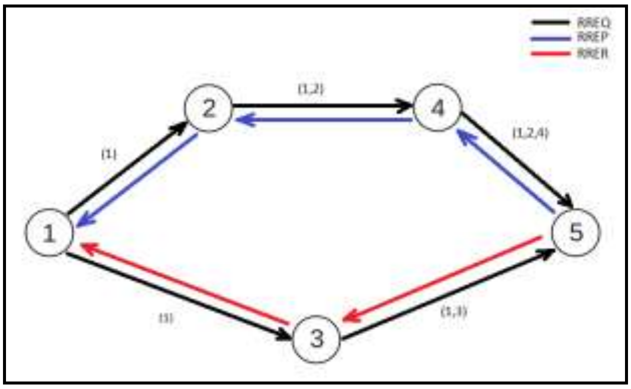

Figure 6: Structure of a DSR Network

As shown in Figure 6, node (1) sends out a route request for discovering a route to node (6). The route request message goes through 2 separate paths. One message travels along the (1-2-4-5) route and the other message travels along the (1-3-5) path. As the message travels, it stores the route taken and this entire path information is carried back in the route reply. If the route is broken then a route error message is sent.

4.3 Hybrid Protocols

Hybrid approaches have features of both proactive and reactive protocols. These are widely used because of their versatility. Each node contains the routing tables of a set of its neighbors. So, every node maintains a routing table of theadjacent nodes but is ignorant of the entire network. One example of this is the Zone Routing Protocol (ZRP).

4.3.1 Zone Routing Protocol

Zone Routing Protocol (ZRP) is a hybrid protocol which encapsulates seemingly the best of proactive and reactive kinds of protocols. It uses the concept of 'zones' in its architecture. The hybrid Zone Routing Protocol (ZRP) framework can adapt to a wide variety of network scenarios by adjusting the range of the nodes'proactively maintained routing zones [20]. The entire network is divided into certain zones and each zone contains a particular number of mobile nodes. There is a central node which facilitates interconnections of all the zones of the network. In intra zone communication i.e. when a source node and a destination node within the same zone need to communicate with each other a table driven routing approach is incorporated, whereas in inter zone communications i.e. when a source node and a destination node are in different zones an on-demand routing approach is found to be more efficient [21].

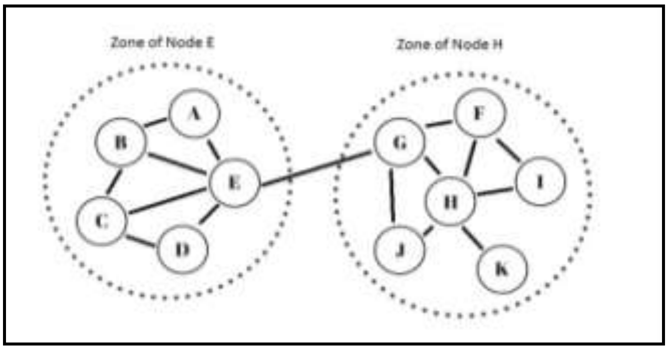

Figure 7: Structure of ZRP Network.

In Figure 7, node E is central source node to a particular zone, similarly node G is a central source node to its indigenous zone. Both the nodes communicate proactively with the other destination nodes in their respective zones. This type of communication is known as intra-zone communication. In inter-zone communication node E and node G representing their respective zones communicate with each other reactively.

5. Conclusion

In this paper, various network performance parameters and challenges involved in mobilead hoc networks along with standard routing protocols have been discussed. Routing protocolshave been divided into three categories:reactive, proactive and hybrid. Different types of routing protocols with such dynamic environment and their complications in implementations have also been illustrated. The standard reactive, proactive and hybrid routing protocols have QoS issues as they are not able to provide optimized QoS in an infrastructure-less network. Moreover dynamic topology of MANETs poses a great problem of link failure and link congestion resulting in low throughput, high end-to-end delay and low packet delivery ratio. Therefore the protocols used for MANETs are designed in consideration of QoS parameters and effects of dynamic topology. The goal of a routing protocol is to maximizepacket delivery ratio, maximize throughput, and minimize the end-to-end delay. A review of the challenges and routing protocol pertaining to MANETs have been carefully studied and presented.

References

[1] J. Loo, J. L. Mauri, J. H. Ortiz, "*Mobile Ad Hoc Networks: Current Status and Future Trends*", Boca Raton: Auerbach Publications, pp. 4-11, 2011.
[2] M.Gast, "*802.11 Wireless Network. Sebastopol*", CA: O'Reilly, pp. 24-28, 2000.
[3] J. Liu, X. Jiang, H. Nishiyama and N. Kato, "*Throughput capacity of MANETs with Power Control and Packet Redundancy",* IEEE Transactions on Wireless Communications, Vol. 12, No. 6, pp. 3035-3047, 2013.
[4] J. Liu, M. Sheng, Y. Xu, J. Li and X. Jiang, "*End-to-End Delay Modelling in Buffer Limited MANETs: A*

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General Theoretical Fraamework", IEEE Transactions on Wireless Communications, Vol. 15, No. 1, pp. 498-511, 2016.
[5] S. Hakak, F. Anwar, S. A. Latif, G. Gilkar and M. K. Alam, "*Impact of Packet Size and Node Mobility Pause Time on Average End to End Delay and Jitter in MANET's*", International Conference on Computer and Communication Engineering, pp. 56-59, 2014.
[6] A. Tsirigos, Z. J. Haas, "*Analysis of Multipath Routing-Part I:The effect on the Packet Delivery Ratio",* IEEE Transactions on Wireless Communications, Vol. 3, No. 1, pp. 138-146, 2004.
[7] M. Karimi and D. Pan, "*Challenges for Quality of Service (QoS) in Mobile Ad-Hoc Networks (MANETs)",* IEEE 10th Annual Wireless and Microwave Technology Conference, pp. 1-5, 2009.
[8] I. Chlamtac, M. Conti and J. Liu, "*Mobile Ad Hoc Networking: Imperatives and Chellenges*." Ad Hoc Networks, Vol 1, No.1, pp. 13-64, 2003.
[9] C. Gui and P. Mohapatra, "*Scalable Multicasting in Mobile Ad Hoc Networks*", IEEE Computer and Communication Society Conference, pp. 2119-2129, 2004.
[10] N. Zhou and A. Abouzeid, "*Routing in ad hoc networks: a theoretical framework with practical implications*," in Proc. 24th Annual Joint Conf. IEEE Computer Commun. Societies (INFOCOM), vol. 2, Miami, FL, USA, pp. 1240-1251, Mar. 2005.
[11] N. Raj, P. Bharti, S. Thakur, "*Vulnerabilities, Challenges and Threats in Securing Mobile Ad-Hoc Network*", Fifth International Conference on Communication Systems and Network Technologies, pp. 771-775, 2015.
[12] C.E.Perkins, and P.Bhagwat. "*Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers*." Proceedings of the Conference on Communications Architectures, Protocols and Applications - SIGCOMM '94 (1994).
[13] L. Bello, P. Bakalis, P. Chintalapudi, K. A. Anang and T. I. Eneh, "*Impact of Topology Control and Traffic Models Performance on Mobile Ad-Hoc Wireless Routing Protocol*", Future of Instrumentation International Workshop (FIIW) Proceedings, pp 156-159, 2011.
[14] S. Geetha and C. Karpagam, "*Routing Protocols in Wireless Ad-Hoc Networks*", International Journal of Scientific Engineering and Applied Science, Vol 2, Issue 2, pp. 455-459, 2016.
[15] C. E. Perkins and E. M. Royer, "*Ad-hoc on-demand distance vector routing*", in Proceedings of the 2nd IEEE workshop on Mobile Computing Systems and Applications, pp 90–100, 1997.
[16] A.Boukerche, M. Ahmad, D. Turgut and B. Turgut, "*Algorithms and Protocols for Wireless and Mobile Ad Hoc Networks",* Canada: John Wiley and Sons Inc., pp.129-163, 2009.
[17] T.Imielinski, H.Korth, "*Mobile Computing*", Kluwer Academic Publishers, pp. 142-166, 1996.
[18] S. Dodke, P. B. Mane and M. S. Vanjale, "*A Survey on Energy Efficient Routing Protocol for MANET*", Second International Conference on Applied and Theoretical Computing and Communication Technology, pp. 160-164, 2016.
[19] D. B. Johnson, D. A. Maltz, "*Dynamic Source Routing in Ad Hoc Wireless Networks*", The Kluwer International Series in Engineering and Computer Science, pp. 153-181, 1997.
[20] Z. J. Haas and M. R. Pearlman, "*The Zone Routing Protocol (ZRP) for Ad-Hoc Networks,*"IETF MANET Working Group, Internet Draft, pp. 14-22, 1999.
[21] N.Raza, M.Aftab, M. Akbar, O. Ashraf and M.Irfan, "*Mobile Ad Hoc Networks Applications and its Challenges*", International Journal ofCommunication and Networks*",* pp.131-136, 2016.

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