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# Methodologies for Addressing the Performance Issues of Routing in Mobile Ad hoc Networks: A Review

**V. Anand* and N. Sairam**

School of Computing, SASTRA University, Tirumalaisamudram, Thanjavur - 613401, Tamil Nadu, India; anandwithah@gmail.com

## Abstract

The objective of this review article is to offer an insight into the performance issues pertinent to routing in Mobile Ad hoc Networks. This work has studied the approaches for solving the performance issues such as changes in topology, energy consumption of mobile nodes, delay, routing overhead, message delivery time, throughput, packet delivery ratio, security of networks and mobility management. To provide a perception of solutions for these issues, this study concentrates on various methodologies such as Effective Hierarchical Routing Algorithm, Link Stability with Energy Aware Multipath Routing protocol, Path Encounter Rate metric and Trust-based Source Routing protocol. Effective Hierarchical Routing Algorithm computes the route and has decreased the load of routing protocols. Link Stability with Energy Aware Multipath Routing protocol finds routes with small delay. Delivery ratio of packet in LSEA is improved on par with Ad hoc On-demand Distance Vector Routing (AODV). Delivery ratio of packets in LSEA was enhanced by 40%. To get an efficient metric for routing in high mobility situations, Path Encounter Rate metric was proposed. Throughput achieved with this metric was 30% higher than those obtained by the hop-count metric. To choose a least-cost route with security constraints, TSR was proposed. TSR has improved the packet delivery ratio, ratio of identifying the malicious nodes as well as network throughput. This review of different methods can be used by researchers to find a better solution to these issues.

**Keywords:** Delay, Multi Point Relays, Node Mobility, Reliability, Routing, Topology

## 1. Introduction

Mobile Ad hoc Networks (MANETs) are infrastructure less networks without fixed routers, which are designed by a cluster of wireless nodes. Each of the nodes in a MANET can assume the responsibility of forwarding packets. Nodes in MANETs can move from one location to other and can be connected dynamically. Because of high node mobility, the network may be affected by frequent changes in topology. This leads to changes in links between a node and its neighbor. Mobility and the absence of fixed infrastructure makes MANET very useful for sharing information, search and rescue operations, defense and military operations.

Figure 1 represents a simple mobile ad hoc network, in which each node is connected with internet through a gateway.

A routing algorithm becomes necessary, when a packet has to be sent to a node through intermediate nodes. For MANETs, routing algorithms are developed with the intention of handling frequent changes in topology. A MANET routing protocol exhibits two properties: Qualitative such as loop freedom, security, demand based routing, distributed operation, multi-path routing etc., and quantitative such as throughput, delay, route discovery time, packets delivery ratio etc.

Routing protocols can be classified as: Table-driven (proactive), proactive protocols also referred as "table-driven" routing protocols. Here, each node keeps comprehensive information about the network topology by constantly estimating routes to all the nodes. As a result, consistent and up-to-date routing information are kept. They are called so, because they preserve the

**Author for correspondence*

routing information before it is required. Source-initiated (demand-driven/reactive), where a routing path is produced only on demand. In these protocols, no need to keep the routing information when there is no communication. When a route is required, a route detection process calls a route-finding procedure. After inspection of all the route combinations, the detection process is finished, when a route is detected or no route exists. Hybrid routing protocol, a mixture of proactive and reactive routing protocols. In this category, each node is associated with a zone termed as clusters. A hierarchical infrastructure is formed with all clusters. For big and complex networks, this routing protocols is usually designed. To circumvent latency and routing overhead, this protocol altogether implements the route detection and the table maintenance methods of reactive and proactive protocols.

Based on few factors, a comparison of table-driven (proactive) and demand-driven (reactive) protocols is presented in Table 1.

Lot of performance issues related to routing in Ad hoc networks can be focused for research. Relevant to this context, a study of various methodologies pertinent to routing in MANETs is presented. A study of various approaches attempted in handling the performance issues such as controlling the changes in topology, reducing the energy consumption of mobile nodes, minimizing the delay, improving the throughput and packet delivery ratio, diminishing the routing overhead, reducing the message delivery time, creating stable paths between all sets of nodes, improving the security of networks and mobility management is found to be vital.

In this paper, various approaches are studied with the purpose of finding a solution to different concerns in routing. This article is planned as follows: Section 2 offers a literature review of various methodologies and protocols for different performance issues. Section 3 presents a detailed exploration into different methodologies mentioned in section 2. Section 4 concludes the article.

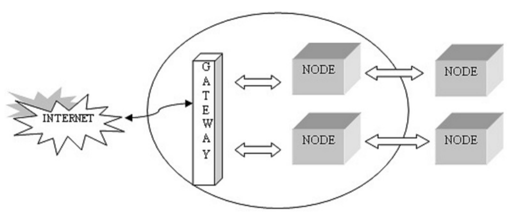


**Figure 1.** Block diagram of MANET.

**Table 1.** Comparison of table-driven and demand-driven protocols

| Factors to be Compared | Table-Driven | Demand-Driven |
|---|---|---|
| Availability of Routing Information | Always available | Only when needed |
| Updation of Routes | Periodic | When requested |
| Structure of Routes | Flat and hierarchical | Generally flat |
| Routing Overhead | Relevant to network size | Based on the number of communicating nodes |
| Latency | Small | Typically long |
| Storage | High | Less than table-driven |

## 2. Classification of Various Approaches

A study of different approaches attempted at solving the problems of routing in MANETs is presented. All these approaches focus on the following issues: controlling the changes in topology, reducing the energy consumption of mobile nodes, delay, routing overhead and message delivery time, improving throughput and packet delivery ratio, creating stable paths between all sets of nodes, improving the security of networks and mobility management.

### 2.1 Controlling the Changes in Topology

For mesh wireless networks, Vazquez-Rodas A. and De La Cruz Llopis L. J.[1] have proposed an innovative protocol for controlling the topology. The proposed protocol was built on the centrality metrics. The offered protocol aimed at creating a connected dominating set, which consists of the dominant nodes. A hierarchical routing algorithm, referred as EHRA-WAVE was proposed by Yan G., et al[2]. EHRA-WAVE was developed and proposed for large-scale wireless mobile networks. This work has justified that; it can quickly find a routing path between Virtual Mobile Nodes (VMN) even without accurate topology information. SARP (Synchronous Adaptive Routing Protocol), a new mechanism proposed by Abid M. A., et al[3]. Based on network cartography, SARP dynamically alters the extent of routing period by sensing the mobility-level.

## 2.2 Reducing the Energy Consumption of Mobile Nodes

An innovative location service protocol was proposed by Wang Z., et al[4]. This protocol diminishes the overall energy cost through the optimization of the distance covered by query and location update packets. In this work, source has to get the information about the position of the target node even before packets are sent. The work proposed by Zijian Wang Z., et al.[4] has concentrated on energy efficiency, since mobile nodes have limited energy. Tamilarasan S. M., et al.[5] have developed a state-of-the-art protocol referred as Link Stability with Energy Aware Multipath Routing Protocol (LSEAMRP). This protocol was proposed to measure the quality of link and maximum energy left (i.e.) minimum energy consumption and less delay. By looking into these factors, this protocol has attempted at improving the delivery ratio of packets, throughput and decrease the delay encountered from end-to-end.

## 2.3 Selecting Relay Nodes in MPR

A protocol termed as TAmOP, was proposed by Wang L., et al[6]. TAmOP was referred as temporal-awareness dynamic routing protocol with order MPR. This approach ponders techniques for mobile networks with multi-hop features. Here, a least group of nodes was referred as Ordered MPR (Multi Point Relay). These MPRs can link the 2-hop neighbors of a node. On the basis of temporal information, arrangement of nodes was done. Gokturk M. S., et al.[7] have proposed an innovative distributed cross-layer cooperative network architecture based on multi-hops. Based on randomized coding, this architecture offers an innovative forwarding mechanism and a couple of distributed adaptable cooperative transmission methods. A Routing Enabled Cooperative Medium Access Control (RECOMAC) empowers cooperative transmission, when joining routing, MAC and physical layers. Authors have assessed the performance of RECOMAC pertinent to delay, routing overhead and throughput. In association with stable and sustainable paths in a Mobile Ad hoc Network, a novel mechanism was proposed by Moussaoui A., et al[8]. This approach has attempted at creating a stable and sustainable paths between all pairs of nodes. In this regard, a metric was proposed based on Stability of NoDes (SND) and the Fidelity of NoDes (FND). This metric selects stable MPR nodes and stable topology. Simulation results have established the efficiency of the proposed mechanism in terms of delay and lost packets. A novel MPR selection technique was proposed by Ahn J. H. and Lee T[9]. In an ad hoc network, this technique focused on enhancing the reliable delivery of broadcast packets in MPR flooding.

## 2.4 Routing in Mobile Delay Tolerant Networks

An innovative adaptive multi-step routing protocol for MDTNs referred as Community-based Adaptive Spray (CAS), was proposed by Miao J., et al[10]. This protocol dynamically allots replicas of message conferring to the remaining TTL of each message to attain a given delivery probability. Results reveal that this protocol has a higher delivery ratio and a lower delivery cost on par with the Spray-and-Wait and Bubble protocols.

Packet delivery delays are not tunable in most of the Delay-Tolerant Networks (DTNs). Because of node movements, topology varies often in mobile DTNs. A significant category of DTNs (i.e.) mobile DTNs was focused by Tasiopoulos A. G., et al.[11], which has dealt with the compromise among the several kinds of transportation cost of a packet and delivery delay of a packet. Experimental results reveal that achieve cost/delay tradeoffs of their protocols were much nearer to the optimal one, when compared with contemporary protocols.

Mobile Delay Tolerant Networks (DTNs) usually lack direct paths between a couple of nodes. Aimed at Delay Tolerant Networks (DTNs), a new multi-copy routing protocol referred as Predict and Forward (PF) was proposed by Elwhishi A., et al[12]. To deliver the messages directly, PF protocol has concentrated on looking at the options of considering mobile nodes for carrying messages.

## 2.5 Mobility Management

A new encounter-based metric for routing in MANETs, referred as PER was proposed by Son T. T., et al[13]. This new metric has the ability to cope up with the changes of mobility in MANETs. The Path Encounter Rate (PER) metric relied on the concept of "encounter". PER has proved its ability to indicate the mobility, density of MANETs. This metric reflects the changes in environment and improves the outcome of routing protocols in MANETs.

A detailed performance study of Distributed and Dynamic Mobility Management (DDMM) was done by Jeon S., et al[14]. DDMM has presented a new architectural standard for sustainable mobile networking, which has offered an IP mobility management. When mobility becomes necessary, IP mobility management was presented with distributed deployment of mobility anchors and dynamic activation. For effective distribution of mobile traffic, a distributed mobility management approach was naturally accepted when compared with Centralized Mobility Management (CMM) approaches.

### 2.6 Routing using Fuzzy Logic

A Fuzzy Logic Dynamic Beaconing (FLDB) strategy presented by Alsaqour R., et al.[15] aimed at improving the reliability of the neighbor list of a node. This strategy has accomplished this by improving the time between transmissions of beacon packets in position-based routing protocols. By employing the Fuzzy Logic Control (FLC) method, optimization is done using the relationship between Node's Moving Speed (NMS), Number of Neighboring Nodes (NoNNs) and Beacon Packet Interval Time (BPIT). Experiments done using simulation illustrates the efficiency of the FLC mechanism in enhancing the overall result of GPSR location-based routing protocol with respect to beacon packet control overhead, non-optimal hop, false node position and end-to-end delay.

F-LQE (Fuzzy Link Quality Estimator) was proposed Baccour N., et al.[16] as a metric. Relying on the four properties of link quality: channel quality, asymmetry, packet delivery, stability, this metric evaluates the quality of the link. Using Fuzzy Logic, link quality is estimated by combining the four properties.

### 2.7 Trust-Based Routing

For data transmission in a network, this model finds an economic route which also satisfies the security requirements. This dynamic trust prediction model was offered by Xia H., et al[17]. Based on the nodes' past and future behaviors, this model assesses the trustworthiness of nodes by means of extended fuzzy logic rules prediction. Relying on their correct packet routing ratio, a computation of neighbors' trusts was done by each node. From the results, it was evident that, an enhancement with regard to delivery ratio of packets, ratio of identifying the malicious nodes as well as network throughput was attained by Trust-based Source Routing protocol.

Mukesh Krishnan M. B., et al.1[8] have proposed an approach for trust estimation in MANETs. This approach aims at offering consistent communication in a MANET. A consensus based algorithm suggested by Haripriya Y., et al.[19], aimed at detecting and preventing malicious nodes in order to avoid the routes with malicious nodes.

## 3. Study of Various Methodologies

### 3.1 Controlling the Changes in Topology

#### *3.1.1 Centrality-Aware Topology Control Protocol*

In mesh wireless networks, an innovative protocol for topology control was contributed by Vazquez-Rodas A. and De La Cruz Llopis L. J., et al[1]. For this type of networks, this approach aimed at constructing a connected dominating set. This set includes a collection of dominant nodes. Here, both the centralized and distributed execution was proposed. Based on three general centrality measures: degree, betweenness and closeness centrality, the authors have done the assessment for the centralized approach. Experimental investigation has revealed that, fragmenting the network with betweenness centrality is substantially smaller than the closeness centralities or degree. By this means, this protocol has concluded that betweenness centrality metric better finds the stations for routing tasks. A distributed execution has been proposed by the authors, since a centralized operation might be impractical in some situations. For distributed implementation, betweenness centrality was only considered. To dispense the duty, each station calculates its own centrality with the knowledge of its own neighbors. Simulations were done to verify the efficiency of this centrality-aware topology control protocol. Estimation has been done for both reactive and proactive path selection modes. In all the results, this approach has shown an improved efficiency or remains equal with a lesser amount of transmission/reception energy consumption. Simulation results also showed a decrease of the end-to-end delay.

#### *3.1.2 EHRA-WAVE Algorithm*

A hierarchical routing algorithm, referred as EHRA-WAVE was proposed by Yan G., et al[2]. In this algorithm, the network is arranged in various Virtual Mobile Nodes (VMN) domains. Routing information is exchanged between the nodes in a particular VMN domain. Among various VMN domains, only interdomain routing information is swapped. On the basis of VMN, the proposed hierarchical routing algorithm EHRA-WAVE can compute the route with a parallel and distributed technique. This approach has significantly decreased the load of routing protocols.

The approach has analyzed the message delivery ratio with Virtual Mobile Nodes (VMNs) via EHRA-WAVE as well as non-hierarchical methods. The above figure, Figure 2 has shown that, VMN's ratio of message delivery evenly decreases with the increasing speed of RMNs.

#### 3.1.3 Synchronous Adaptive Routing Protocol (SARP)

SARP (Synchronous Adaptive Routing Protocol), a new mechanism proposed by Abid M. A., et al[3]. The authors have examined the dynamic characteristic and irregular movement of mobile networks. To navigate the entire network, Virtual Mobile Nodes (VMNs) are used. On communication, VMNs gather data from nodes close to the route and takes it to the target. With a distributed algorithm, this proactive routing protocol, SARP gathers the network cartography periodically. Using the network cartography, SARP dynamically alters the current routing period size. By this way, SARP lessens the control traffic and improves the routing pertinence. Simulation results demonstrate that SARP properly identifies the topology changes and alters the extent of current routing period resulting in improved performance. SARP outclasses the results achieved by conventional proactive routing protocols.

### 3.2 Reducing the Energy Consumption of Mobile Nodes

#### 3.2.1 Location Service Protocols

A state-of-the-art location service protocol presented by Wang Z., et al.[4] has offered two innovative location service protocols. With this protocol, diminishing the distance covered by query and location update packets has resulted in the enhancement of total energy cost of location service. One protocol, ADJ, fine-tunes the route for query and location update packets; other protocol, OPT, positions the location servers at ideal locations. Simulations were carried out to prove that the novel methods attain greater energy efficacy and increase the complete outcomes on par with existing methods. Results of simulation validate that these protocols achieve better energy efficiency on par with the previously proposed algorithms.

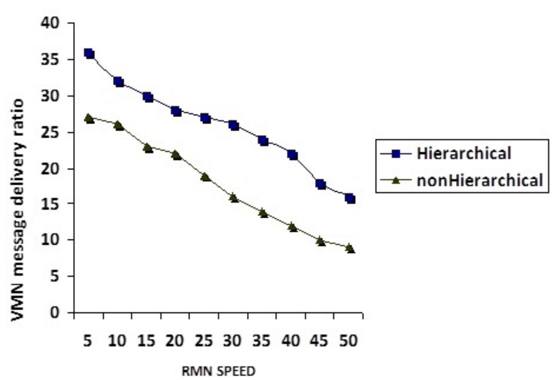


**Figure 2.** Comparison of VMN message delivery ratio with various RMN speed.

#### 3.2.2 Link Stability with Energy Aware Multipath Routing Protocol (LSEAMRP)

Tamilarasan S. M., et al.[5] have proposed a new routing protocol (i.e.) Link Stability with Energy Aware Multipath Routing Protocol (LSEAMRP), associated with RREQ flooding phase. Among nodes, this protocol has focused on obtaining multiple routes with small delay. This routing protocol works as follows. To flood the RREQ only in the way of target node, a node obtains the way of the target node. By this means, the proposed protocol evades the forwarding of route request packet in other directions. Simulation results portray that LSEAMRP increases the network lifetime in all range of movements. By increasing the lifetime of links, an enhancement in the delivery ratio of packet as well as reduction in energy consumption was achieved. The following figure, Figure 3 has revealed that, the approach has done the assessment and proved that the delivery ratio of packet in LSEA is considerably enhanced on par with Ad hoc On-demand Distance Vector Routing (AODV) and delivery ratio of packet in LSEA was enhanced by 40%.

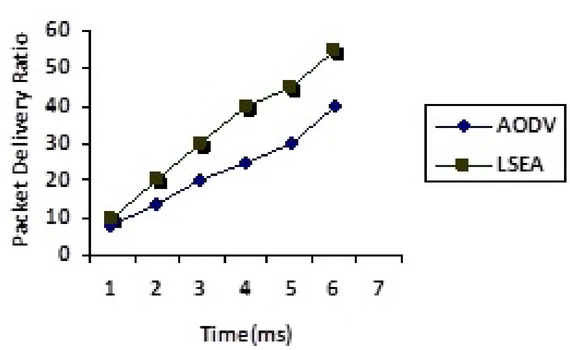


**Figure 3.** Comparison of packet delivery ratio.

## 3.3 Selecting Relay Nodes in MPR

### *3.3.1 Temporal-Awareness Ordered-MPR Protocol*

Wang L., et al.[6] have proposed a new dynamic routing protocol using order MPR (TAmOP), which blends two strategies: First strategy is, selecting relay nodes in MPR (Multi Point Relays). A node with greater evaluation value was selected as forwarding node by this strategy. By this means, the likelihood of packets reaching the target was raised and the ratio of delivery was improved. Relying on an evaluation function, nodes in MPR are ranked. Second strategy is, outside MPR. In non-wired networks, there is a possibility that nodes which are not MPRs transmits data to the target within a short duration. In this strategy, some nodes external to MPR are arbitrarily chosen as alternate for relay nodes. This strategy improves the delivery ratio of packets. NS2 has been used to assess the performance of TAmOP. Simulations were carried out with the parameters as simulation area, and simulation time. Results reveal that, TAmOP performs better when compared with AODV algorithm in terms of packet loss ratio, delivery ratio, route load and average delay. The figure shown below, Figure 4, has revealed comparison results of AODV and TAmOP. When the node count increases, both the approaches decrease with the delivery ratio. However, TAmOP is significantly enhanced than AODV in the communication of packets and outcome of TAmOP is greater than AODV with regard to delivery ratio of packets.

### *3.3.2 Routing Enabled Cooperative Medium Access Control Protocol*

A cooperative network architecture with cooperative routing methods was proposed by Gokturk M. S., et al[7].

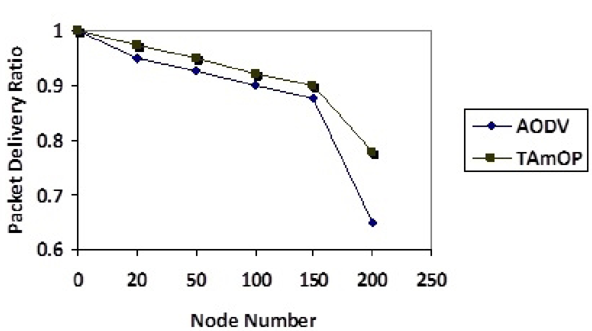


**Figure 4.** Evaluation of TAmOP and AODV for packet delivery ratio with different node count.

In this proposed method, end-to-end communication is recognized using cooperative sets with negligible amount of resources and without the demand for an established route. This proposed work presents an innovative cooperative transmission method and a couple of distributed adaptable cooperative transmission mechanisms. Routing Enabled Cooperative Medium Access Control (RECOMAC) empowers cooperative forwarding. RECOMAC applies randomized coding, in order to ease the relay selection and decrease the MAC costs. The coded packets were sent through network with these cooperative forwarding schemes. For solid mobile networks, the proposed RECOMAC architecture greatly improves the performance when compared with the traditional layered architecture with non-cooperative transmissions.

### *3.3.3 STable OLSR Protocol*

A novel mechanism was proposed by Moussaoui A., et al.[8] which creates stable and sustainable paths between all pairs of nodes in a Mobile Ad hoc Network. By computing a node's mobility degree relative to its neighbor, this approach has applied a stability function as the main route selection criterion. The authors have employed this approach on the OLSR protocol (Optimized Link State Routing Protocol) to select stable and sustainable MPR (Multipoint relays) nodes and topology. This mechanism greatly reduces the recalculation process of MPR and the routing tables. Besides these gains, it promises minimum packet loss and the response time. This approach has proposed a novel metric based on the Stability of NoDes (SND) and Fidelity of NoDes (FND). Stability of NoDes (SND) estimates the stability by applying a function based on Bienayme-Chebyshev inequality and Fidelity of NoDes (FND) is the degree of reachability with only the stable nodes. This approach has integrated SND and FND. To compute the regular SND and FND, the approach has chosen the OLSR protocol for periodic distribution of the control messages. Simulation results have proved the efficacy the proposed mechanism in terms of delay and lost packets.

### *3.3.4 MPR Selection Method for Improved Broadcast Packet Delivery*

A method proposed by Ahn J. H., Lee T.[9] has focused on enhancing the consistency of broadcast packet delivery in MPR flooding. The proposed approach chooses extra MPR nodes for including 2-hop MPR nodes m times and not to cover all 2-hop neighbor nodes m times. To take in 2-hop MPR nodes a minimum of m times, a node may attempt to choose its MPRs between its 1-hop neighbor nodes. By exchanging hello messages with a group of 1-hop neighbor nodes, a node chooses its own set of MPR nodes. On comparison with the MPR selection technique of OLSR, the presented technique has significantly improved network throughput and delivery ratio. Results also exhibit that, the proposed algorithm is poised in terms of the robustness and overhead. Figure 5 shows the distribution of broadcast messages through MPR nodes.

## 3.4 Routing in Mobile Delay Tolerant Networks

### *3.4.1 Community-based Adaptive Spray (CAS) Protocol*

An innovative adaptive multi-step routing protocol for MDTNs referred as Community-based Adaptive Spray (CAS), was proposed Miao J., et al[10]. This protocol has focused on allocating the less number of message replica of a message for achieving a high delivery ratio. In this protocol, routing process consists of many sub-processes. Here, messages are sent to the intermediate nodes or the destination node if the latter fits with the same community as the source node. Simulations carried out on a commonly used community-based mobility model exhibits that, CAS increases the routing performance when equated with quota-based Binary Spray-and-Wait protocol and community-based Bubble protocol.

### *3.4.2 Hybrid Delay-Tolerant Protocols*

A framework proposed by Tasiopoulos A. G., et al.[11], focused on the compromise among the delay in packet

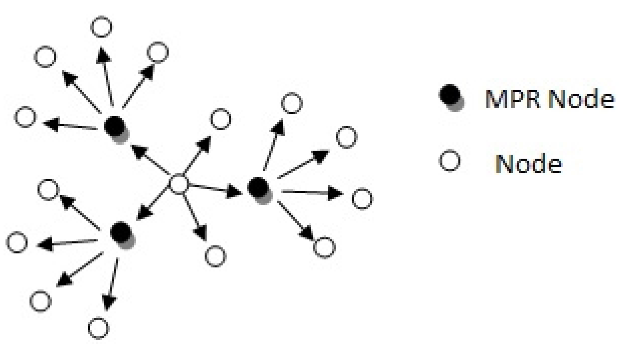


**Figure 5.** Dissemination of broadcast message using Multi Point Relays.

delivery and transportation cost. Cost of transportation is measured with respect to the OC/DC (Optimal Cost/Delay Curve) while nodes send optimally and with respect to the AC/DC (Achievable Cost/Delay Curve while nodes employ the suboptimal routing protocol. This approach has developed a group of hybrid delay-tolerant/ geographic routing protocols. Results illustrate that, the average AC/DCs of their protocols were much nearer to average OC/DC when compared with the average AC/ DCs of other protocols.

### *3.4.3 Predict and Forward (PF) Protocol*

An innovative DTN routing protocol proposed by Elwhishi A., et al.[12] named as Predict and Forward (PF), concentrated on solving the inadequacies of utility based routing schemes. Key characteristics of the presented protocol are: 1. Using an effective prediction of contact, relied on the probability distribution of interaction between nodes at various network partitions. 2. Ability to adjust the changing network status, user behaviors and traffic patterns/features. Simulation results proved that the proposed Predict and Forward (PF) outpaces the other multi-copy encounter-based routing protocols pertinent to delay in delivery, number of communications needed for delivery of messages and delivery ratio.

## 3.5 Mobility Management

### *3.5.1 The Path Encounter Rate (PER) Metric*

To find an efficient metric for MANET's routing in mobility situations, a new encounter-based metric, PER was proposed by Son T. T., et al[13]. The proposed model does not rely on any proactive or reactive strategies. As a replacement for the hop-count or other prevailing metrics, it can be implemented for many routing protocols in MANETs. To calculate the PER metric, certain performance metrics like throughput, packet delivery ratio, and routing overhead can be considered. Analysis and results exhibited the improvements of routing performance under PER metric when compared with hop-count and Expected Transmission Count (ETX) in several mobility and density situations. Reasons for these gains are: packets are sent over the paths that evades high mobility and high density regions. The throughput attained with the PER metric is 30% higher than those gained by the hop-count metric.

### 3.5.2 *Distributed Dynamic Mobility Management (DDMM)*

Relevant to Distributed and Dynamic Mobility Management (DDMM), an extensive study was presented by Jeon S., et al[14]. This study has done an analysis of DDMM and presented the results. These results indicate how DDMM increases mobility performance. This study has compared DDMM approaches with Mobile IPv6, Proxy Mobile IPv6 (PMIPv6), and PMIPv6 localized routing (PMIPv6-LR).By using the shorter routing distances between nodes and empowering flexible non-tunneled packet delivery, DDMM altogether accomplishes increased throughput, less packet delivery cost and minimum tunneling overhead than the other protocols. Results proved that DDMM attains improvements based on the topology and deployment of DDMM routers (DMRs). Investigative results validate that DDMM normally realizes improved performance on par with CMM-based protocols, with regard to packet delivery cost, tunneling overhead, as well as throughput.

## 3.6 Routing using Fuzzy Logic

### 3.6.1 *Fuzzy Logic Dynamic Beaconing (FLDB) Strategy*

A Fuzzy Logic Dynamic Beaconing (FLDB) strategy presented by Alsaqour R., et al.[15] aimed at improving the reliability of the neighbor list of a node. FLDB strategy has solved the problem of inaccurate position information in the neighbor list of a node. This strategy has used Fuzzy Logic Control (FLC) mechanism. This method increases the maximum period of time that can emerge before the node broadcasts the next beacon packet. The FLDB approach maintains precise and updated position information in the neighbor list of nodes and improves the routing process. By applying Fuzzy Logic Control (FLC) mechanism, improvement is done based on the association between Node's Moving Speed (NMS), Number of Neighboring Nodes (NoNNs) and Beacon Packet Interval Time (BPIT). Simulations were carried out, and the results depict that, in low mobility scenarios, the FLDB strategy greatly reduced the beacon packet overhead; in high mobility situations, the FLDB strategy has improved system throughput with regard to non-optimal hop, end-to-end delay, and node false position for different network parameters and metrics.

### 3.6.2 *Fuzzy Link Quality Estimator*

Baccour N., et al.[16] have presented an approach for estimating the link quality. This approach was named as, F-LQE (Fuzzy Link Quality Estimator). To assess the influence of F-LQE on the performance of tree routing, a new routing metric for CTP (Collection Tree Protocol) was constructed. This metric was coined as F-LQE/RM(F-LQE/Routing Metric). To choose the best route in relation to global quality and length (i.e.) hop-count, F-LQE/RM takes the link quality estimates given by F-LQE. A detailed experimentation of F-LQE has shown an enhanced performance over prevailing and representative LQEs, in terms of reliability and stability.

## 3.7 Trust-based Routing

### 3.7.1 *Trust-based Source Routing Protocol (TSR)*

To select a shortest route which addresses the security requirements of a network, Xia H., et al.[17] have presented a dynamic trust prediction model. For computing the node's current trust, this approach has applied the fuzzy logic rules prediction technique. With the intention of detecting a malicious node, the computed value provides a forecast of one's future behaviors and identification of node's properties.

An innovative Trust-based Source Routing protocol (TSR) offers a worthwhile technique for selecting an economical route, which satisfies the security conditions for data communication. In finding a route, trust value of a node was presented as a condition. An evaluation vector was formed for each route, with route trust value and

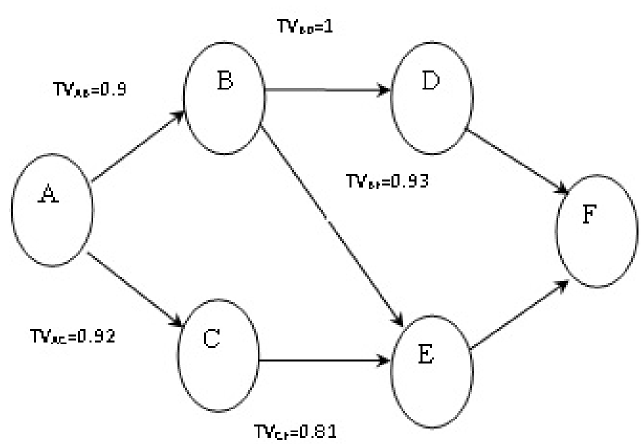


**Figure 6.** Communication based on Route Trust Value.

hop count. A destination will reply with candidate routes, which satisfies the condition. One of these routes will be chosen as the shortest and transmitting route. As depicted in Figure 6, the node trust $TV_{AB} = 0.9$ from node A to B and $TV_{BD} = 1$ from node B to D. Route Trust from A to F is calculated as, Route $TV_{AF} = TV_{AB}$ X $TV_{BD} = 0.9$ X $1 = 0.9$. There are three routes from A to F, but the trustworthy route is identified as A->B->D->F. Experimental results have proved that Trust-based Source Routing protocol (TSR) has accomplished an enhancement in packet delivery ratio, ratio of identifying the malicious nodes as well as network throughput.

### 3.7.2 Trust Estimation Model for MANETs

An approach presented by Mukesh Krishnan M. B., et al.[18] has two agents installed to evaluate the node's trust. The first agent tracks link failure of the network and dropping of packets. The second agent tracks network attacks and malicious behavior. This method offers an option for the nodes to link with the trusted nodes. This raises the level of QoS for MANETs. On comparison with other models pertinent to metrics viz., throughput, delay, and attacks, the results reveal that this model performed well than the other models.

### 3.7.3 Detection of Malicious Nodes

The approach suggested by Haripriya Y., **et al.**[19] has different steps such as discovery of route using AODV, maintaining route and a consensus based algorithm. This approach proposed for detecting and avoiding the malicious nodes from the wireless ad hoc networks. Results exhibit that, the method improves the efficiency, security and enhances the performance of routing.

## 4. Conclusion

Mobile Ad hoc Networks (MANETs) are mostly used for communication, because it needs no fixed infrastructure. A variety of routing protocols and algorithms are available. Based on the requirements, an application can choose the routing algorithms. Even with the presence of many algorithms, there are some issues to be addressed in routing. Extensive research has been done in this context. Many approaches have focused a lot on various routing issues. This article has reviewed and presented certain performance issues relevant to routing in Mobile Ad hoc networks. An attempt has been made to explore into methodologies, which deal with issues such as frequent topology changes, high energy consumption of mobile nodes, routing overhead and mobility management. Each of these methodologies has proposed solutions for some of the performance issues in different, innovative ways. Relevant to routing in mobile ad hoc networks, this review article offers a perception of various methodologies, with due weightage for concept, implementation and results achieved. Since routing in mobile ad hoc networks is a vast, open area for research, this review article has attempted in unwrapping some problems which needs attention.

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