

# Recent Research on Energy Efficient Clustering Based Secured Multihop Routing Protocols in MANET

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## Abstract

This article provides a comprehensive review of different techniques related to the proposed models available in the literature. It depicts a concise survey of distinct energy efficient clustering approaches in MANET. Next, a brief survey of various routing techniques has been discussed, including classical and recently proposed techniques. Besides, an elaborate survey of diverse energy aware routing techniques in MANET is explained. Along with that, the trust-based schemes are also discussed briefly. Followed by, security enhancement techniques have been elaborated. Moreover, an extensive comparison of the reviewed techniques has also been made in this article.

## 1. Introduction

Mobile Adhoc NETWORK (MANET) is an independent adhoc wireless network, which contains a collection of mobile nodes resulting to a temporary network. The movable nodes in MANET converse with one another by exploiting wireless links. Based on the type of available MANET, it could be possible to gain access from particular hosts in a fixed infrastructure.

### 1.1 Route Discovering process

It comprises the way of detecting the feasible routing nodes to transmit data between two nodes. If a route to recipient node could not be generated, then it has been initiated to search route from routing table. For unavailable paths to recipient node, the transmitting node forwards a route request packet to corresponding nodes.

### 1.2 Route discovery at intermediate nodes

While the request message has been received at intermediary node, then it begins to verify the lifespan of in terms of energy. If a node is comprised with minimum volume of energy, then it has been treated as proper node to perform data transmission and drops the packet. Followed by, a route entry has been made in routing table. The relevant data from a route request will be

passed to the adverse neighboring nodes. Once route reply is transmitted, the intermediate node computes the RE of a node with good reliability that selects the data transmission path.

### 1.3 Route Selection at Destination

The receiver node could obtain more number of route reply packets from different possible paths. At each probable path, the selection criteria have to be estimated. In case of available nodes, the node which has constrained with optimal selection criteria would be decided to transfer a reply to minimize the control overhead in data communication. At this point, it is as same as massive number of request process in AODV protocol.

### 1.4 Energy Efficient Clustering Techniques in MANET

Various techniques are deployed to report the complexity involved in mobility and battery dependent behaviour of mobile nodes from MANET. (Bokhari et al., 2012) established taxonomy of clustering technique which is applied in MANET to reduce the power consumption. It attains the improved energy application with reduced power utility. A single variable of CH selection method is simple and needs minimum overhead. The productive Weight Based Clustering Algorithm (WCA) in MANET is developed in (Chatterjee et al., 2000). It has been considered that a combined weight of several parameters affects the CH selection. (Choi et al., 2006) deployed a Distributed WCA (DWCA) for MANET to reduce the configuration as well as reconfiguring clusters and demerits of CHs in terms of energy prerequisite. However, none of the parameters denote node reliability in CH election. In (Bednarczyk et al., 2013), the updated model of WCA termed as Enhancement on WCA (EWCA). The attributes applied to select the CH are transmission power; transmission radius, mobility, as well as battery are most required elements. The cluster-developing task is reduced by eliminating a suitable variation of CHs. It maintains the overhead and improves the reliability of clusters in MANET. In (Khatoon, 2017), a cluster based method in MANET named Comprehensive Learning Particle Swarm Optimization (CLPSO) is applied. The parameters are considered to elect CHs is similar to WCA which does not contain any of the node's mobility while creating a decision on CH election. A mobility aware energy efficient clustering for MANET with the help of PSO named as MEPSO technique is projected. The report of previous models reveals that, clustering is overviewed as an effective model to provide an energy efficiency as well as reliability of a network.

### 1.6 Clustering Techniques for Secured Data Transmission in MANET

The most challenging task in clustering is the dilemma of user. (Wijayanto et al., 2016) have discussed a set of new properties which explain the difference between common clustering paradigms and exhibits the merits of Centre-based approaches in certain applications. These properties deal with responsive algorithms which modify the element frequencies confined in generalized setting. In generalized setting, every element has been linked with real-valued weight. However, the methods for enhancing clustering accuracy remain unaddressed.

(Xie et al., 2015) have developed Dynamic Entropy based Combination Weighted (DECW) clustering technique for solving the problem of cluster continuance cost and stability. In DECW, upper and lower bound values of each clustering index have been determined with respect to past messages of evaluation node in the network. Then, linear combination weight

of estimation nodes has been estimated and multi-node dynamic entropy weights are attained through the reduction of Ant colony Based Cluster head (ABC) eight vector derivation. In addition, a Monte Carlo optimization has been designed for restricting repeated CHs substitution cause by high node mobility. DECW increases the adaptability in high speed mobile environment. Though data transmission speed has been higher, energy consumption is not decreased.

(Saravanan et al., 2016) have designed Node Weight Based Cluster Formation (NWBCF). Minimum high potential score in NWBCF technique is considered to broadcast data among a set of nodes. Therefore, a node with energy capacity node chooses communication of data. The rest of the nodes have been restricted from the area of CH which aids in transmitting data from a source to target via hop1, hop, etc. When the selected CH dropped the threshold, another high potential score node is adopted as CH to broadcast data packets to the destination node, but NWBCF has failed in increasing the security level.

(Nabar et al., 2017) have developed Gauss Markov Mobility-based Affinity Propagation-driven Distributed (GMMAPD) clustering approach. GMM-APD deals with the greedy clustering heuristics. The problems of local optima as well as frequent event-driven broadcasts have been solved by GMM-APD. In GMM-APD, Gauss Markov (GM) distribution has been evaluated with estimating node movement pattern. With employing modified Affinity propagation technique, proximity criteria are determined through temporal dependency of GM distribution.

## 2. Classical Routing Techniques in MANET

Generally, routing approaches in MANET is partitioned into three kinds and are explained below.

**Proactive Technique:** In this type, every node manages the routing details of all nodes in network. The differences between such techniques are in the form of updating the routing data among the protocols present, predicted and data type is recorded in each routing table. Additionally, all routing protocols retain different values of tables.

**Destination-sequenced distance vector (DSDV):** The variation of Distributed Bellman-Ford (DBF) is DSDV model (Perkins et al., 1994) that assures loop free routes. By employing distance vector shortest path routing method, it gives a separate path towards the chosen receiving node. Two kinds of update packets are employed with a view to decrease the sum of overhead passed over the network called as “incremental” and “full dump” packets. Because of the periodic update messages requirement, massive sum of network overhead is introduced by DSDV with the increased overhead of  $O(N^2)$ . In massive network, this protocol is not suitable since it needs high bandwidth in the updating processes.

**Wireless routing protocol (WRP):** Loop freedom is ensured by WRP protocol (Murthy et al., 1995) and through the predecessor data, it prevents temporary routing loops. But, every node in WRP needs to manage 4 routing tables. If the network size is improved, at every node, memory overhead is introduced by it. The other drawbacks are that it guarantees linkage by the implication of hello messages. Among the neighboring nodes, these hello messages are

transformed where there exists no packet transmission. As every node needs to remain active in the whole lifetime, this would take a considerable sum of power and bandwidth.

**Global state routing (GSR):** GSR protocol (Chen, 1998) depends upon conventional link state method. But, using update messages restriction among intermediate nodes, GSR has enhanced the manner in which data is segmented in link state method. This has majorly decreased the sum of control message passed by the network. But, relatively, the update messages size is huge and it may grow higher with an increase in network size. So, by the use update messages, certain amount of bandwidth is utilized.

**Fisheye state routing (FSR):** This protocol (Gerla, 2002) is the predecessor of GSR protocol. In GSR, the update messages size is decreased by FSR through modifying the network data for adjacent nodes at high frequencies when compared to remote nodes that reside exterior to scope of fisheye. Towards large networks, FSR seems highly scalable when compared to other protocols but with the cost of minimized precision.

**Source-tree adaptive routing (STAR):** The STAR protocol (Garcia-Luna-Aceves et al., 1999) depends on link state method. A source tree is maintained at every router, which comprises the possible paths to reach the destination. Through employing least overhead routing approach (LORA), which has majorly reduced disseminated routing loads towards the network to exchange routing data. When needed, it aids in optimum routing approach (ORA). But, in huge mobile networks, this protocol might comprise major processing and memory overheads.

**Distance routing effect algorithm for mobility (DREAM):** On comparing with routing protocols, DREAM routing protocol (Basagni et al., 1998) uses various methods for routing. By GPS, every node may know its position in DREAM. These positions are communicated regularly and saved in a routing table. Some of the advantages of location data sharing are that it takes less bandwidth over exchanging whole link state or distance vector data. RO is decreased in DREAM; additionally, the update messages are segmented with respect to distance effect and mobility. It is not required to transmit data packets by static nodes.

**Reactive routing approaches:** They are developed for reducing the load exists in a proactive technique by controlling the data for active routes. It states that, the routes have been determined as well as retained for nodes that require to be transmitted to certain reception node. These path developments can be done with the application of flooding RREQ from a network. If a node attains the receiver, RREP is forwarded again to the transmitter by exploiting link setback and when a route request is moved via bidirectional links, the route from a RREP packet is flooded. Thus, the overhead involved in discovering routes would be developed by  $O(N + M)$  while the link reversal is feasible as well as  $O(2N)$  for unidirectional links. Reactive routing approaches are classified into 2 kinds as source and hop based routing.

The initial type has an intermediary node to send the packets according to the data present in a packet header. This shows that there is no requirement to update route details for every individual active path for packet for data forwarding to a destination. Additionally, the node has no requirement to manage neighbour connectivity by sending regular beaconing messages. The main limitation in source routing protocol is its inability of proper processing. In hop based

routing, every data packet has receiver address and consecutive hop addresses. Hence, all in-between nodes from a route to the target applies the routing tables for sending messages to receiver.

AODV (Das et al.,2002) technique depends on Dynamic source routing (DSR) and DSDV methods. It employs series numbering process and periodic beaconing of DSDV. It follows same route discovering task like in DSR. However, two significant variances among AODV and DSR exist. Every packet in DSR holds entire routing data, wherever, the packets in AODV hold destination address alone. When compared to DSR, AODV has significantly low RO. The benefit of AODV is high suitability to non-static networks. But, while constructing the routes, the node may suffer from huge delays and another route discovery may be initiated through link failure. It leads to the consumption of high bandwidth and additional delay with a rise in size of the network. If a successor is available start a diffusing search, else send a query with infinite metric.

**Dynamic source routing (DSR):** From source to destination, as stated above, every packet in DSR protocol is subjected to hold entire address. In huge networks, this protocol would not be more efficient due to increased packet overhead. But, when comparing with routing protocols like AODV, LMR, AODV, and TORA offers several benefits. The main advantage is it can save numerous routes in the route cache, prior to route discovery process.

**Light-weight mobile routing (LMR):** It is a type of reactive technique that employs flooding method for data routing. Towards every needed destination, LMR nodes manage numerous routes. By enabling the node to choose subsequent available routes to a particular destination, the protocol reliability is increased. With managing entire routes, it eliminates storage overheads and extra delays. But, LMR might give invalid temporary routes that initiate additional delay in validating a perfect loop.

**Temporally ordered routing algorithm (TORA):** It is depending upon LMR technique. Similar to LMR, it employs same route repair and link reversal (Royer, 1999). Hence, it comprises of similar advantages as LMR. The benefit of TORA it is comprised with far-reaching control messages that are reduced to an adjacent node set wherever the modification in topology has occurred. It aids multicasting as another benefit of TORA. To offer multicasting, TORA might be combined with Lightweight Adaptive Multicast (LAM) approach. The drawback of this method is this might create ineffective routes temporarily similar to LMR.

**Associativity-based routing (ABR):** ABR(Toh, 1996) employs query-reply method to decide the routes towards the needed destinations. Every node manages associativity with its adjacent node to choose a stable route. The ABR drawback is that it needs periodic beaconing to decide associativity links degree. The beaconing condition needs entire nodes to remain active over entire life that might incur extra utilization of power. It does not manage route cache or numerous routes. And, in case of link failure, it does not provide alternate routes immediately. Through introducing the process of localized route discovery, it has to be adjusted to some degree for not comprising with numerous routes.



### 3. Energy Aware Routing techniques in MANET

Most of the routing techniques for MANET are derived from the available routing techniques for wired networks that do not consider energy utilized protocols. So, these techniques do not consider energy utilization in the routing process. But, nodes in MANET usually operate on battery constrained platform and energy efficient routing is the primary design issue (De Rango et al., 2008). The energy exhaustion of a node will make the node to lose its capability of forwarding packets and affects the total network lifetime. So, various researchers attempt to develop energy-aware routing protocols.

To solve the shortcomings involved in previous routing protocols, (Sarkar et al., 2016) proposed several routing measures relied reliable as well as energy-aware routing protocol. At the initial stage, this model produces a route among 2 nodes after relating the measures of multiple routing with adjacent threshold rates of routing parameters, while the traditional routing protocols tries to find the optimal routes by means of single metric. Also, it is dynamically provisioning the path blocks of analyzed route under the application a trust module which often examines the intermediary nodes. Later, the route maintains around 4 functions such as inspection, substitution, inclusion, and elimination of nodes.

(Rashid et al., 2017) resolve the problem of disconnection as well as nodes which are comprised with maximum RE and minimum mobility pace is essential. It assures that, the nodes are selected with enough sustainability network management for prolonged duration. To attain the effective energy application, a novel reactive routing protocol is named as Mobility and Energy Aware AODV (MEAODV) is projected by the combination of fundamental actions from AODV as well as Multipath AODV. In this model, AODV has been selected as it is obtained with minimum power application when compared with alternate approaches that functions maximum mobile cases. It is clear that, RE and mobility are assumed at the same time in route developing stage that exhibits vital improvement across MAODV-X and RAODV specifically. MEAODV shows a rapid enhancement in PDR, lifespan and profit by 5%, 10-15% and 20-24% correspondingly than RAODV and MAODV-X. Hence, the attained simulation outcome pointed that, the simultaneous consideration of mobility and RE tends to decreased possibility of misconnection as well as greater reliable routing paths.

(Bergamo et al., 2010) employed a Distributed Power Control (DPC) model to enhance the energy efficiency in MANET. All nodes compute the energy required attain the closer nodes, and energy evaluation has been applied to turn the transmission power and cost to reduce energy routing. The deployed DPC scheme computes in two levels such as hop-by-hop and end-to-end. Also, transmitting energy level is employed used in the form of link cost at the time of path discovery. Some of the existing models like Dijkstra and Link State, and AODV, the final outcome displayed that the developed DSC approach provides vital power savings during the establishment of degradation with respect to throughput and latency.

(Cano et al., 2003) implied a novel approach named as drain rate used in detecting the node's lifetime on the basis of current traffic status. Also, it is combined with the rates of RE and allows to select the node might be active or not. A Minimum Drain Rate (MDR) technique has been established to be used in previous MANETs routing protocols in a form of route deploying procedure to reach prolonged battery life and link time. An extended version termed as

Conditional MDR (CMDR) to reduce the overall transmission energy applied to prolong the battery lifespan as well as link time. It is based on the computation of deciding a route with lower overall transmission power among every path involved by nodes with an increased lifetime when compared with a provided threshold. Under the application of ns-2 simulator and DSR protocol, a relation among MDR and Conditional Max-Min Battery Capacity Routing (CMMBCR).

#### **4. Routing protocols for Stable Data Transmission in MANET**

Jamali et al., 2013) have introduced an improved TORA routing protocol with Binary Particle Swarm Optimization algorithm (BPSO). In BPSO-TORA approach, the route length and energy level has been evaluated to choose the stable route. BPSO-TORA resolves routing issue by reducing the energy consumption for effective communication. However, data delivery ratio is not enhanced by BPSO-TORA. (Singh et al., 2014) have designed an Innovative ACO based routing model by taking arbitrary election of transmitting and receiving nodes and transferring the Ants (agents) between them. Innovative ACO based Routing Algorithm is also known as ANT ALGORITHM (ANTALG). This helps to provide optimal routing thereby increasing communication process in the network. However, the security features have not been considered while communicating among the ants in MANET.

(Xia et al., 2011) have planned trust management model to provide reliable routes in MANET. Based on the Analytic Hierarchy Process (AHP) theory and logic rules predictive model, trust evaluation model has been designed to estimate the trust of nodes. This, in turn, performs reliable routing using trust management model in MANET. However, the model has been vulnerable for more cruel attacks owing to the behaviour of network topologies.

The concept of multicasting in MANET is said to be a complex function. (Singh et al., 2012) have analyzed the multicasting routing protocols. The effective measures taken against the problem of short life time, dynamic topology, power and bandwidth consumption has also been studied and analyzed, but effective measures are not taken to avoid delay. (Xiang et al., 2010) have introduced Efficient Geographic Multicast Protocol (EGMP). In EGMP, a network wide zone based bidirectional tree has been introduced to gain resourceful membership controlling as well as multicast delivery.

(Zhao et al., 2013) have introduced Loose-Virtual-Clustering based (LVC) Routing Protocol for power Heterogeneous (LRPH) in MANET. LVC algorithm has been employed in implementing hierarchical network for avoiding unidirectional links. This helps in directing data packets towards high-power nodes. However, security level is reduced in LVC routing protocol.

#### **5. Trust Based Schemes in MANET**

(Subramaniyan et al., 2014) have introduced Record and-Trust-Based Detection (RTBD) approach. In RTBD technique, the node with malicious issues has been effectively detected by employing trust values. RTBD technique has been very efficient in identification of selfish node with minimizing data delivery ratio. (Hamouid et al., 2015) have developed certificate less Pretty Good Privacy (PGP) like trust establishment scheme. The reliability of network and authenticity of public key is achieved, but certificate less PGP-like trust establishment scheme

failed to decrease the overhead of the network. (Seo et al., 2017) have developed a trust-based reputation scheme called Global Trust for MANET. In Global Trust, a clustering algorithm has been constructed and the scheme has been framed as Cluster based Global Trust (CGTrust). An optimal group size has been evaluated through CGTrust for decreasing arrangement time taken to fulfil the trust demands. The end to end delay has been reduced without increasing security level efficiently by using CGTrust.

(Yan et al., 2016) have considered two practical schemes depending on additive homomorphic encryption for increasing privacy of trust evidence providers. In the first scheme, higher computational efficiency has been attained while the second scheme provided increases security to the data. The traditional trust evaluation algorithm has been supported by these two practical schemes in implementation of several applications. In these two schemes, trust evaluation has been executed for avoiding the malicious attack, with reducing data delivery ratio.

(Cho et al., 2016) have introduced fully distributed trust-based public key management (TPKM) model on the basis of trust, a security mechanism called Composite TPKM (CTPKM) has been incorporated for improving the security aspects of the network. Each and every node is verified with respect to their trust value. The risk of security in data communication is reduced by using CTPKM with resolving communication overhead through trust and key management. However, fully distributed TPKM is not capable of minimizing delay. (Abdel-Halim et al., 2015) have considered Agent based Trusted Dynamic Source Routing (ATDSR) technique for MANET. ATDSR protocol has been employed in maintaining the trust information locally and reducing the time delay. In ATDSR protocol, a Multi-Agent System (MAS) has been implemented in each node for achieving higher security level with decreased time delay. An MA includes two agents namely Monitoring Agent (MOA) and Routing Agent (ROA). Then, the trust value of each node has been estimated through a mathematical and realistic objective model. The selective forwarding behavior of the node has determined by weighting mathematical and realistic objective model with number and routed packet size. ATDSR protocol has been proved to be a secure and trusted protocol against various malicious nodes, with minimizing data delivery ratio.

(Wei et al., 2014) projected an integrated trust management method for increasing security level in MANET. Two components have been included in Trust management scheme namely trust from direct and indirect observations. The trust value has been determined with the aid of Bayesian inference through direct observation. Bayesian inference is a variety of uncertain reasoning. While second hand information offered by neighbor nodes also termed as indirect observation determines the trust value through Dempster-Shafer theory. Dempster-Shafer theory has been another variety of uncertain reasoning. The mixture of both direct and indirect observation in unified trust management scheme attains more perfect trust values of observer nodes. The PDR and throughput of MANET has been enhanced by using Unified trust management, but trust management scheme has failed for raising the security of data communication to the desired level.



## 6. Security Enhancement Techniques in MANET

Security is a crucial problem, which offers preserved data transmission in a harsh platform. The security challenges take place because of the abilities of self-configurable capability with number of nodes that are placed arbitrarily in operational environment. The reason is that the nodes do not have any fixed infrastructure and mobility as the nodes are weaker for intrusions and attacks. Therefore, securing mobile nodes is a vital application. (Nadeem et al., 2014) have designed an Intrusion Detection and Adaptive Response (IDAR) model in MANET. It has been employed in the identification of attacks and network degradation has been avoided. The response mechanism scheme prevents the attacks through three intrusion response behaviors. However, IDAR process has failed to improve data delivery ratio.

**Table 2.4:** Survey of Cluster based Routing schemes

Author (Year)	Methods/ Technique	Proposal Contribution	Merits	Demerits
Borkar et al., 2017	AOMDV-SAPTV routing protocol	From Mesh multipath routing technique, every secure and best path has been predicted by using SAPTV Protocol.  Dolphin Echolocation technique aims in extracting optimal connections in data transmission task.	An optimal correlation to transmit the data is attained by using Dolphin Echolocation model.  AOMDV-SAPTV increases information security.	Delay at the time of telecasting data from source to receiver is improved.
Anita, 2017	joint cost and secured NDEMR method	NDE-MR is applied to reduce the power utilization as well as implementing duration.  An optimal path including lower transmission expense can be derived by applying cost-based multipath route exploration method	A better route along with lower communication cost is gained by consuming cost-based multipath route exploration technique.  Data packets are divided as different classes to offer security with the help of node disjoint path approach.	Energy utilization is high from all nodes.

Nadeem et al., 2014	IDAR mechanism	IDAR model is used to identify the attacks.  According to the estimated confidence from suspicious attacks, nodes that decompose the network have been eliminated.	Response model eliminates the attacks which are based on estimated confidence.	Number of data submitted at final node has been minimized.
Zhou et al., 2016	ACECR protocol	ACECR protocol has been used to get best routing by the application of positive feedback of ACO. Hence, routing is considered in terms of hops from nodes and node energy with higher and lower energy of routes.	ACO is increased to get optimal link in data transmission.  ACECR improves lifetime of network.	PDR is improved by resulting in poor interaction.
Havinal et al., 2016	MECOR	A simple communicating principle is evaluated to solve the issue of ineffective energy in MANET.  The task of identifying shortest path in forwarding data packets in a secured manner is achieved.	A communication pattern is applied to solve the issue of energy inefficiency.  Shortest path can be found data transmission.	MECOR failed to report about the problems in dangerous attacks.

## 7. Conclusion

In this chapter, a detailed review of existing research available in the literature for energy efficient clustering based secured multihop routing protocols in MANET. The challenges in the current scenario were identified and possible solution were proposed in the current study. The routing process in MANET, which faces major challenges and many of the researchers working on optimizing the results. We are also focusing on the same, in addition the energy efficiency also considered in this study.

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