

# An Efficient Routing Protocol Based on Modified Ant Colony Optimization and Cuckoo Search for Mobile Ad Hoc Networks

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**Abstract:** The technology of MANET represents self-governing mobile-based nodes resulting in a network on ad hoc basis in absence of fixed infrastructure. The property of dynamically built topology of MANETs may result in degradation of the network performance. This paper suggests methods to improve the performance-based routing over several parameters such as energy, packet delivery, and overhead by the process of optimizing the value of threshold using NLP based initialization along with ant-colony optimization process. This type of initialization process helps in improving the optimization performance on random basis and it results in an efficient and effective path for the reduction of energy and it also increases the rate of packet delivery. The results based on experimental analysis shows that the proposed approach significantly improves the performance of the system.

**Keywords -** Mobile ad hoc network, Ad hoc on demand distance vector, Multipoint Relay, Optimized Polymorphic Hybrid Multicast Routing Protocol

## I. INTRODUCTION

Wireless Ad-hoc networks presents a new prototype shift in a wireless multi-hop networking process and these are becoming popular and a necessary part of computing that involves the mobile networks based on infrastructure or infrastructure-less networks [1]. Mobile ad hoc network presents a multi-hop network based on infrastructure-less methodology where each of the node performs the process of communication with other type of nodes whether on direct or indirect basis with the help of nodes of intermediate form. The praise for improvement of ad-hoc based network mainly goes to the property of self-organizing/configuring properties. All the nodes in MANET operate as mobile-based routers participating in few basic types of routing protocols. This is necessary for decision and maintenance of routes [14]. As the technology of MANETs presents a structure that is infrastructure-less, quickly deployable, self-organizing, these attributes results in a proper and suitable formation of applications consisting of specific outdoor events, regional communications with non-wireless framework, natural disasters and emergencies, and operations of military, mining site operations, business urgent meetings and robotic acquisition of data [2] [3].

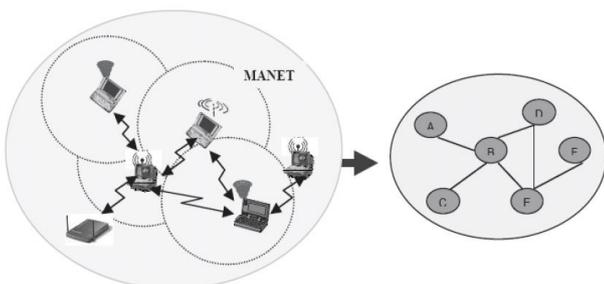


Figure 1: Mobile Ad Hoc Network (MANET)

Generally, the nodal routes in an ad hoc type of network may involve multiple type of hops. Hence, these networks are known to be wireless multi-hop ad hoc networks. Figure 1 depicts an

instance of mobile network on ad hoc basis and its topology of communication.

## 1.1 Characteristics of MANET

The Ad hoc based networks consist of various features or characteristics that make them quite suitable and distinct from the other wired type of networks. Thus, it desires various inventive ways for implementing the functionalities of the network.

(1) *Medium (Wireless):* The medium used by the system nodes for the process of communication with other type of nodes attains the property of asymmetric propagation and time-varying coverage. It is more prone and less reliable to the mechanism of interference when compared to a medium of wired type.

(2) *Dynamic Topologies:* Here, the nodes move freely or arbitrarily with distinct speed. Thus, the topology of the network may shift on random basis and at uncertain times.

(3) *Infrastructure less Network:* The operation of the network does not depend over constant or fixed infrastructure.

(4) *Management of Power:* As the nodes are free to move, they mainly depend over the batteries as their source of power. Thus, protocols and mechanisms designed for such type of networks requires to keep an eye over the constraint of energy.

(5) *Peer-to-Peer approach:* Here, all the protocols need to be modelled for environments (distributed) formed by "peers" and such a system needs to be potent enough to care such distributed type of dynamic built topologies [4].

(6) *Energy resources and limited computing:* Here, the system has finite power for computing memory, size of disk, and power because of finite capacity of the battery as well as device size, cost, and weight.

(7) *Finite coverage of service:* Distance between several devices, limitations of network conditions, implementation of service for devices of wireless nature presents a challenging scenario as compared to the wired networks along with their elements and simultaneously the technology of MANETs faces several constraints.

(8) *Low reliability due to high interference:* The Infrared type of signals usually face interference from heat sources and sunlight, and it can be absorbed or shielded by several materials and objects. Radio signals are mainly less prone to the process of being blocked. But these can be hampered by other forms of electrical devices [5] [6]. Here, the mechanism of self-interference takes place due to multipath.

(9) *Highly variable network conditions:* High rates of data loss occurs due to the mechanism of interference. The movements of the user results in a common disconnection. The changes in a channel takes place due to movement of users around it.

(10) *Limited Bandwidth:* Wireless-based links continues to have low capacity than the infrastructural type of networks.

## 1.2 Applications of MANET

Research on MANETs is still taking place and this concept can be employed in any region where a cheaper and faster network can be instantly setup for data-based communication.

- *Military Services:* Military services represents a common area of application in the terminology of mobile ad hoc networks where the process of installing any constant infrastructure is not allowed in the territory of enemies. Here, the technology of MANETs helps in providing the necessary mechanism of communication. Here, the movement of soldiers is indicated by mobile nodes.

- *Emergency Services:* This type of services occurs due to natural calamities when the overall infrastructure of communications is in chaos for instance, earthquake, tsunamis, etc. where a quick process of restoring communication is necessary. With the use of ad hoc type of networks, the set of an infrastructure can be done in a couple of hours rather than days or weeks necessary for the process of communication.
- *Education:* Campus and Universities settings, Virtual built classrooms, communication on Ad hoc basis during lectures or meetings.
- *Sensing:* The sensor-based network depends on ad hoc basis where the concept of mobility is not considered generally. However, the concept of battery-based power presents a significant factor in the technology of sensors. Each of the sensor gets equipped with a source of energy, transceiver, and a small type of microcontroller. The sensors relay the informational data from other type of surrounding devices such that they can transport informational data to central system-based monitor [7]. The sensors are helpful in sensing the conditions of environment such as humidity, pressure, temperature, etc.
- *Personal Area Networking:* Personal device of communication such as PDAs, mobile phones, laptops design a network for sharing informational data with others, this process is known as Personal Area Network (PAN). It mainly covers short communicational range [11].

### 1.3 Ad hoc on demand distance vector (AODV)

AODV algorithm of routing is another popular on demand-based routing algorithm which can undertake unicast and multicast. AODV maintains routes till required by the system sources. It uses sequence-based numbers to assure the freshness property of route and is of self-starting and loop free nature, and it helps in scaling too many mobile-based nodes. AODV builds routes with the help of a cycle based on route request (RREQ) or route reply (RREP). When data needs to be transmitted from source to destination, the source of the system floods the network with a packet of RREQ in case if a route is not available for a specific destination. When an intermediate/neighbor node gets a RREQ packet, it takes care whether it is the node-based destination node, or otherwise it checks whether it receives this RREQ or not earlier by investigating the source node IDs and request [10]. The nodes of intermediate form forwards request to neighbors till RREQ message reaches its destination place or otherwise it ends at intermediate type of node that involves an updated form of route to the place of destination. After this process, packet is dropped by the nodes without passing the route request. Every node works by maintaining a number-based sequence in AODV along with a broadcast ID. A RREQ message has the source and destination's sequence numbers and is always analyzed by the address and broadcast IDs of node-based sources. The sequence number of destinations ensures a routing i.e. loop free and consists of updated routing information. A reply to the RREQ message by intermediate nodes is possible only when they have a destination route [12] [13]. Also, the sequence number should either be equal or greater to that in the RREQ. RREQ is comprised of SrcID (Source Identifier), DestID (Destination Identifier), SrcSeqNum (Source Sequence Number), DestSeqNum (Destination Sequence Number), BcastID (Broadcast Identifier) and TTL (Time-to-Live) fields. DestSeqNum presents the property of route freshness (new) acceptable by the source. When forwarding RREQ (route request) messages an intermediate type of node on daily routine basis, it keeps an eye over the neighbor's address from where it received first RREQ message copy which becomes helpful when a reverse path is needed. When a route request is obtained many times, as revealed by a pair of BcastID-SrcID, the duplicates message copies of RREQ's are trashed. Intermediate type of nodes along with the routes to the place of destination node become able to send packets of RREP to the source position. These nodes record previous node address and BcastID when forwarding route requests. A timer automatically erases such entries if RREP is not obtained before the time limit expiry. When the route reply ends at the intermediate/destination node with a new (fresh) route, the

intermediate/ destination node reverts a packet of RREP back to a neighbor from whom it received its first message of RREQ. As RREP gets back routed on a reversing path, the nodes on such type of route, sets up forwarded path-based entries in the caches of routing [9] [12].

## II. RELATED WORK

Vijayalakshmi et al. [2] presented a multicasting LSMAODV i.e. Link Stability based Multicast Adhoc on demand vector routing protocol that uses a received strength of signal in terms of a metric for estimation of node and link stability. The challenging problems faced by MANETs involve the consumption of energy, service quality, attacks exposure, and stability of links. The stability of links forms a necessary part for improving the process of communication. The stability of links is important as the radio links in general variates because of node-based mobility. Such kind of instability results in an increased process of rerouting that escalates the mechanism of routing-based overhead. Routing overhead can be reduced by using a mechanism of multicasting rather than unicast routing. The protocol of Multicast Routing transmits the data on concurrent basis to a class of destination-based nodes in order to achieve better utilization of resources. The comparison between AODV, MAODV and LSMAODV is measured for link and node stability. In this paper, three clusters are modelled and a single node from each of the cluster is selected as the cluster-based head following packet priority. This paper aims to determine the link with a large probability of having longer nodal lifetime. Gupta et al. [3] proposed an enhanced Cuckoo Search-based Clustering Algorithm (ICSCA). In a vast scale Wireless Sensor Networks (WSNs), planning of a vitality effective information gathering convention has turned into a testing research issue. This is because of actuality that every sensor hub is by and large outfitted with constrained vitality asset. In the writing, grouping based system for information gathering has been demonstrated exceptionally productive regarding vitality sparing. In spite of the fact that, it is called attention to in the writing that outline of a vitality adjusted bunching for expanding the system lifetime of WSNs is a NP-difficult issue. For taking care of this NP-difficult issue, numerous meta-heuristic approach-based grouping conventions are proposed in the ongoing years. Be that as it may, these current grouping conventions experience the ill effects of lopsided vitality utilization issue. In this issue, bunch heads are not consistently appropriated and over-burden group takes cease to exist speedier than under-stack group heads. Execution assessment of the ICSCA and its examination with the condition of-craftsmanship grouping plan in wording all out vitality utilization and lingering vitality were introduced. Kout et al. [4] proposed a new form of routing convention that was propelled by the strategy of cuckoo search. MANETs are turning into a developing innovation that offer a few focal points to clients as far as cost and convenience. A MANET is a gathering of versatile hubs associated by remote connections that frame a transitory system topology that works without a base station and brought together organization. Steering is a technique through which data is sent from a transmitter to a particular beneficiary. Routing is a technique that certifications, whenever, the association between any two hubs in a system. This steering convention is actualized utilizing Network test system 2. Gopalan et al. [5] anticipated Improved Cuckoo Search Optimization (ICSO) based Energy-Delay Aware Routing Algorithm to resolve the energy and delay issues particularly for the rescue and emergency applications. In this anticipated system, the MANET nodes are optimally grouped with the cluster head selection procedure is done by means of an Improved LEACH (I-LEACH) protocol. Once the CH is elected, the intra and inter-cluster communication is recognized. The energy efficient and delay aware shortest paths are resolute by the ICSO Algorithm. Thus, the routing paths are designated with energy efficiency and minimal delay with abridged security threats from diverse attacks. Investigational outcomes display that the anticipated ICSO grounded Energy-Delay aware Routing system offers efficient routing with improved recital in rescue and emergency applications in context to the ratio of packet delivery, bandwidth, delay (end-to-end), energy utilization, throughput, network lifetime and consistency. Adhvaryu et al. [7] presented a mechanism of present work that addressed the protocols of multicast routing with less overhead control overhead in MANETs technology. The present scenario consists of distinct

problems, issues and solutions that witnessed the requirements of group-based management in wireless ad hoc networks. The main objective of a MANET based routing multicast protocol was to back the data-based propagation from sender to receivers (all) of a multicasting group and at the same time using the bandwidth (available) in the presence of persistent changes of topology. The process of multicasting helps in improving the performance of wireless link by forwarding messages having multiple copies and by exploiting the property of inherently built broadcast of wireless-based transmission. Moreover, multicast route with minimum overhead control presents a very challenging and difficult task. Presently, several protocols of multicast routing have been planned and proposed for the application of MANETs. Such type of protocols involves distinct features and mechanisms for supporting different parameters of Quality of Services [10]. Kruthika et al. [8] considered, the distinct protocols based on multicasting routing in the technology of wireless MANETs. Ad hoc based network consists of mobile-based nodes in the absence of a wired infrastructural support. In such an environment multicast protocols faces lots of challenges in production of multihop-based router under mobility of host and the constraints of bands. Several routing protocols and their approaches have been proposed in order to address the problems of Ad hoc networking and the needs of multiple efforts of standardization under Internet-based Engineering Task Force, along with industrial and academic projects of research. Recent year study presents a large number of multicasting protocols with distinctive styles for the Ad hoc based networks. GAMER i.e. Geocast Adaptive Mesh Environment for Routing provides geocast type of communication on Ad hoc basis and it further adapts to a proper environment-based network by changing the mesh density on dynamic basis. FGMP i.e. Forwarding Group Multicast Protocol is mainly based on the approach of a forward group and it refreshes the members of the forward group dynamically by using On-Demand routing procedure. The applicability, weakness, and strengths of each of the multicast protocol for diversion of operation has been analyzed and considered for further analysis. Hinds et al. [9] investigated the range of routing protocols of MANETs and discussed several functionalities ranging from initial protocols like DSDV to a more advanced form such as MAODV, the study of protocol mainly cares about the work done by Perkins in development and improvement of MANET based routing. The rise in popularity and availability of mobile-based wireless devices has resulted in development of a huge variety of MANET based protocols for exploiting exceptional opportunities of communication as presented by such type of devices. These devices were capable for communicating on direct basis with the help of using a peer-to-peer based wireless spectrum, and the route-based messages through nodes of intermediate type. Further, the study of literature associating the field of MANET based routing was reviewed and identified, the process of securing AODV in the terminology of MANETs was also studied. Finally, this review investigated trending methodologies within the research study like exclusive use of mobility model based on random waypoint, and excluding the key metrics from the results of simulation and further it does not compare the performance of protocol against its alternatives. Nagaprasad et al. [11] worked on two distinct forms of routing protocols such as DSDV (Destination sequenced Distance vector and DSR (Dynamic Source Routing) protocols. The protocols-based performance was measured with the following scenario like 1) fraction of packet delivery 2) end-to-end point packet delay 3) routing based on load. The results of simulation indicate that the DSR protocol performed better than the DSDV. It also pin-pointed some time-based DSDV were also better than the DSR. Further it analyzed the performance and speed of DSR. When the nodal number increases, then the performance of DSDV goes down. In case of DSDV based routing each of the host forms a strategy to maintain table routing, which may result in routing-based load over the network. It also investigated the performance based on pause time which was better in case of DSDV. But if it goes higher, then DSR performs better as compared to DSDV. Kant et al. [12] presented a typical protocol for routing based on multicast or unicast schema of routing from a similar class-based approaches reflecting the research work state-of-the-art on MANETs routing. The other method for classification of routing protocols i.e. reactive, proactive, and hybrid methodologies have been considered later used in the classification of unicast and multicast

routing and a difference in characteristic for typical kind of routing protocols representatives was designed for MANETs based on the comparison and description of schemes. Hybrid multicast or unicast protocol of routing are considered as a better candidate than purely built reactive and proactive protocols of routing. Most of the application of the system uses unicast type of protocol whereas in case of group communication, the multicast type of routing protocol provides better performance comparatively. However, the performance requires to be exploited fully and the Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR) represents another form of routing protocol as OPHMR presents a hybrid form of multicast protocol of routing. For additional efficiency of the system, OPHMR helps in utilizing an optimized scheme with the help of MPR i.e. Multipoint Relay. It is mainly used for decreasing the control overhead of the system. So OPHMR presents a better form of routing protocol than the others. This paper provides a comparative analysis of several protocols of routing for MANETs based technology. Olagbegi et al. [13] presented a research survey to address the energy-efficient multicast protocol of routing and secured a multicast routing protocols in the environment of MANETs. The method consists of several problems and their respective solutions witnessing the requirement of energy security and management in wireless ad hoc networks. The major goal of a multicast protocol was to support the process of data propagation based on sender receiver policy while supporting the use of present bandwidth on efficient basis in presence of topology-based frequent changes. The process of multicasting helps in improving the efficiency of wireless link while forwarding multiple messages copies through exploitation of inherent broadcasting property of wireless-based transmission.

### III. THE PROPOSED METHOD

Source node forwards the route request packets in the network to find a route to destination. This is the basic procedure of AODV, which has been used in the existing scheme.

#### 3.1 Proposed Methodology

First thing incorporated in the proposed scheme will be routing the packets according to modified ACO. Basic ACO is modified using NLP method (node-link parameters-based selection). Since this is based on any colony optimization, therefore the fourth factor that determines the fitness of the solution will be the pheromone value of the path. Higher this factor, more fit will be the path.

We define fitness function of the path as:

$$F(p) = (1-\alpha)* \text{Length} + \beta* \text{Energy factor} + \gamma* \text{Stability of the path} + \lambda* \text{Pheromone value}$$

Where  $\alpha, \beta, \gamma, \lambda$  are constants with sum equaling to 1.

When destination node receives the FANT packets, it will formulate all the paths to the source node. These paths will represent the initial solutions. The fitness function of each solution will be computed. From the initial solutions, the solutions having fitness value lesser than the average fitness value of the entire solution set will be removed. Thus, destination node will now be filtered initial solutions for which levy's walk will be applied to find a new solution. In the existing work, the fitness value used for initial solution is calculated using the hop count and levy's walk obtains the new solutions based on same fitness value, i.e. hop count. In the proposed work, the fitness value for any solution will be based on three factors described in NLP and levy's walk will be generated according to the same. After generating the new values, if the fitness value of new solution is more than the old solution, then old solution will be replaced by new one and vice-versa. The destination node will send BANTs to the source node for the newly generated solutions. The source node will choose the solution having highest fitness value to route the data to destination node

### 3.2 Proposed methodology: Flowchart

The proposed methodology works over the following flowchart as represented below:

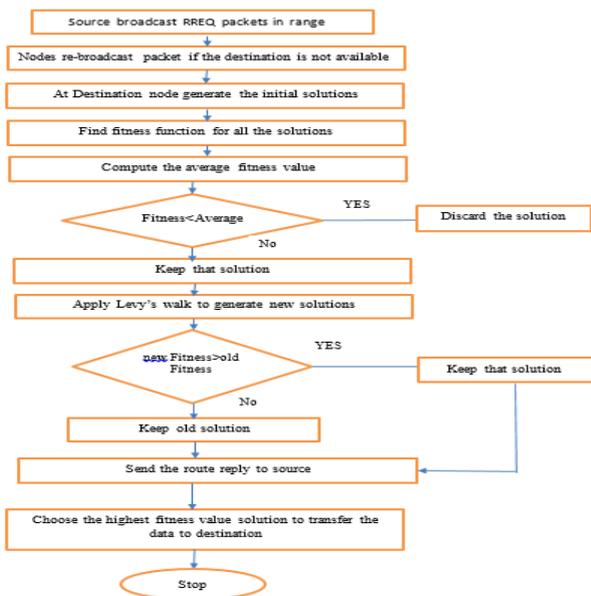


Figure 2: Proposed Flowchart

### 3.3 Algorithm Used

The algorithm used in the process is discussed below:

**Ant Colony Optimization:** As explained by CH. V. Raghavendran [13], in recent years, the interest of the scientific community in ACO has been increased. Because of robustness, and adaptive nature, ACO has finally managed to find its applications in routing, assignment & scheduling. The basic idea behind ant-based routing algorithm is food searching strategy of real ants. The ants deposit pheromones on the ground while searching the environment for food. This pheromone attracts other ants and the ants tend to follow trails of previous ants. This mechanism enables the ants to find shortest paths between the nest and a food source. There are chances that when ants fan out to find food, any ant finds a short path to a new food source. It then takes some food with it and makes its way back to the nest. Since it is attracted by its own pheromone trail, it is likely that the ant follows its own path back to the nest, thereby leaving a second pheromone trail. If other ants happened to take a longer path to the food source, they arrive after the first ant and, when trying to make their way back to the nest, there is a good chance for them to be attracted by the short path, where already two pheromone trails have been laid. This reinforces the short path even more and makes it more attractive. Concerning the longer path, pheromones tend to evaporate after some time, so in the long run the long paths will be forgotten and almost all ants will take the short path. The characteristics of ants are similar to the characteristics of MANETs. This helps us to apply the food searching characteristics of ants for routing packets in MANETs. The basic principle of an ant routing algorithm is mainly the depositing of pheromone on the path followed by the ant. They follow simple rule of following the path which has higher concentration of pheromone. The pheromone concentrations on a path allow the other ants to find their way to the food source. Thereby more ants follow the same path and more and more pheromone is deposited on the path which is the shortest route to the food source.

### IV. RESULT ANALYSIS

The result analysis is based on the following objectives as presented below:

Simulation Environment:

PARAMETERS	VALUES
Simulator version	NS-2.35
Routing protocols	AODV, AODV-CS, AODV-ACO-NLP
Topology	3000 * 1600
Channel type	Wireless Channel
Radio propagation model	Propagation/Two Ray Ground
Packet length	512
Antenna type	Omni Antenna
Number of nodes	20-300
Transport agent UDP Speed (min-max)	5-20 m/s

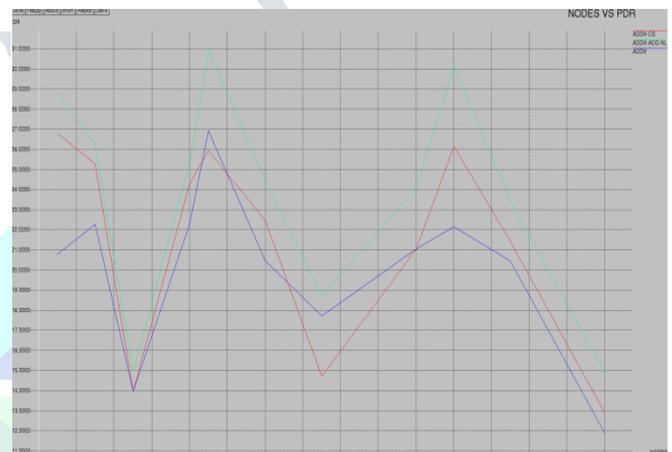


Figure 3: Represent the graph between PDR and NODES

Figure 3 presents the comparison of packet delivery ratio between proposed AODV-ACO-NLP, AODV, and AODV-CS approaches. Here, X-axis represents the number of nodes and Y-axis represents the PDR. When nodal number is increased, rate of PDR fluctuates in a zigzag manner. This occurs due to increase in number of nodes, and further the searching time for cuckoo search (CS) method increases. When there are 50 nodes, the rate of PDR is 15 but it is 19 at 150 nodes. The variance of zigzag changes according to various approaches such as AODV\_ACO\_NLP, but it does not reduce the rate of PDR as much as compared to the other kind of approaches as the approach of Ant-colony optimization initializes by NLP methodology which do not start randomly and get effective threshold early compare to AODV-CS. It shows that when number of nodes increases, PDR does not reduce as much. AODV-CS use optimization but it does not initialize any heuristic like proposed approach. So, its PDR overlap with AODV and sometime reduce to AODV. Its reason is not finding the effective threshold. Figure 4 represents the overhead by the proposed AODV-ACO-NLP, AODV-CS, and AODV approaches. In this graph, X-axis presents the nodal number and Y-axis presents the overhead. When there is increase in number of nodes, the rate of overhead also increases. But it will not increase as much as compared to the proposed approach (AODV-CS-NLP).



Figure 4: Show the graph between OVERHEAD and NODES

This usually occurs because the AODV\_ACO\_NLP does not increase the rate of overhead as much as compared to other kind of approaches. Here, Ant-colony optimization approach gets initialized by NLP approach which do not start at random and it gets its effective early threshold as compared to AODV-CS approach, which shows that when there is increase in number of nodes, the overhead rate does not increase as much. In AODV-CS approach, use of optimization is done but it does not initialize any heuristic method such as the proposed approach when there is increase in number of nodes. The method of Cuckoo search (CS) increases the time of searching, so it increases the overhead and its effect on throughput. When there are 50 nodes, the value of overhead is 9. But it is 24 at 150 nodes. It indicates the increase in number of nodes along with increase in overhead due to the time of searching.

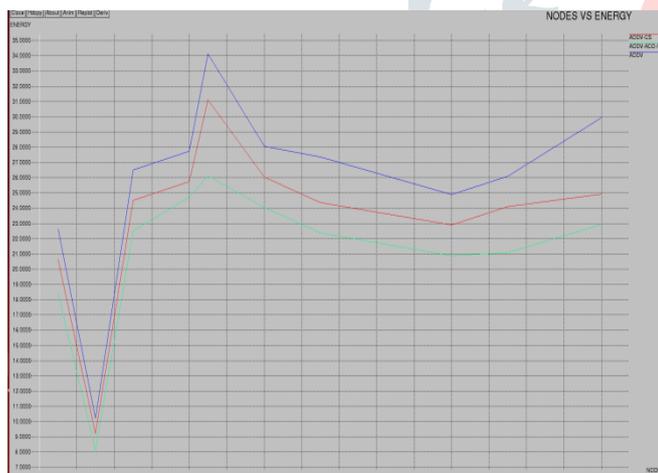


Figure 5: Show the graph between ENERGY and NODES

Figure 5 represents comparison of energy reduction between proposed AODV-ACO-NLP, AODV-CS, and AODV approaches. In graphical section, X-axis represents the number of nodes and Y-axis represents the mechanism of energy reduction. When number of nodes increases, the rate of energy is increased and it further fluctuates in a zigzag manner. This occurs when number of nodes increases, and the time of searching increases for cuckoo search (CS) method. In case of 12 nodes, energy is 13 but at 150 nodes, it is 19. But zigzag variance changes according to approaches like AODV\_ACO\_NLP not as much reduce energy compare to other approaches because of Ant-colony optimization approach initialize by NLP approach which not start random and get effective threshold early compare to AODV-CS It shows that when number of nodes increases, energy does not reduce as much. In AODV-CS use optimization but not initialize any heuristic like proposed approach. So, its energy overlaps with AODV and sometime reduce to AODV. Its reason is not finding the effective threshold.

#### IV CONCLUSION

The main objective of the scheme proposed is to enlarge the energy-aware routing path on the basis of PSO in mobile ad hoc networks. The evolution of reliable routing is done using ACO and the method of initialization by NLP is conversed. The proposed NLPACO scheme uses the mechanism of ACO to disclose the optimal route in order to minimize the routing-based overhead and it further ensures a reliable process in MANET technology. A novel scheme of energy-aware routing based on Ant colony optimization is developed to ensure MANET based reliable routing process. In this paper, the improving performance by ACO initialized by NLP approach takes place which do not initiate on random basis and it achieves an effective early threshold as compared to AODV-CS. When there is an increase in number of nodes, the energy does not reduce as much. Whereas in case of AODV-CS, it uses optimization process but it does not initialize any heuristic method like the proposed approach. So, the energy sometimes overlaps with AODV or it may reduce to AODV. It is the main reason of not finding an effective threshold value.

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