

A Review on Cluster based Routing Protocols in MANET

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Abstract – A Mobile Ad hoc Network (MANET) is an assortment of wireless mobile terminals that are able to dynamically form a temporary network without any aid from immovable infrastructure or centralized administration. In recent years, MANETs are continuing to appeal the attention for their potential use in several fields such as military activities, rescue operations and time-critical applications. In recent years, several routing protocols and Cluster based protocols have been anticipated for mobile ad hoc networks. This survey paper provides an overview of these protocols by presenting their characteristics, functionality, benefits and limitations and then makes their comparative analysis so to scrutinize their performance and compare some of existing works on clustering in MANETs.

Keywords – Cluster, MANET, Routing.

I. INTRODUCTION

In recent years there have been some different approaches on cluster-based routing. The essential works that are taken into consideration here apart from CBRP are those of [1], [2] and [3]. The cluster-based routing protocol (CBRP) was introduced by [4]. In CBRP the nodes of a wireless network are divided into several disjoint or overlapping clusters. Each cluster elects one node as the so-called clusterhead. These special nodes are responsible for the routing process. Neighbours of clusterheads cannot be clusterheads as well. But clusterheads are able to communicate with each other by using gateway nodes. A gateway is a node that has two or more clusterheads as its neighbours or when the clusters are disjoint at least one clusterhead and another gateway node. The routing process itself is performed as source routing by flooding the network with a route request message. Due to the clustered structure there will be less traffic, because route requests will only be passed between clusterheads.

Cluster Formation

There are two approaches of cluster formation one is identifier based clustering and other is connectivity based clustering. When using identifier-based clustering a node elects itself as the clusterhead if it

has the lowest/highest ID in its neighbourhood, or a neighbour node if one has a lower ID. Connectivity-based clustering elects the node, which has the most neighbour nodes, as the clusterhead. So, whenever a clusterhead loses a neighbour node its connectivity decreases and it is most likely that another node has to be elected to act as clusterhead. While in the identifier-based approach, a new clusterhead has to be chosen only when nodes with lower/higher ID appear.

The CBRP uses a variation of the lowest-ID algorithm specified by [4] which is an identifier-based algorithm. In order to support the cluster formation process each node uses a neighbour table, where it stores information about its neighbour nodes, such as their ID's, their role in the cluster (clusterhead or member node) and the status of the link to that node (uni-/bi-directional). The neighbour table is maintained by periodically broadcasting HELLO messages. A HELLO message contains information about one node's state, its neighbour table and its cluster adjacency table. The various states describe the clustering process depending on the current node state. These states are:

1. Undecided

This means the node does not belong to any cluster: this usually occurs if a new node appears in the network. Thus, if it receives a HELLO message from a clusterhead and there is a bi-directional link between them it changes its state to be member of the cluster indicated by the clusterhead. Otherwise it looks up in its neighbour table if it has any bi-directional links. If so, it becomes itself the clusterhead of a new cluster, if not, it remains in the undecided state and tries again.

2. Clusterhead

If a clusterhead detects that it has a bi-directional link to another clusterhead for a time period, it changes its state to member if the other clusterhead has a lower ID.

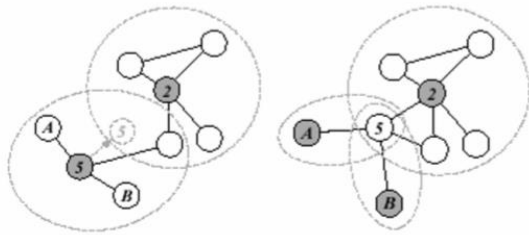


Fig 1: Clusterhead Movement [4]

Otherwise it stays the clusterhead and the other node has to change its state. This is a special case which may result in cluster re-organization (Fig 1).

3. Member

If a member loses its clusterhead, it looks for bi-directional links to other nodes. If it detects any, it changes its state to clusterhead if it has the lowest ID, otherwise it switches to the undecided state. Each member node belongs at least to one cluster striking for the goal to minimize cluster re-organization, the structure of the clusters should change as seldom as possible. That means “a non-cluster head never challenges the status of an existing cluster head”, even if it has a lower ID.

Routing

CBRP uses two data structures to support the routing process:

1. The cluster adjacency table (CAT)
2. The two-hop topology database.

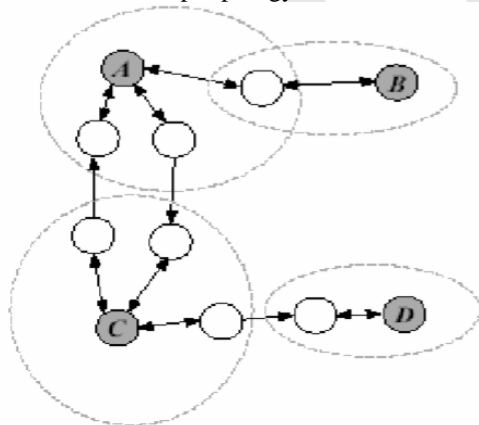


Fig 2: Link between nodes of cluster network [7]

The CAT stores information about neighbouring clusters. This is, whether they are bi-directionally or uni-directionally linked. That means, a cluster is called

- Bi-directionally linked, if there is a bi-directional link between two nodes of the clusters, or if there are at least two opposite

uni-directional links between two nodes (Fig 2).

- Uni-directionally linked, if there is just one uni-directional link between them.

II. ENERGY EFFICIENT CLUSTER NETWORK FOR AD-HOC NETWORK

In MANETs, the nodes are mobile and battery operated. As the nodes have limited battery resources and multi hop routes are used over a changing network environment due to node mobility, it requires energy efficient routing protocols to limit the power consumption, prolong the battery life and to improve the robustness of the system.

Many authors presented energy based structure in Mobile Ad-Hoc network, in most of the scenario, the cluster head selection is dependent on energy consumption in network to save battery power. Cano, J.C. et al presents a similar model using the intra cluster data-dissemination protocol for reducing energy consumption in a clustered MANET [5]. The protocol is used to group nodes around a special one, called the cluster leader (CL). The CL centralizes the power.

Management mechanism and acts as a proxy for data transfer between the cluster and the rest of the nodes in the region. When a cluster node enables the power management it goes into "sleep" mode, to minimize power consumption. The CL buffers data frames for power saving stations and delivers them on station request. We analyse here that author periodically distribute the cluster leader role among all the nodes inside the cluster to not overload a single node.

As the design goal we discussed earlier in the section, an author propose a “Signal and Energy Efficient Clustering (SEEC)” algorithm based on signal strength and energy level of nodes in MANET to improve system performance. The algorithm focuses on cluster head formation and maintenance, and prevents death of cluster head by making another cluster node as the cluster head when power level falls below certain threshold value [6]. As we know, Topology of network plays an important role for energy conservation. One issue is to addresses how the topology of the network can be adjusted by controlling the transmission power. In a work [7] the node in the farthest transmission range will take part in routing and the node that is geographically closer to the destination node is the candidate. Energy conservation is based on sleep based approaches. The energy is conserved by controlling a set of neighbour to which the node communicates, this

kind of intelligent sensing efficiently increase the network lifetime.

Table 4.1: Simulation Parameters used by most of the researches

Simulation Time	100s
Topology Size	1000m × 1500m
Number of Nodes	50
Mac Type	MAC 802.11
Radio Propagation Model	Two Ray Model
Radio Propagation Range	250m
Pause Time	0s
Max Speed	4m/sec – 24m/sec
Initial Energy	100J
Transmit Power	0.4W
Receive Power	0.3W
Traffic Type	CBR
CBR Rate	512 bytes × 6 per second
Number of Connections	50

Another approach is to minimize either the active communication energy required to transmit or receive packets or the inactive energy consumed when a mobile node stays idle but listens to the wireless medium for any possible communication requests from other nodes. Transmission power control approach and load distribution approach belong to the former category, and sleep/power-down mode approach belongs to the latter category as described in a research [8].

Adding an intelligent sleeping behaviour to sleep the device in steady state can also prolong the network lifetime and increase the throughput of network, one author in [9] describe a similar work, adding sleeping behaviours in mobile devices, This process proposes an Energy based Ad-Hoc on-Demand Routing algorithm that balances energy among nodes so that a minimum energy level is maintained among nodes and the lifetime of network is increased. This research, focused on increasing the prolonged existence of node in the network.

In this proposed work, one set the minimum energy threshold limit of a mobile node, when a node reach the minimum threshold limit the node goes to sleep mode, save energy and participate in the event as long as possible. Another adaptive sleep behaviour was proposed by Tripti Nema et al in [10]. In most of the paper, simulation parameters considered are shown below. Some Other Approaches considering energy as a routing parameter includes [11], [12], and [13]. The author consider the issue that is dynamically establish the connection whenever required for the communication network resulting in a quickly changing in topology of the network and increase communication overheads. This dynamic topology, leads to significant routing overhead, scalability problems and battery power consumptions in

MANETs. Consider this problem, in this research a clustering approach have been proposed for ad hoc networks.

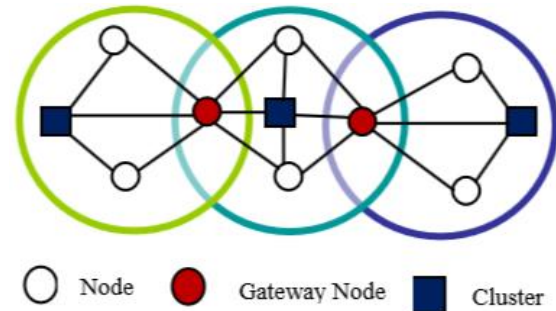


Fig 3: Cluster Head Election [10]

In Clustering approach, the cluster head election is call upon for the constructing the path, reduce the communication over heads and scalability. For the path construction cluster-AODV routing protocol is applied and also the design goals of clustering algorithms are presented in research [14].

III. INTELLIGENT APPROACHES IN CLUSTER BASED ROUTING IN MANET

One the important research on energy based routing we are not discuss in previous section is “A New Energy Efficient Routing Algorithm Based on a New Cost Function in Wireless Ad hoc Networks” presented by Mehdi Lotfi et al because it is kind of intelligent selection approaches.

In order to maximize the lifetime of ad hoc networks, traffic should be sent via a route that can be avoid nodes with low energy. In addition, considering that the nodes of ad hoc networks are mobile, it is possible that a created path is broken because of nodes mobility and establishment of a new path would be done again. This is because of sending additional control packets, accordingly, energy consumption increases. Also, it should avoid nodes which have more buffered packets. Maybe, because of long queue, some of these packets are dropped and transmitted again. This is the reason for wasting of energy. Hence a method need to propose a new energy efficient algorithm, that uses a new cost function and avoid nodes with characteristics which mentioned above as proposed in [15].

A survey on genetic algorithm based optimization approaches in mobile Ad-Hoc network presented by Sumathy S et al in [16], as Genetic Algorithm (GA) presents an improved solution for the multi-constrained multicast routing problem. By choosing proper fitness function and values for metrics such as initial population size, crossover and mutation that closely relates to the chosen scenario, the

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genetic algorithm optimizes the routes in terms of selected metrics.

Some important research paper publish in the particular section in IEEE digital library includes [17], [18], [19], and [20]. Include The Study on the Synchronization Clustering Control, sectorized clustering scheme based on transmission range, Selective Prioritized Clustering Algorithm, and Weight based adaptive clustering for large scale heterogeneous MANET.

In [20], a design methodology is presented, named weight based adaptive clustering for large scale heterogeneous MANET (WACHM), in order to build a large scale hierarchical MANET using heterogeneous nodes to construct different layers. The main aim in [19] is to reduce power consumption at network level. It uses topology control and hierarchical clustering based approach, and is applicable to an environment where the complete network is divided into a specific number of clusters which includes sub-cluster. As stability is also an important factor in designing a network, To enhance the network stability, in [18] introduce an Enhanced Sectorized Clustering Scheme based on Transmission Range for MANETS (ESCS), that pays special attention to the selection of a suitable node for the role of cluster head and the formation of cluster. An Enhanced Sectorized clustering scheme is achieved by electing a cluster head based on residual energy along with the staying time of nodes and the cluster is formed based on the transmission range of the cluster head.

Since, MANET also depended on the property as like variable energy, high degree of mobility, location environments of nodes etc. In recently years, the various clustering technique and routing algorithm would have proposed for improving the energy efficiency. However, the proposed clustering method in [21] results remain the problems in high energy consumption on the cluster head node. These proposed an algorithm were presented about composition of cluster that was being node clustering algorithm process. However, it could not provide a solution that is also improving energy efficiency and making energy consumption to reduce through reconstruction of cluster. So, in [21], author propose an algorithm techniques which is TICC (Time Interval Clustering Control) based on energy value in property of each node for solving cluster problem.

An Adaptive Weighted Cluster Based Routing were also proposed by S. karunakaran et al in [22], which amends swiftly to the topological changes and establishes the routing efficiently. [23] Proposes a new approach to geographic routing for location

aided cluster based MANETs, mainly points that GPS utility in nodes reduces the end to end delay even during its high mobility. High computational overhead and high mobility of the nodes typically require completely GPS enabled MANETs for higher performance. In [23], Improved Location aided Cluster based Routing Protocol (ILCRP) for GPS enabled MANETs has been evaluated for performance metrics such as end to end delay, control overhead, and packet delivery ratio. Some Other approaches include Cluster Based Zone Routing Protocol and Cluster-based Inter-domain Routing (CIDR) Protocol designing for network. This approach generates clusters using group affinity. In each domain, the distributed clustering algorithm discovers the set of “traveling companions” – these are the nodes that stick together as a group for some time or for some common tasks. MANET (mobile ad-hoc network) is a type of dynamic configuration wireless ad-hoc network that does not require the basic Internet construction. Clustering of devices in MANET could reduce overhead, flooding and collision in communication and make the network topology more stable. Cluster Heads (CHs) are determined dynamically and in charge of the routing of the cluster. Frequent search of CH nodes would lower the efficiency of network. Many clustering algorithms used in searching CH nodes only consider the hop counts. However, the hop numbers do not demonstrate the exact distance between two CH nodes. Therefore a location based selection mechanism in routing must be necessary in such networks. In [20] the location aided hierarchical cluster routing (LHCR), a more suitable way for mobile ad-hoc network routing is proposed. The LHCR method arranges the nodes in the networks into hierarchical clusters by the amount and position of the data. Thereby, it avoids the nodes that are far away from each other being assigned to the same cluster, and at the same time taking the CH nodes' power amount into consideration to avoid over-transformation. Routing is taken care of by the highest level of the nodes in each cluster.

In designing procedure of network for web services, a better Clustering Framework must necessary in order to form a better routing scheme, Unlike the common Web service used in wired applications, the web service applications based on MANET have so many differences in data transmission, service registration and service discovery. All components of web service of MANET need to consider the features of mobile devices and mobile environment. Cheng Zhang et al in [24] proposes a method, Considering the characters and requirements, this paper presents a new framework for Web service in

MANET, which supports SOAP-over-UDP and adopts cluster architecture. And to make the service working smoothly in such framework, this research prompts special service registration and discovery strategies.

To prolong the lifetime of all nodes, each cluster should elect a node with the most remaining energy as its cluster head. But, the selfish nodes may behave selfishly by lying about their remaining energy and avoiding being elected. A research [25] represent the existence of selfish nodes really has a bad effect on the lifetime of the networks and propose a solution based on auction mechanism. More specifically, author design a mechanism with the following attributes: First, the mechanism can always elect the most energy remaining nodes as cluster heads. Second, the mechanism can encourage the selfish nodes behave honestly by providing incentives. Ritchie, L. et al develop and analyze Cluster Overlay Broadcast (COB), a low-complexity routing algorithm for MANETs. COB runs on top of a one-hop cluster cover of the network, which can be created and maintained using, for instance, the Least Cluster Change (LCC) algorithm. Author formally prove that the LCC algorithm maintains a cluster cover with a constant density of cluster leaders with minimal update cost. COB discovers routes by flooding (broadcasting) route requests through the network of cluster leaders with a doubling radius technique [26].

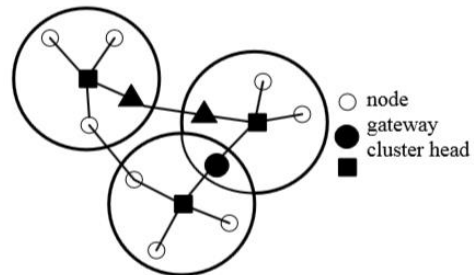


Fig 4: Cluster structure [27]

In terms of controlling overhead, and increasing scalability, An Huiyao et al, proposes a Cluster-Based Multipath Routing in MANET (CBMRP). It distributes traffic among diverse multiple paths to avoid congestion, which optimizes bandwidth using and improves the sharing rate of channel. It uses clustering's hierarchical structure diverse to decrease routing control overhead and improve the networks scalability [27].

In the current issue, we also want to discuss Renovated Cluster Based Routing Protocol (RCBRP) for reducing routing overhead and to improve the routing discovery by integrating the inter-cluster on-demand and intra-cluster table-driven routing, which can increase the performance in the throughput [28]. Most of the topology control algorithms proposed have high control overhead to discover and maintain route from source to destination. They also have very high topology maintenance cost. To minimize routing overhead and topology maintenance cost CBRP (Cluster Based Routing Protocol) was developed. It performs better than other approaches in most of the cases [29]. Other issues covered by some authors in [30], [31], [32] can be vital for future designing of cluster based network.

Table 4.2: Comparison table of different researches

Author	Research	Description
Bravo, J. [32]	Cluster topology formation in MANET: A mathematical model approach	Present a model to simulate high traffic load using MANET. The MANET topology is studied in three different scenarios with different loads and the minimal capacities for wireless connection between cluster heads, among nodes with corresponding cluster heads, and the minimal capacity for a node to become a cluster head is attained in order to assure the network function.
Jieying Zhou [33]	Cluster-Based Gateway-Aided Multicast Routing Protocol in MANET	Paper proposed a new multicast routing protocol aiming at networks of many nodes: CGMRP, Cluster-based Gateway-aided Multicast Routing Protocol in MANET. In CGMRP, gateways can share some multicast routing task from the cluster heads in order to reduce the risk of single point issue of the leader nodes.
Rohini, S. [31]	Consistent cluster maintenance using Probability Based Adaptive Invoked Weighted Clustering Algorithm in MANETs	Propose a Probability Based Adaptive Invoked Weighted Clustering Algorithm (PAIWCA) which can enhance the stability of the clusters by taking battery power of the nodes into considerations for the clustering formation and electing stable cluster-heads using cluster head probability of a node.
Shin-Jer Yang [20]	Design Issues and Performance Analysis of	Many clustering algorithms used in searching CH nodes only consider the hop counts. However, the hop numbers do not demonstrate the exact distance

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	Location-Aided Hierarchical Cluster Routing on the MANET	between two CH nodes. Therefore, the location aided hierarchical cluster routing (LHCR), a more suitable way for mobile ad-hoc network routing is proposed in research.
Sethi, S. [6]	Scalable Cluster Based Ad hoc On-demand distance vector routing protocol for MANET	Propose a novel scalable cluster based routing protocol for Mobile Ad hoc Network (MANET) named as Scalable Cluster Based Ad hoc On-demand Distance Vector (SCBAODV). This proposed SCBAODV is scalable, minimizes route failure, controls the Network Routing Load (NRL), end-to-end delay and improves the Packet Delivery Ratio (PDR).
Na Zhang [5]	Research on mobile hidden station for weighted clustering algorithm in MANET system	Paper analyses the mobile hidden station problem for WCA in MANET. Computer simulates the network average throughput, load balance factor (LBF) and fairness between traditional WCA with or without mobile hidden station.
Yi Wang [30]	WACHM: Weight based adaptive clustering for large scale heterogeneous MANET	A design methodology is presented, named weight based adaptive clustering for large scale heterogeneous MANET (WACHM), in order to build a large scale hierarchical MANET using heterogeneous nodes to construct different layers. Four critical issues are addressed. First the optimal number of CHs is analyzed in theory.
Vijeesh, T. [34]	SPC: The Selective Prioritized Clustering Algorithm for MANETs	Propose an algorithm called selective prioritized clustering (SPC), to reduce power consumption at network level. It uses topology control and hierarchical clustering based approach, and is applicable to an environment where the complete network is divided into a specific number of clusters which includes sub-cluster.
Roy, A. [19]	Energy Efficient Cluster based routing in MANET	Propose a "Signal and Energy Efficient Clustering (SEEC)" algorithm based on signal strength and energy level of nodes in MANET to improve system performance. The algorithm focuses on cluster head formation and maintenance, and prevents death of cluster head by making another cluster node as the cluster head when power level falls below certain threshold value.
Yanqing Zeng [25]	A Cluster Header Election Scheme Based on Auction Mechanism for Intrusion Detection in MANET	To prolong the lifetime of all nodes, each cluster should elect a node with the most remaining energy as its cluster head. But, the selfish nodes may behave selfishly by lying about their remaining energy and avoiding being elected. Work represent the existence of selfish nodes really has a bad effect on the lifetime of the networks and propose a solution based on auction mechanism.
Cheng Zhang [24]	A Novel Clustering Framework for Web Service in MANET	Considering the characters and requirements, this paper presents a new framework for Web service in MANET, which supports SOAP-over-UDP and adopts cluster architecture. And to make the service working smoothly in such framework, this paper prompts special service registration and discovery strategies.
Li Wang [35]	A Secure Clustering Scheme Protocol for MANET	In this protocol, all the nodes within the networks are clustered into several clusters. Here we analyze how to calculate the trust value between the nodes according to their interaction behaviors.
Young-sam Kim [17]	A Study on the Synchronization Clustering Control for MANET	Propose an algorithm techniques which is TICC (Time Interval Clustering Control) based on energy value in property of each node for solving cluster problem. It provides improving cluster energy efficiency how can being node manage to order each node's energy level.
Gomathi, K. [36]	An efficient cluster based key management scheme for MANET with authentication	Proposes a new cluster based tree (CBT) algorithm for secure multicast key distribution, in which source node uses Destination Sequenced Distance Vector (DSDV) routing protocol to collect its 1 hop neighbors to form cluster.
Dongsheng Chen [21]	An efficient cluster update model in MANET	Establish a cluster update interval model which uses the expected link lifetime with respect to the cluster-head (CH) as the update interval. The proposed model takes all of the above mentioned factors into consideration and no weights combination is needed.
Muthuramalingam, S. [18]	An enhanced sectorized clustering scheme based on transmission range for MANETS	Introduce an Enhanced Sectorized Clustering Scheme based on Transmission Range for MANETS (ESCS) that pays special attention to the selection of a suitable node for the role of cluster head and the formation of cluster. An Enhanced Sectorized clustering scheme is achieved by electing a cluster head based on residual energy along with the staying time of nodes and the cluster is formed based on the transmission range of the cluster head.
Xibin Zhao [37]	Availability based trust model of clusters for MANET	Many approaches have been suggested to trade-off between the security strength and efficiency, and most of them focus on the confidentiality and integrity of MANET while pay less attention to the availability issue. Based on the analysis of availability related factors in MANET.
Ritchie, L. [26]	Cluster overlay broadcast (COB): MANET routing	Develop and analyse Cluster Overlay Broadcast (COB), a low-complexity routing algorithm for MANETs. COB runs on top of a one-hop cluster cover of

	with complexity polynomial in source-destination distance	the network, which can be created and maintained using, for instance, the Least Cluster Change (LCC) algorithm. Author formally prove that the LCC algorithm maintains a cluster cover with a constant density of cluster leaders with minimal update cost.
Cano, J.C. [38]	Reducing energy consumption in a clustered MANET using the intra cluster data-dissemination protocol	Present the intra-cluster data-dissemination protocol (Icdp). The Icdp is used to group nodes around a special one, called the cluster leader (CL). The CL centralizes the power management mechanism and acts as a proxy for data transfer between the cluster and the rest of the nodes in the region.
Jaya Jacob [13]	Efficiency enhancement of routing protocol in MANET	This paper evaluates the performance of various Ad-Hoc routing protocols such as DSDV, AODV, DSR, TORA and AOMDV in terms of energy efficiency and it also proposes a new routing algorithm that modifies AOMDV and it provides better performance compared to all the above protocols.
Suchismita Rout [7]	Energy Aware Routing Protocol in MANET using Power Efficient Topology Control Method	In this work the node in the farthest transmission range will take part in routing and the node that is geographically closer to the destination node is the candidate.
Chansu Yu [8]	Energy Efficient Routing Protocols for Mobile Ad Hoc Networks	This article surveys and classifies the energy aware routing protocols proposed for MANETs. They minimize either the active communication energy required to transmit or receive packets or the inactive energy consumed when a mobile node stays idle but listens to the wireless medium for any possible communication requests from other nodes. .

IV. CONCLUSION

In this paper we have identified and reviewed a range of literature on the topic of cluster based MANET routing protocols, our initial work discussed a pair of survey papers from which we identified early reactive and proactive MANET routing protocols.

We analyse that the mobility of the nodes has reduced the cost of infrastructure units such as access points and base stations. In the recent years, people stay connected and the need of group applications for communication has increased. To support this trend of communication efficiently in MANETs, multicasting is used for routing. Several multicast routing protocols have been designed, each one to meet specific requirements. It becomes essential for a researcher to carefully choose a multicast routing protocol appropriately. The different categories of routing protocols presented above give an overall idea on group formation, maintenance and data forwarding in the network.

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