JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF COMPUTING

Improved Cluster Based Routing Protocols through Optimal Cluster Head Selection for MANET

By:

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THIS RESEARCH STUDY SUBMITTED TO DEPARTMENT OF COMPUTING, INSTITUTE OF TECHNOLOGY, JIMMA UNIVERSITY, IN MEETING PARTIAL FULFILLMENT FOR THE AWARD DEGREE OF MASTER SCIENCE IN COMPUTER NETWORKING

Principal Advisor: Dr. Girum ketema

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DECLARATION

I, the undersigned, declare that this thesis entitled Improved Cluster Based Routing Protocols through Optimal Cluster Head Selection for MANET is my original work and has not been presented for a degree in this or any other universities, and all sources of references used for the thesis work have been appropriately acknowledged.

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APPROVAL SHEET

This thesis entitled Improved Cluster Based Routing Protocols through Optimal Cluster Head Selection for MANET has been read and approved as meeting the requirement of faculty of computing in partial fulfillment for the award of degree of master of science in Computer Networking, Jimma University, Jimma, Ethiopia.

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Dedication

——I dedicate this thesis for my beloved family——

Acknowledgments

It is my great delight to Acknowledge every body who has contributed to my work during this travel. First of all, I want to thanks to God who supports me in every challenges of my life including this journey, with out his help this can not achieved. I would like to express my deepest gratitude to my advisor, Dr Girum Ketema, Mr.Kebebew Ababu and Mr.Gemechu Berhanu for their sincere support, encouragement, and meaningful guidance on doing this work.

List of Acronyms

MANET: Mobile ad hoc network

AODV: Ad hoc On-demand Distance Vector

DSDV: Destination-sequenced distance vector routing

DSR: Dynamic source routing

OLSR: Optimal link state routing

RREQ: Route request

LID: Lowest-ID

HCC: Highest connectivity clustering

CBRP: Cluster based routing protocol

MCBRP: Modified cluster based routing protocol

CH: Cluster head

BCH: Backup cluster head

MAC: Media access control

WCA: Weighted clustering algorithm

OSCA: Optimized stable clustering algorithm

WCA SWDCBRP: stable weighted double cluster based routing protocol

Ns2: Network simulator 2

Copt: Optimal member

PRNET: Packet radio network

SURAN: Survivable Adaptive Radio Networks

QoS: Quality of service

CGSR: Cluster head Gateway Switch Routing

DT: Distance table (DT)

RT: Routing table

LCT: Link-cost table

MRL: Message retransmission list

FSR: Fisheye state routing

WRP: Wireless routing protocol

LCC: Least cluster change

TORA: Temporally-Ordered Routing Algorithm

DAG: Directed a cyclic graph

DYMO: Dynamic MANET On-demand

RREP: Route reply

RERR: Route error

IPv4: Internet protocol version 4

IPv6: Internet protocol version 6

ZRP: Zone routing protocol

IZR: Independent zone routing

CEDAR: Core Extraction Distributed Ad hoc Routing

CM: Cluster member

CGW: Cluster gateway

DWCA: Distributed Weighted Clustering Algorithm

MOBIC: Mobility Based Metric for Clustering

MobDHop: Mobility-based d-Hop Clustering algorithm

NBCRA: Node Based Cluster Routing Algorithm

PF: Priority factor

Res: Residual energy of node

Ni : Mobile node

Dni: Distance of node

CHn: Cluster head n

CH-PF: Cluster head priority factor

BCH-PF: Backup cluster head priority factor

Init: Initial energy of mobile node

Cone: Consumed energy of mobile node

RW: Random walk mobility

RWP: Random way point

ARGM: Autoregressive group Mobility Model

RPGM: Random point group mobility model

NAM: Network animator

FTP: File transfer protocol

TCP: Transmission control protocol

UDP: User data gram protocol

A:Alfred Aho

W:Peter Weinberger

K:Brian Kernighan

N: Neighborhood

Nei : Neighbor of node n

Abstract

Mobile ad hoc network (MANET) is a wireless network that communicate mobile hosts without the need of fixed infrastructure. They are characterized by mobility of mobile node (since mobile nodes in MANET move in and out) and limited resources (such as battery power). Mobility causes change in topology of network. Because, of this to create stable network is the most challenging task. It is also the same when battery power of an intermediate node is drained. To overcome these exiting problems clustering is essential, and used to control the topology of network. In clustered network most battery is consumed during communication to select cluster heads and when it routes where the data is sent from source to destination. Hence, optimal clustering algorithm has received significant research attention. A number of clustering algorithm has been proposed to improve cluster based routing protocol like weighted clustering algorithm (WCA), optimal stable clustering algorithm (OSCA), The Lowest ID clustering algorithm (LID), The highest connectivity clustering algorithm (HCC) etc. Still, they need enhancement to create stable, and optimal clustered network for mobile ad hoc network(MANET).

This thesis focuses on improving CBRP(cluster based routing protocol) protocol, which is a clustered network to create stable and long-lived network. During cluster head (CH) selection, cluster head, and backup cluster head (BCH) is selected based on the parameters (residual energy or degree centrality). A node has high degree centrality or high residual energy is selected as cluster head and second highest is selected as backup cluster head. In member joining, the member is join based on parameters (relative mobility behavior, and distance of node) until it reaches its optimal member node. Mobile node which has the same relative mobility behavior and minimum distance to cluster head they grouped in the same cluster. Then there is no re clustering because there is backup cluster head and cluster maintenance, during cluster maintenance when a CH fail due to some reasons backup CH replaces CH and it finds its backup CH based on priority factor. The proposed work has been evaluated by using network simulator 2. The simulation result verify the modified cluster based routing(MCBRP) protocol is more energy efficient by selecting optimal cluster head, and by balancing the load based on energy model.

keywords: MANET, CBRP, clustering, optimal cluster head selection.

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Chapter 1

INTRODUCTION

1.1 Background of the Study

Wireless networks are computer networks that forms networks without the aid of wired materials or cables for communication purpose. It is omnipresent, we can communicate by the network anywhere at any time, and portable devices needs an access point or base station. To overcome this problem mobile ad hoc network (infra-structure less network) is essential. Wireless networks are classified into infra-structure based mobile network and infra-structure less mobile network, it is commonly known as mobile ad hoc networks. Infra-structure based networks wireless nodes can communicate with each other with a wired network and first it go to the access point or base station. Infrastructure less networks are there is no the need of access point or base station. Mobile ad hoc network (MANET) is a wireless networks that communicate mobile hosts without the need of fixed infra-structure. Because of this, they are called infra-structure less network. Those mobile nodes in mobile ad hoc network (MANET) generate and forward packets. I.e. they act as hosts and routers [1].

The routing protocol in mobile ad hoc network (MANET) is essential because they decide the path from source to destination to transmit data packets over multiple hopes. Basically, routing protocols in mobile ad hoc network (MANET) can be classified Proactive, reactive and hybrid routing protocols. In proactive or table driven protocols each node contains routing information on reaching every other node on the network. Destination-sequenced distance vector routing (DSDV), optimal link state routing (OLSR) is the most examples of proactive routing protocols.

Dynamic source routing (DSR), Ad hoc On-demand Distance Vector (AODV). AODV and cluster based routing protocol (CBRP) are the most reactive routing protocols [2].

MANET still have some challenges those are limited battery power, limited bandwidth, routing overhead, delay during route discovery, route request (RREQ) flooding traffic etc. It causes the change in topology of network due to high mobility of nodes because of this to create stable network is the most challenging task. To overcome those exiting problems clustering is essential and used to control the topology of network. CBRP (Cluster Based Routing Protocol) is an on-demand Routing protocol, where the nodes are divided up into clusters. It uses clustering structure for routing protocol. Clustering is divides mobile nodes into groups to create stable network. I.e. is used to prolong the network lifetime. Clustering is the challenging task because the nature of nodes in mobile ad hoc network (MANET) are mobile, due to dynamic topology of nodes the mobile nodes move in and out from the network it makes the network topology unstable in mobile ad hoc network (MANET). In each cluster there is a cluster head which coordinates the members and responsible for intra cluster communication and inter cluster communication, gateway which has bidirectional or unidirectional link with a node in other cluster and member node is all nodes within a cluster and each member node has bidirectional link with the cluster head and forwards data packets to the cluster head. There are two types of clustering algorithms, active clustering algorithm and passive clustering algorithm. In passive clustering algorithm piggybacks the information or the procedure is run when the data is transmitted. Here-as in active clustering algorithm nodes communicate each other by exchanging information to select a cluster head.

In general existing clustering algorithm is done in the following two steps, cluster formation and cluster maintenance phase [3]. In cluster formation phase select the cluster head by considering single performance metric or multiple performance metrics to calculate the ability of node and form group of nodes. During cluster maintenance when the cluster head fails select other cluster head by invoking the algorithm or replace the second cluster head if the algorithm supports that. So far many algorithms have been developed to select cluster head. Among those lowest-ID (LID), the highest connectivity clustering (HCC), weighted clustering algorithm (WCA), optimized stable clustering algorithm (OSCA) etc. A lot of improvements has been developed on those algorithms. For example in WCA SWDCBRP (stable weighted double cluster based routing protocol) [2], [3].

The main issues in clustering is how to select optimal and stable cluster heads, gateways and how to make the number of nodes optimum to increase throughput of a network, to minimizes control overhead, to maximize cluster stability, and to decrease the energy consumption during inter cluster and intra cluster communication and to offer effective and efficient clustering in MANET. Because to reduce the communication cost and energy consumed during inter clustering communication and also optimal number of nodes is required in a single cluster to increase throughput of network and to minimize energy consumed during intra cluster communication. When the number of nodes increase in a given cluster it reduces throughput, and the energy consumed during communication of cluster head within member node is increase and the energy needed to communicate with other cluster is decreases.

In order to balance this we must find optimal number of nodes within a given cluster, and select suitable cluster head in order to reduce energy utilization. Most clustering algorithm is focuses only on selection of cluster head and gateways, but doesn't consider number of member nodes in a given cluster.

OSCA (optimal stable clustering algorithm) is clustering algorithm to form stable cluster for mobile ad hoc network (MANET). The cluster head is selected by considering multiple performance metrics those are (node degree, and degree difference, distance, mobility, battery power). To calculate the combined weight there is more energy consumption and during cluster maintenance the priority factor calculation is not efficient. The proposed work improve cluster based routing protocol(CBRP) by addressing those problems. The degree of a node is calculated by the distance from others. I.e. if high number of node is having the shortest distance a node joins a single cluster head and when the number of node increase the throughput is decrease. In this case it is better to considering optimal number of member nodes in a given cluster by specifying minimum and maximum number of nodes that a cluster head can handle instead of node degree, and we must consider distance, and relative mobility behavior of each mobile node during member joining. A mobile node that locates with minimum distance to the cluster head is member of that cluster head. This parameter is used to reduce energy consumption during communication. And we consider remaining battery energy of node or degree in centrality during cluster head selection. Because a node that is having high remaining battery energy, or it locates at the center in a given member increases performance of network. During cluster maintenance calculation of priority factor of cluster head node, backup node and member node must consider mobility of node and remaining battery life. This paper tries to address the problem of high energy consumption during clustering process and to increase performance of network.

1.2 Statement of problem

Clustering is the process of dividing networks in to subgroups, and the interconnected subgroups are clusters. Cluster-based routing is based on clustering, the routing path is between cluster head and gateway rather than between nodes. Clustering is necessary for increasing routing performance, scalability of network and to reduce RREQ flooding traffic in the whole network, routing overhead, and delay during route setup. Clustering is a challenging task in mobile networks because mobile nodes frequently move in and out of network it makes network topology unstable. As a result, it is difficult task to create stable network in wireless ad hoc network, especially cluster head and gateway selection, and estimation of optimal number of nodes in a given cluster is a challenging task. The cluster head coordinates the cluster activities inside the cluster, and it spends their energy for intra cluster communication and inter-cluster communication, by manages all cluster members. Cluster head manages all the information and finds the adjacent cluster through the gateway. The main problem in cluster-based routing protocol is to select the best cluster head and to balance the load of the cluster head. Because the node might move in and out from the cluster and the cluster head consumes more energy than other nodes and it has many responsibilities than member nodes.

OSCA is one of the algorithms proposed to form a stable cluster for mobile ad hoc network. In this algorithm, cluster head changes are reduced to make cluster head more stable, and sustain for longer period which reduced clustering overhead and makes network more durable. In cluster formation process, the node with the lowest combined weight would be elected as cluster head and the second lowest combined weight would be acting as backup node for the cluster. During cluster maintenance the priority of cluster head, and backup node is calculated by the node degree, and remaining battery power. However, during this cluster formation there will be more energy consumption, they do not consider the load of each cluster head and overheads to calculate the average combined weight of a node and also the cluster maintenance is not efficient. This is because the priority factor is calculated by considering the node degree and the remaining energy, they do not consider the mobility of a node. Since, mobility affects the transmission ranges of nodes during communication. It must be considered for cluster formation.

The study aims to propose a modified CBRP by considering relative mobility behavior of node during member node joining to CH, and distance of mobile node until it reaches optimal member node. And during cluster head selection we consider performance metrics such as remaining battery energy, or degree in centrality in order to reduce overheads during cluster head selection. In other words, we must consider remaining energy of node, or degree centrality during cluster head selection.

In general this study we consider how to reduce energy consumption during intra cluster and inter cluster communication and arrangements.

1.3 Objectives of the study

1.3.1 General objective

The general objective of our work is to enhance CBRP to offer efficient and effective clustering, to maximize throughput of the network, and to reduce energy consumption of the protocol.

1.3.2 Specific objectives

To achieve the general objective the following specific objectives are set: -

- Reviewing related works to identify the gap and to understand the existing approach of clustering algorithm.
- Analyzing different performance metrics for cluster head selection and for member joining from the existing one.
- Analyzing existing CBRP protocol in MANET and existing clustering algorithms.
- Modifying CBRP clustering algorithm for optimal cluster head and gateway selection by using appropriate performance metrics.

- Test and evaluate the performance of the proposed work.

1.4 Research question

The following research questions is considered in our proposed system should be solved.

- To what extent considering optimal member joining and relative mobility of nodes reduce energy consumption of CBRP protocol. Since energy is consumed during inter cluster and intra cluster communication.
- Secondly to what extent we increase throughput of the network. In general our proposed system answers the question considering the topology of nodes and both inter cluster and intra cluster management of the mobile ad hoc network.

1.5 Methods

To achieve the objective of the study the following methods will be performed.

- Literature review

  To understand the details of the area different literature is used from research papers, books, journal articles and different documents related to on the areas of MANET routing protocols and clustering algorithm. Technique and approach for the development of clustering algorithm is reviewed.

- Design algorithm

  From the literature we find the gap, and we propose an algorithm that makes cluster head stable and it can increase throughput and reduces energy consumption during cluster formation by selecting a cluster head, and backup cluster head. The cluster head is selected by considering battery power, or node centrality, and the member node is joining by distance, and relative mobility. After this the optimal number of nodes in a given cluster is decided. During cluster maintenance the priority factor is calculated by the cluster head by using remaining energy and mobility of node. During cluster maintenance the immediate cluster head selection is not performed instead the secondary cluster head elect new back up node by calculating priority factor.

In general the coordinator node or cluster head is selected, inter-cluster links (gateway node) is selected. The CH selection is done based on performance metrics (residual energy of nodes or degree centrality) and gateway selection is done by considering the distance between the respective cluster head of the source node and the destination node. And also the backup node is selected in this phase by using those parameters we used in CH selection, it is second cluster head when cluster head is die or move from the cluster it acts as a cluster head in order to reduce communication overhead during re-clustering. Next to CH selection a group of mobile nodes based on mobility behavior and distance is created. Those have the same movement direction and those mobile node have minimum distance to the CH is grouped in one cluster. Optimal number of nodes in a cluster that a CH can handle is considered.

- Evaluation of the proposed work

  We simulate the proposed work on ns2 and compared what is already done in CBRP. We evaluate our work with OSCA(optimal stable clustering algorithm) regarding throughput of the network and energy consumption.

1.6 Scope and limitation

The scope of this study is limited to design and implement optimal cluster head selection and calculate optimal number of nodes in a given cluster. Different algorithms are developed for CBRP. The approach is designed to improve the existing cluster head selection and offer effective and efficient clustering for MANET. The study is used to reduce energy consumption during inter cluster and intra cluster communication, increase throughput of the network load balancing by specifying maximum and minimum number of nodes. The maximum and minimum number of node is decided by optimal member node limitation formula.

1.7 Application of result

The expected outcome of this thesis is effective and efficient clustering in MANET by optimizing the number of nodes in a single cluster, and by selecting optimal cluster head. The significance of this outcome be facilitated the services of MANET in many areas such as battle field, educational areas, business sector , emergency case, etc. When we compared with the infrastructure based network, the nodes in MANET are self-organized and the topology is dynamic. Because of this nature we can use MANET in different areas as we needed. Because of lacking of efficiency and scalability of network MANET has many limitations to fully give the benefits of MANET. Therefore, our proposed work would increase the importance of MANET by offering effective and efficient clustering for MANET.

1.8 Organization of the thesis

The remaining part of this thesis is organized in five chapters. In chapter two we cover the general background of mobile ad hoc network (MANET) routing protocols with their characteristics and details of the existing work about clustering. In Chapter three discusses related work that has been done on CBRP protocol and will discuss about the reason how can we choose CBRP with this advantage. It also covers the algorithms that are implemented on the improvement of CBRP protocol. Chapter four describes the proposed solution part, how to solve the problem by using existing techniques and by mobility models with their features. Chapter five describes simulation results, experimental procedure and performance evaluation of the proposed work. The last chapter, chapter six describes the conclusion part, recommendation and future work.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Mobile wireless networks are gaining it's quality in recent years. it's omnipresent, we are able to communicate by the network at anyplace anytime. It is often classified in to two variations. They're infrastructure mobile network and infrastructure less mobile network, normally called ad hoc network [2]. Present mobile ad hoc networks are thought of the third generation during this generation the concept of economic ad hoc networks arrived with notebook computers and different viable communication equipments. At a similar time, the concept of a set of mobile nodes was proposed at many researchers gatherings [4]. The first generation goes back to 1972, at the time, they were referred to as PRNET (Packet Radio Networks) [4]. The second generation of ad hoc networks emerged within the 1980s, when the ad hoc network systems were additional enhanced and implemented as a section of the SURAN (Survivable adaptive Radio Networks) program. This provided a packet-switched network to the mobile field of battle in associate environment without infrastructure. This On-Demand Routing in Multi-Hop Wireless Mobile ad hoc Networks summary of Mobile ad hoc Networks twenty program proven to be useful in up the radios' performance by improving them smaller, cheaper, and resilient to electronic attacks[4].

Mobile ad hoc Network (MANET) could be a collection of wireless mobile hosts forming a short lived network while not the help of any complete infrastructure or centralized administration. Because of the mobility of the nodes within the network, these nodes are self-organizing and self-configuring. Not only they act as hosts, but additionally they operate as routers [5]. Because of the mobile nature of nodes ad hoc networks change topologies dynamically. Naturally mobile ad hoc networks are appropriate for things wherever either no fixed infrastructure exists or deploying network isn't possible. Ad hoc mobile networks have found several applications in numerous fields like military, emergency, conferencing and detector networks. Every of those application areas has their specific necessities for routing protocols [4].

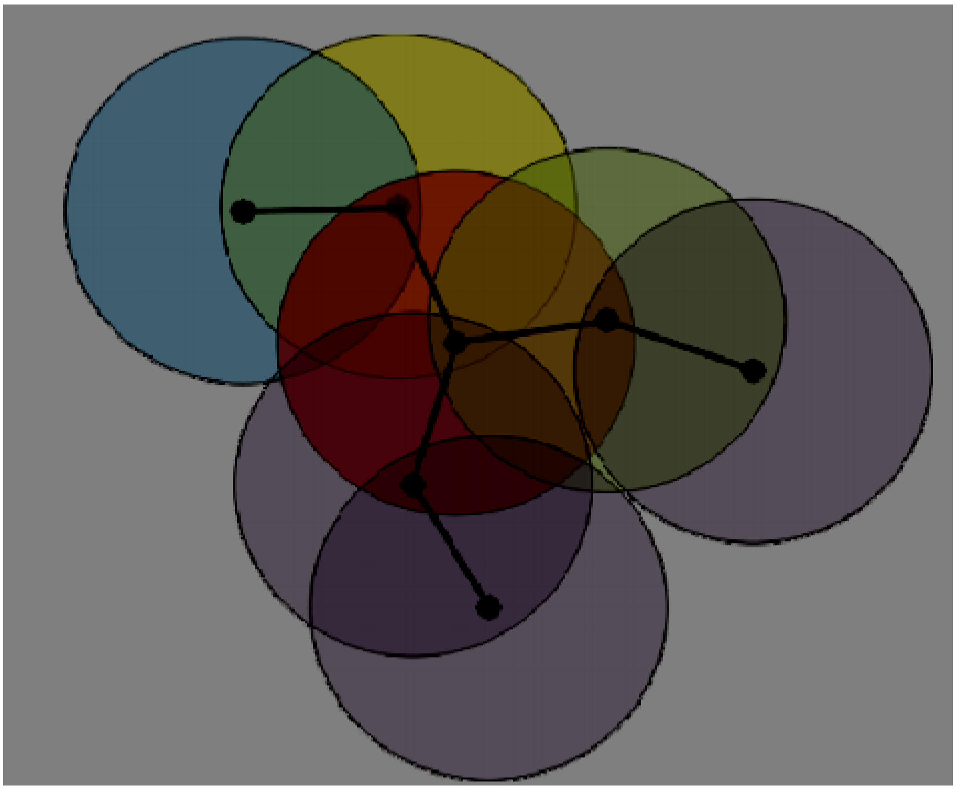


Figure 2.1: Examples of MANET structure [24].

As depicts in the above figure Mobile ad hoc network is special kind of wireless network. It is aggregation of source node, destination node normal mobile node and gateway node with out having fixed infrastructure. Those mobile nodes are connected to transfer data from source node to destination node. The above figure shows MANET has no central controller and it has dynamic topology.

2.2 Characteristics of mobile ad hoc network (MANET)

Mobile ad hoc networks are characterized by the following criteria [5]

- **Decentralized network control:** The decentralized nature of networks control in MANETs supports additional strength against the one points of failure found in centralized approaches.
- **Constrained physical security:** Mobile wireless networks are additional more to be at risk of physical security threats than are fixed cable nets. For instance, there's an increased possibility of eavesdropping, spoofing, and denial of service attack that ought to be strictly considered.
- **Low power and resource:** Mobile nodes are likely to trust batteries. Therefore, the first criterion ought to be energy conservation.
- **Dynamic topology:** Nodes are free to move arbitrarily, which means that the topology, that is often multi-hop, might change randomly and quickly at unpredictable times.
- **Bandwidth-limited and fluctuating capability links:** Wireless links, by nature, have well lower capability as compared to their hardwired counterparts. Besides the throughput of a wireless communication in a real surroundings is often much not up to a radios most transmission rate. This is often because of the existence of multiple negative effects like weakening, noise and interference conditions.

2.3 Applications of MANET

With the rise of portable devices as well as progress in wireless communication, ad hoc networking is gaining importance with the increasing variety of widespread applications. Ad-hoc networking may be implemented anyplace wherever there's very little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use. Ad hoc networking permits the devices to take care of connections to the network as well as simply adding and dispatching devices to and from the network [6]. Due to their versatile nature MANETs have several application these days. Manet may be used to form the essential infrastructure for ad hoc applications. Some application of Manet described as follows [7] [8] [6].

- **Mobile conferencing:** Ad hoc networks enable mobile conferencing for business users who need to collaborate outside their workplace wherever no network infrastructure is accessible. There's a growing need for mobile computing environments wherever completely different members of a project need to collaborate on style and development. The users need to share documents, transfer and download files, and exchange ideas.
- **Military Battlefield:** Military equipment currently routinely contains some variety of pc equipment. Ad hoc networking would allow the military to require advantage of commonplace network technology to assert an information network between the soldiers, vehicles, and military information headquarters. The crucial techniques of ad hoc network came from this field.

- **Commercial Sector:** Ad hoc will be employed in emergency/rescue operations for disaster relief efforts, e.g. In fire, flood, or earth-quake. Emergency rescue operations should happen wherever non-existing or broken communications infrastructure and speedy deployment of a communication network is required. Information is relayed from one rescue team member to a different over a little hand-held. Alternative commercial situations include e.g. Ship-to-ship ad hoc mobile communication, law enforcement, etc.
- **Local Level:** Ad hoc networks will autonomously link a rapid and temporary multimedia system network using notebook computers or palmtop computers to spread and share information among participants. E.g. conference or room. Another applicable local level application can be in home networks wherever devices will communicate on to exchange data. Similarly, in alternative civilian environments like cab, stadium, boat and tiny craft, mobile ad hoc communications can have several applications.
- **Personal space and home networking:** Ad hoc networks are quite appropriate

for home as well as personal space networking applications. For instance. Cellphone, laptop, earpiece etc.

- **Emergency services:** When the present network infrastructure has ceased to control or is broken because of some reasonably disaster like earthquakes, hurricanes, fire, so forth, ad hoc networks may be simply deployed to provide solutions to emergency services. These networks also can be used for search and rescue operations, retrieval of patient data remotely from hospitals and lots of alternative helpful services.

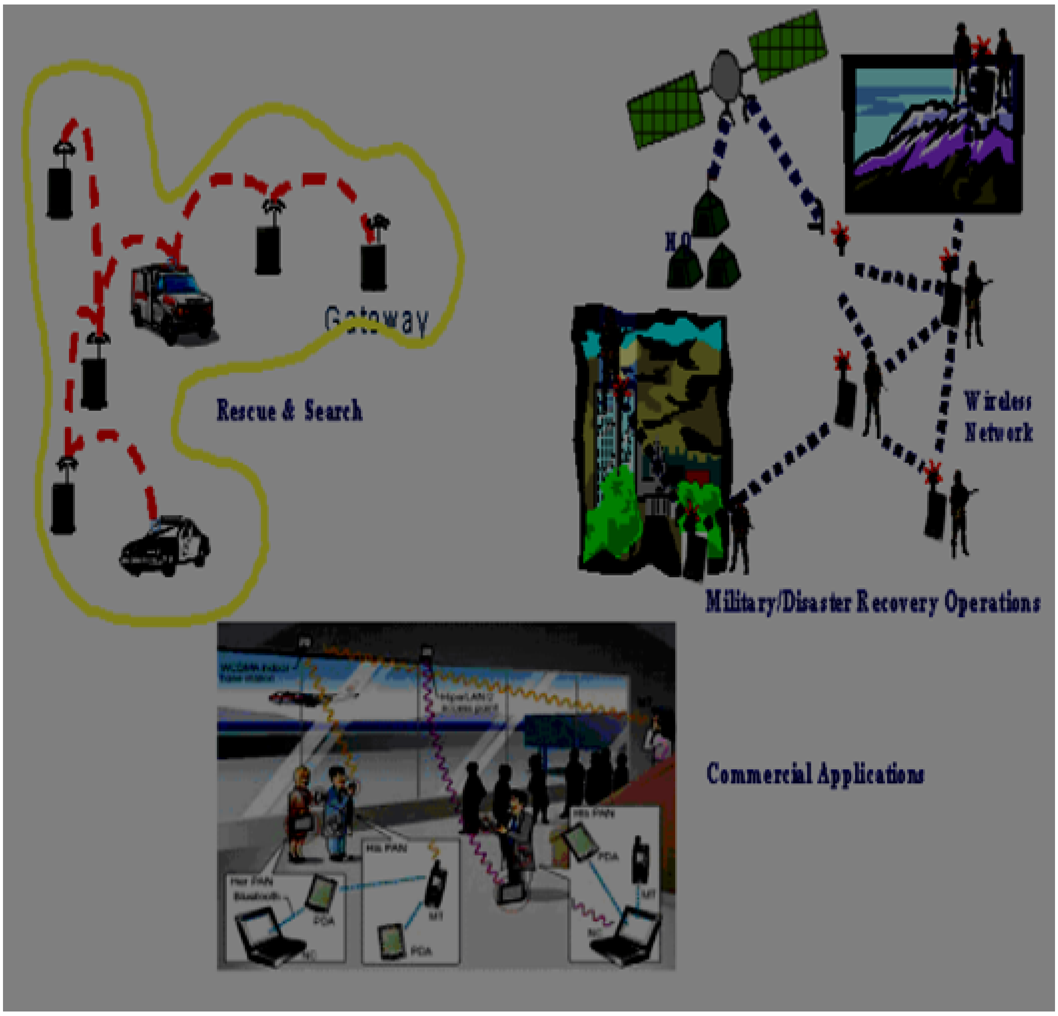


Figure 2.2. Examples of MANET application [24].

As depicts in the above figure Mobile ad hoc network is applicable in different areas from those (military battlefield) Ad hoc networking would allow the military to require advantage of commonplace network technology to assert an information network between the sol-diers, vehicles, and military information headquarters. The crucial techniques of ad hoc network came from this field, (commercial sector and rescue and search) Information is relayed from one rescue team member to a different over a little hand-held. Alternative commercial situations include e.g. Ship-to-ship ad hoc mobile communication, law enforcement.

2.4 Challenges in MANET.

As already expressed, the particular characteristics of MANETs impose several challenges to network protocol designs on all layers of the protocol stack [9]. The physical layer should deal with fast changes in link characteristics. The media access control (MAC) layer must permit honest channel access, minimize packet collisions and deal with hidden and exposed terminals. At the network layer, nodes need to get together to calculate ways. The transport layer should be capable of handling packet loss and delay characteristics that are very totally different from wired networks. Applications ought to be ready to handle possible disconnections and re-connections [9]. The following are challenges of MANET [8] [6].

- Power-constrained and operation: Some or all of the nodes in a Manet might rely on batteries or alternative exhaustible means that for their energy. For these nodes, the foremost necessary system design criteria for improvement is also energy conservation. For many of the light-weight mobile terminals, the communication-related functions ought to be optimized for lean power consumption. Conservation of power and power-aware routing should be taken into consideration. I.e. mobile nodes have short battery lifespan and restricted capacities.

- Security and Reliability: In addition to the common, vulnerabilities of wireless connection, an ad hoc network has its explicit security issues. e.g. nasty neighbor relaying packets. The feature of distributed operation asks totally different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability issues, because of the restricted wireless transmission range, the broadcast nature of the wireless medium (e.g. covered terminal problem), mobility-accelerated packet losses, and data transmission errors. Mobile wireless networks are generally a lot of at risk of physical security threats than are fixed-cable nets. The raised risk of eavesdropping, spoofing, and denial-of-service attacks ought to be rigorously considered.

– Education: Universities and field settings, Virtual school rooms, ad hoc communications throughout conferences or lectures.

– Dynamic topology: Nodes are liberated to move arbitrarily; so, the configuration that is typically multi-hop, might change randomly and quickly at unpredictable times, and may consist of each duplex and one-way links.

– Routing: Since the topology of the network is continually ever-changing, the issue of routing packets between any try of nodes be-comes a difficult task. Most protocols ought to be based on reactive routing rather than proactive. Multicast routing is another challenge as a result of the multicast tree isn't any longer static because of the random movement of nodes inside the network. Routes between nodes could probably contain multiple hops, that is a lot of complicated than the only hop communication.

– Bandwidth-constrained-variable capability links: Wireless links will continue to have considerably lower capability than their hard wired counterparts.

– Diffusion hole problem: The nodes set on boundaries of holes might suffer from excessive energy consumption since the geographic routing tends to delivers data packets on the hole boundaries by border routing if it needs to bypass the hole. This could enlarge the hole attributable to excessive energy consumption of the node boundaries.

– Quality of Service (QoS): Providing completely different quality of service levels in an exceedingly in a dynamic atmosphere are going to be a challenge. The inherent random feature of communications quality in a Manet makes it troublesome to supply fixed guarantees on the services offered to a tool. An adaptive QoS should be implemented over the traditional resource reservation to support the multimedia system services. By considering special properties and challenges of Manet a lot of routing protocols is proposed to overcome those challenges and issues [10].

A routing protocol for MANET ought to be distributed in manner so as to extend its reliableness. A routing protocol should be designed considering simplex links as a result of wireless medium might cause a wireless link to be opened in simplex only because of physical factors. The routing protocol ought to be power-efficient. The routing protocol ought to take into account its security. A hybrid routing protocol ought to be much more reactive than proactive to avoid overhead. A routing protocol ought to be aware of Quality of Service (QoS).

2.5 MANET Routing Protocols

Routing is that the key challenges in this moon-faced in network layers of MANET as we tend to expressed within the above section because of the challenges of MANET such as routing, dynamic topology of network, mobility and so on. A routing protocol is required whenever a packet needs to be transmitted to a destination via variety of nodes and various routing protocols are proposed for such reasonably ad hoc networks [12]. In order to determine effective and efficient route between any two nodes routing protocol is required. A routing protocol activities is involves in two phases. Initial realize best path and second deliver the packet to the right target node. Generally routing protocols in MANET while depending on the routing strategy will be classified in to three types as Table Driven (proactive), On-Demand (reactive) and Hybrid routing protocols. And based on the network structure it will be classified as flat routing and hierarchical routing [13].

2.5.1 Table-Driven routing protocols (Proactive)

These protocols also are referred to as as proactive protocols since they maintain the routing information even before it's required. Every node within the network maintains routing information to each alternative node within the network. Routes data is mostly unbroken within the routing tables and is periodically updated as the configuration changes. Several of those routing protocols return from the link-state routing. There exist some variations between the protocols that come beneath this class depending on the routing information being updated in every routing table. What is more, these routing protocols maintain completely different variety of tables. The proactive protocols aren't appropriate for larger networks, as they have to take care of node entries for every and each node within the routing table of each node. This causes additional overhead within the routing table resulting in consumption of additional bandwidth [13]. DSDV, OLSR, FSR, WRP, CGSR are a number of Table driven or proactive routing protocols in MANET.

Advantages of Table-Driven or proactive routing protocols : The advantages of proactive routing protocol is nodes will simply get routing information and it is easy to determine a session and information is usually available with less latency within the network.

Dis advantages of Table-Driven or proactive routing protocols : The disadvantage is simply too much information keep by the nodes for route maintenance and it's slow to restructure when there's a failure in a specific node link and there's high communication overhead, routing information is flooded within the whole network.

2.5.2 Reactive (On-demand) routing protocol

Reactive Protocols use a route discovery process to flood the network with route Source routing uses data packet headers containing routing information meaning nodes don't need routing tables; however, this has high network overhead. Distance vector routing uses next hop and destination addresses to route packets, this requires nodes to store active routes information until no longer required or an active route timeout occurs, this prevents stale routes. Flooding is a reliable method of disseminating information over the network, however it uses bandwidth and creates network overhead, reactive routing broadcasts routing requests whenever a packet needs routing, this can cause delays in packet transmission as routes are calculated, but features very little control traffic overhead and has typically lower memory usage than proactive alternatives, this increases the scalability of the protocol query requests when a packet needs to be routed using source routing or distance vector routing [14]. AODV, DSR, TORA, CBRP, DYMO are some examples of reactive routing protocol.

* Cluster Based Routing Protocol (CBRP)

  Unlike those other On-demand routing protocols CBRP organized the nodes in hierarchy. The nodes in CBRP are grouped in to clusters. Each cluster has a cluster head, which coordinates the data transmission within the cluster and to other clusters. The advantage of CBRP is that only cluster heads exchange routing information, therefore the number of control overhead transmitted through the network is far less than the traditional flooding methods. The protocol suffers from temporary routing loops. This is because some nodes may carry inconsistent topology information due to long propagation delay [15].

Advantages of reactive routing protocol : The advantages of reactive routing protocol is there's low communication overhead than proactive routing protocol, and it's free from loops then the path is available when required.

Dis advantages of reactive routing protocol : The main disadvantages of reactive routing protocol there is high latency in the network.

2.5.3 Hybrid routing protocol

These protocols attempt to incorporate numerous aspects of proactive and reactive routing protocols. They're generally used to give hierarchical routing; routing generally can be either flat or hierarchical. The issue of all hybrid routing protocols is a way to organize the network according to network parameters. The common disadvantage of hybrid routing protocols is that the nodes that have high level topological information maintains additional routing information, that results in a lot of memory and power consumption. Some samples of Hybrid Routing Protocols include CEDAR, ZRP. In what follows, we present a few of the proposed routing protocols from every category developed for the ad hoc networks. The most important protocols and those which dominate recent literature are AODV, DSR, SRP, ZRP, DSDV and TORA [15].

2.6 Flat structure routing

In a flat structure, all nodes within the network are within the same hierarchy level and thus have identical role. Though this approach is efficient for tiny networks, it doesn't permit the scalability when the quantity of nodes within the network large. In massive networks, the flat routing structure produces excessive information flow which might saturate the network [17]. When the network size will increase especially in face of node mobility as well, due to link and process overhead. Samples of Flat routing protocols are AODV, DSR, DSDV, etc.

2.7 Hierarchical structure routing.

When we see MANETS based on flat structure routing there's scalability problem, so as to solve this problem hierarchical structure is proposed by different Manet researchers. It's dividing the network in to teams known as clusters. This results in a network in hierarchical structure [17]. To build hierarchy is to cluster mobile nodes geographically each other one another into explicit clusters and assign different functionalities to mobile nodes within and out of doors a cluster. In a cluster structure, mobile nodes could have different cluster-related status or function, like cluster head (CH), cluster member (CM) and cluster gateway (CGW). A mobile node designated as a CH is the coordinator for its cluster, and its ID is usually used to identify the corresponding cluster and it's designated based on specific metric or based on combined metric like identity, degree, mobility, distance, density. A CGW is a non-CH node that either belongs to two or additional clusters or can directly connect to some non-CH node residing in a different cluster. A CM is a non-CH node of a cluster with none inter cluster links. Routing based on this type of cluster structure is taken into account as cluster-based routing [16]. In clustering the routing information is transmitted through restricted nodes based on the cluster status. Mobile nodes that participating during routing is cluster head and cluster gateway as well as the supply and destination node. I.e. RREQ flooding is between the cluster heads instead of flooding between all member nodes. The cluster based routing protocol will increase scalability of mobile ad hoc network, reduces RREQ flooding overhead, will increase routing efficiency.

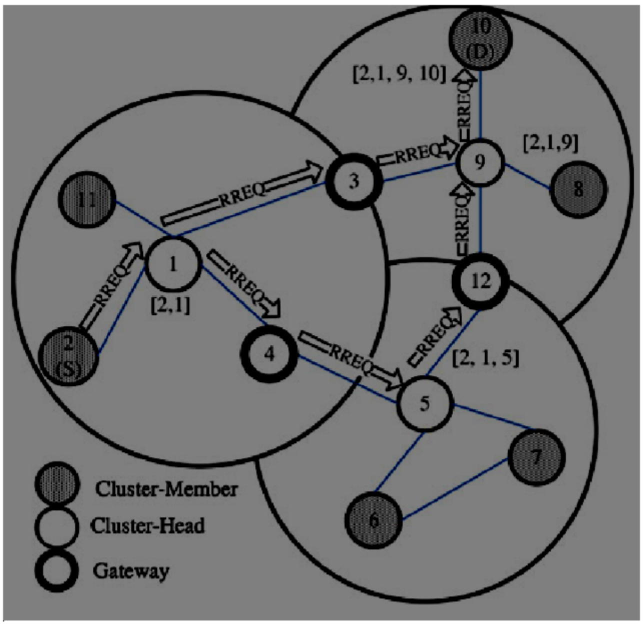


Figure 2.3 Examples of RREQ flooding in clustering

In the above figure RREQ flooded from the supply node to the destination through the cluster head and gateway. If supply node and destination node isn't two hopes away from the supply node send RREQ request to the cluster head. Gateway node receive RREQ request and forward to the next cluster head. And if the supply node and destination node is exist within the same cluster member, supply node broadcasts RREQ request to the cluster head and cluster head send to the destination node. Since, they're within the same cluster member.

A cluster-based routing scheme consists of two major parts: The cluster algorithmic program and the routing algorithm. The cluster scheme discusses how to form and maintain a cluster structure in a dynamic MANET. The routing scheme discusses how to discover and maintain routes on the top of the cluster structure [16]. An earlier CBRP cluster algorithm relies on LID and LCC. Throughout cluster head choice consider only unique ID of node and LCC. This algorithm isn't efficient for cluster head choice and the performance of MANET is poor. As a result of throughout cluster head choice doesnt consider the other ability of node. So as to enhance the performance of MANET several researchers develop different algorithms. To enhance the performance of huge scale network on demand routing protocol is most popular. The algorithms developed for cluster head choice in MANETs are Lowest-ID, Highest-Degree, Distributed cluster algorithm, Weighted cluster algorithm (WCA) and Distributed Weighted cluster algorithm (DWCA) [17].

2.8 Mobility models

MANET is an autonomous ad hoc wireless networking system consisting of independent nodes that move dynamically and alter network connectivity. The mobile nodes acts as like router and host the presence of mobility makes MANET is difficult to design and implement within the reality. Mobility models is employed to control the movement and activity of mobile nodes in ad hoc network. In MANET mobility model is employed to manage rate of node, speed of node and location of node. It is a key attributes of mobile ad hoc network and the performance of MANET required to review with the presence of mobility. Many cluster-based algorithms for the MANET topology generation have been proposed over time, but it's clearly shown that the mean cluster member (that is, range of mobile nodes) below any transmission ranges, chance of a node remaining in a cluster, or node duration in a cluster decreases with the rise in speed of mobile nodes [26]. The descriptions of mobility model in [26] the possible approaches for modeling the mobility patterns are two types. In trace the mobility patterns are observed in real life, everything is settled. The syntactical mobility models can also be classified based on the description of the mobility patterns in ad hoc networks. And it's classified within the two mobility patterns. Individual mobile movement: Mobility models attempt to the anticipate Mobile's traversing patterns from one place to another at a given point of your time below various network scenarios. Every node moves independent of one another. Group mobile movement, assumes that one node affects the movement of another node additionally to that mobility models try to characterize the groups traversing patterns with individualism averaged. Group-based mobility models, individual nodes movement is depended on the movement of close-by nodes. The mobility model is used to identify the parameters of mobile nodes such as speed, pause time, direction, and velocity, those parameters is varied based on the categories of mobility models. The main goal to use mobility model is clustering with considering mobility of mobile node is better than without considering the mobility of node. Since mobile ad hoc network is move in and out. There is also variety of mobility models that described represented for various functionality. This paper address on the given mobility model and to intend a better models for mobile ad hoc, and for clustering.

2.8.1 Random Walk Mobility

RW mobility model is an individual mobility model, this mobility model is the most typical in mobile ad hoc network. Mobile node moves from one location to another location randomly, the direction and speed of node at any given time are random. The next movement here is totally independent of the past movement and hence there aren't any bounds enforced on the max deflection that the nodes can take up for his or her next movement, and this randomness in selecting the longer term direction vector delivers this type of motion completely unpredictable. The random walk represents a mobility model that tests the movement of entities around their beginning points without care of the entities wandering away and never to come. These properties produce a less complicated mobility modeling from a mathematical point of view, which can be solved through markov processes and chains, but generally an unrealistic approach in users movement generating a non-realistic movement for every MN, with sharp turns, sudden stops, and sudden accelerations.

2.8.2 Random way point

This mobility model has been wide utilized in mobile ad hoc network. This mobility model is easy and straightforward random model. In RWP , a mobile node moves on a finite continuous plane from its current position to randomly location by indiscriminately selecting its destination coordinates, its speed of movement, and also the quantity of time that it'll pause when it reaches the destination. On reaching the destination, the node pauses for a few time distributed according to some random variable and the process repeats itself. Once the pause time expires, the node picks out a new destination, speed, and pause time. The movement of a node from the beginning position (waypoint) to its next destination (waypoint) is defined as one movement epoch, movement period, or transition time. The gap traveled between the movements of a node from the beginning waypoint to its next waypoint is defined as transition length. Destination points (waypoints) are uniformly randomly choosen within the system space. In general, it's the most common mobility model in mobile ad hoc network as a result of the node moves at constant speed or not moving in any respect, and it's a lot of preference to predict the mobility of the mobile node.

2.8.3 Autoregressive Mobility Models

The autoregressive (AR) mobility model makes the actual realistic mobility patterns of individual nodes correlating the mobility states that may consist of position, velocity, and acceleration at the consecutive time instants. The AR group mobility (ARGM) model creates the cluster mobility behavior considering correlation among node mobility states. This model can groups the presence of teams among the nodes of a network by activity a correlation index check on the node mobility states. The group estimation scheme can significantly scale back the number of data collection needed to track nodes exhibiting group mobility in mobile ad hoc networks.

2.8.4 Random point group mobility model

In our proposed system we tend to use reference point group mobility model. RPGM model is used to predict the random movement of a group of mobile nodes as well as the random movement of individual mobile nodes. RPGM is employed in 2 network situations, clustering and routing. It's used to understand the relations of mobile nodes that move together. The movement of the mobile node for every group and the random motion of every individual mobile node inside the group are implemented via the random waypoint mobility model. Generally RPGM is used to know the group movement behavior of mobile ad hoc network nodes.

Chapter 3

RELATED WORK

3.1 Introduction

Mobile ad hoc networks are applicable in different areas and are hot research issues due to their limited battery constraints, RREQ flooding, limited bandwidth and network scalability. Many researchers do various methods to offer effective and efficient clustering, to maximize the lifetime of network. Different clustering algorithm can improve the lifetime of network. By creating stable and optimal clustered network and by selecting optimal CH and gateway node in a cluster. Those existing clustering algorithms have their own advantages, and disadvantages. In this section, we try to document some clustering algorithms that are developed by many researchers with their strength and limitation.

Lowest id clustering (LID) algorithm

Authors in [18], The lowest id clustering (LID) algorithm it is an algorithm each node is assigned a unique id, and the node broadcasts a hello packet including id, a node with the lowest id is chosen as cluster head. The drawback of this algorithm is considering one performance factor it reduces the performance of network, because the id is assigned arbitrarily without considering other performance metrics of a node, and it is prone to power drainage due to the cluster head is used for a long time, and this algorithm doesnt consider stability of node and the re-election of cluster head affect the cluster structure, increases overhead during re clustering and does not consider optimal node distribution for each CH based on energy. Because the node id is do not change within a long time. The advantages of this algorithm is the selection of cluster head is simple, and there is no clustering overhead during cluster selection algorithm. It is not a preferred method as here the lowest minimum identifier is elected as a CH. Since the lowest identifier is used. It results in high battery consumption. Since MANETs have limitations on battery usage, this algorithm results in short lifetime of devices of the system.

Highest connectivity clustering (HCC)

Authors in [18], Proposed highest connectivity clustering (HCC) algorithm the node which has the highest neighbors is selected as a cluster head, and it is computed based on distance from others. The limitation of this algorithm is if the cluster member is greater than upper bound or if the member is high the throughput is decreases. Because the number of node is high it will increase the load of cluster head, and it increases network overhead, there is no re-election of cluster head and this algorithm is considering only one performance factor to calculate quality of nodes for a cluster head, it reduces network performance and load of network increases due to single cluster head.

K-CONID

According to [2] the author reviewed several literatures from those K-CONID algorithm combines two clusters algorithms those are LID and HCC. During cluster head selection, connectivity is the first criterion and lowest id is the second criterion. In this algorithm if the node have the same connectivity, the cluster head is selected based on id. The drawback of this algorithm the performance factor to calculate the ability of node to select as cluster head is not efficient.

Max-Min d-cluster formation algorithm

In Max-Min d-cluster formation algorithm [19] the performance metrics in this algorithm considered is size of the cluster. This algorithm is developed to overcome the limitation of LIC, generalizes the cluster definition to a collection of nodes that are up to dhops away from cluster head. The limitation is how to select the value of d is not specified, performance metrics such as mobility, load balancing does not consider during cluster head selection and stability of network is less.

WCA(weighted clustering algorithm) According to [20] this algorithm is used multiple performance factor for calculating quality of node to select as a cluster head, uses mobility, battery power, node degree and distance or degree difference to calculate combined weight and chooses the smallest combined weight nodes as a cluster head this is called The objective of WCA is to select cluster head which is not biased towards a specific performance metrics, so selecting cluster head by considering more than one performance metrics improves performance of network and increase stability. The limitation of this algorithm is to calculate the average combined weight there is more overhead, delay and the difficulties of WCA is to know the combined weighted of each node. I.e. First each mobile node computes it's individual parameter value, and then they must compute average weight value.

Mobility Based Metric for Clustering (MOBIC)

According to [21], Mobility Based Metric for Clustering (MOBIC): In this algorithm proposes a local mobility metric for a cluster formations process. First, the pair wise relative mobility metrics is computed and then aggregate relative mobility metric is computed before sending the next broadcast packet to its neighbors. In hello message every node broadcasts it's own mobility metric to its 1-hop neighbors, and it is stored in the neighbors table of each neighbor with a timeout period. In such a way, every node receives the aggregate mobility values from its neighboring nodes, and then compares its mobility value with those of its neighbors. Moreover, clusters are formed in such a way that, mobile nodes with low speed relative to their neighbors have the chance to become cluster heads. The difference between MOBIC and LIC it uses mobility metric for cluster formation instead of ID information. The advantages of this algorithm is it increases stability of network. Since MANET is dynamic by nature but this algorithm considers mobility metrics of mobile nodes.

Mobility-based d-Hop Clustering algorithm (MobDHop)

According to [22], Mobility-based d-Hop Clustering algorithm (MobDHop) estimates the stability of clusters based on relative mobility of cluster members, and the diameter of cluster is flexible. In this algorithm nodes which have similar moving pattern is grouped in one cluster. The author proposed two mobility metrics based on relative mobility: (a) variation of estimated distance between nodes over time and (b) estimated mean distance for cluster, in order to measure the stability of a cluster. Those two metrics are used to decide the member of nodes in one cluster. The advantages of this algorithm is used to create stable cluster in a given network and minimize number of clusters by considering group mobility pattern. The limitation of this algorithm is optimal clustering may not be achieved in the network and optimal number of nodes are not considered in one cluster. I.e. if high number of nodes moves in the same direction they can be grouped in the same cluster, it reduces throughput.

Node Based Cluster Routing Algorithm (NBCRA)

According to [23], Node Based Cluster Routing Algorithm (NBCRA) this algorithm takes four parameters to calculate the ability of node (degree of node, battery power, transmission power and stability of node) and the node having a maximum ability is elected as cluster head. The strong points of this algorithm is have a better performance than WCA. The limitation of this algorithm is there is no backup node which acts as a cluster head when a cluster head is fail, or moves out from the cluster.

Optimized stable clustering algorithm (OSCA)

According to [3], optimized stable clustering algorithm (OSCA) a cluster head is selected by calculating the combined weight or WCA, a node having the smallest combined weight is cluster head and the cluster maintenance has done by priority factor. The priority factor is done by node degree, and remaining battery. The limitation of this algorithm is there is overhead during calculation of combined weight, and election of backup node is not efficient. And optimal member node that a cluster head can handle is not limited.

3.2 Summary

In this chapter, we have reviewed related works that have been done by different researchers on enhancing CBRP, to create stable MANET networks. They have touched several perspectives like, by considering single performance metrics, and multiple performance metrics and by considering cluster head selection and cluster maintenance criteria. From this LID, MOBIC, MOBDHOP and HCC is an example of single performance metrics consideration. And NBCRA, WCA, OSCA are an example of multiple performance metrics from those some of the algorithm they haven't BCH. But none of them consider network overhead during cluster formation, node mobility direction, residual energy of each cluster head to select BCH and limitation of number of member nodes to reduce energy consumption during inter cluster and intra cluster communication. In our proposed work CBRP protocol is improved by using parameters residual energy of node, optimal node degree (the number of member nodes that a cluster head can handle), and mobility of node (speed and movement direction of each node). In general to make the number of member nodes optimum is used to avoid MAC layer protocol problem, and low energy consumption during inter-cluster and intra cluster communication. And communication overhead during cluster formation has significant impact on performance of network.

The summary of related works we have covered above is summarized in the following table.

Table 3.1 Summary of related works.

Authors and year	The algorithm they used	Limitation
M. Gerla and J. T. Tsai, 1995	LID: clustering algorithm for MANET	It considers only single performance metric, it degrades network performance. Because node they do not consider other performance metric
M. Gerla and J. T. Tsai, 1995	HCC: clustering algorithm for MANET	like LID, HCC degrades network , performance because doese not consider other performance metrics
Tamil Nadu 2014	KCONID clustering algorithm for MANETs	The performance factor to calculate the ability of node to select as cluster head is not efficient.
A. D. Amis, R. Prakash, T.H.P Vuong, Huynh, 2000	Max-Min d-cluster formation algorithm	Performance metrics such as mobility and load balancing is not considered, and it is not clear how to calculate d.
A. H. Networks, Chatterjee, S. K. Das, and D. Turgut 2002	WCA clustering algorithm for MANET	There is communication overhead during calculation of combined factor.
S.Talapatra and A. Roy, 2014	MOBIC clustering For MANET	They do not consider the load balance between cluster head node

W. K. G. Seah, 2004	Mobility-based d-Hop clustering algorithm For MANET	If high number of nodes moves in the same direction they can be grouped in in the same cluster, it reduces throughput.
C. Uikey 2013	NBCRA clustering algorithm For MANET	Re affiliation and communication overhead
S. Pathak, 2017	OSCA: clustering algorithm For MANET	Communication overhead during calculation of combined parametres and backup node priority factor is not efficient

Chapter 4

PROPOSED SOLUTION

4.1 Introduction

Mobile ad hoc network contains mobile nodes that change their locations through time. Mobile nodes move in and out from the network. Performance of MANET network can vary within different mobility models. And the relative changes in speed, and direction of mobile nodes causes topology changes of mobile ad hoc network. The stability of nodes in clustering is decrease with the increase in speed of mobile node and with the decrease energy of node. Because of this the clustering should take in to consideration mobility behavior and direction of each node and residual energy of node with respect to each neighbors to create stable network. As described in chapter three current clustering mechanism to select cluster head is not efficient. I.e. the existing clustering algorithm does not consider the overhead generated during combined weight calculation and the impact of member nodes in a given network. The number of nodes in a given cluster must be optimal to minimize energy consumption, and to maximize the network throughput. The study aims to improve cluster based routing protocol through optimal cluster head selection. In our proposed solution we use different performance metrics for CH selection such as residual energy of node and degree in centrality. And we use relative mobility, distance between the CH and member node, and we try to balance the load of the CH based on energy. We are to going in detail how to calculate those metrics. In general our proposed algorithm deals with node stability as well as link stability and both inter cluster and intra cluster management.

4.2 Topological architecture

Topological architecture of our system contains cluster head, backup cluster head, member node and gateway node. Cluster head is a mobile node which is selected based on the parameters we used and it acts like a manager, backup cluster head it is second cluster head it replaces cluster head when cluster head fails due to some reasons backup cluster head replaces cluster head. The advantages of backup cluster head there is no re clustering. The data packet is flows from member node to cluster head. Gateway node is sensed two or more cluster head. In general the topological architecture of our proposed system looks like this.

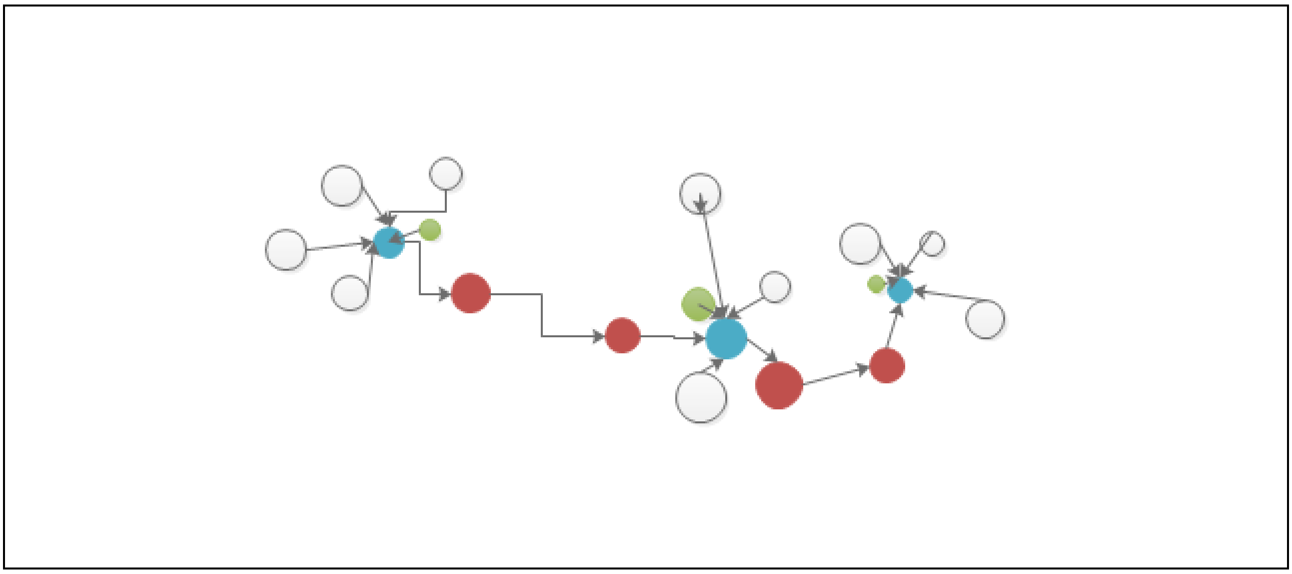
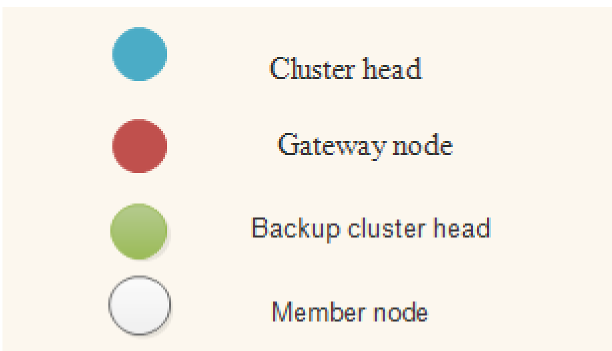


Figure 4.1. Topological architecture of the proposed clustering algorithm



Cluster head selection, and cluster formation is a big task because it depends on the size of network, number of nodes and types of application.

4.3 Proposed work

In infrastructure less network (MANET) are located anywhere, and a flat structure network encounters network scalability problem with large network size, especially with low battery power and high-speed of mobile nodes. In MANET when network size and number of nodes exceeds its optimal value reduces network performance, and there is high energy consumption during cluster head selection. The major challenges to create energy efficient and optimal cluster head selection algorithm is related to the consideration of parameters that used to select cluster head.

In this section, we discuss on the new algorithm that we proposed based on the gap identified in the statement of the problem. CBRP protocol has certain number of clusters and there is special node called cluster head that is responsible for reviving data from member node and will pass to the gateway. To improve CBRP by using algorithm for cluster formation and cluster maintenance. During cluster formation a CH is selected by using degree in centrality or residual energy of mobile node and a member node is join to this CH based on their distance and relative mobility until it reaches its optimum number of node. During cluster head selection degree in centrality is the first criterion and residual energy is second criterion. If mobile node have the same degree centrality the cluster head is selected based on residual energy.

Metrics are parameters used to know the ability of node to improve cluster formation and cluster head selection algorithm. In multiple performance metrics single performance metrics is used. And during cluster formation, CH selection and cluster maintenance we use different performance metric to improve performance of the protocol. Since our proposed work is focused on how to form our clustered network and how to select optimal cluster head. So we going to discuss how those parameters are calculated in MANET.

Parameters that we consider during cluster head selection

4.3.1 Residual energy of node

Energy model is used to find the energy level of each individual node. Residual energy is the metrics we used to improve the performance of CBRP protocol. Residual energy is the remaining energy of a node after performing process. The remaining energy is essential to increase the lifetime of the node in MANET. Residual energy of node means the power left in node. Nodes consume energy while they are transmitting RREQ or HELLO message to neighboring nodes for the purpose of detecting their existence or for selecting cluster heads. When an intermediate node selected as cluster head, it consumes more energy than node in idle state. The nodes residual energy is important parameter to select best cluster head. Nodes residual energy is calculated based on nodes initial energy and energy consumed by nodes for transmitting, sending, receiving and forwarding packets between source and destination nodes and for cluster head selection communication.

Residual_ energy=E_ initial - Energy_ consumed.................eqn(4.1)

Where Residual_energy stands for residual energy of nodes, E_intial stands for intial energy of node Energy_consumed stands consumed energy. Consumed energy is energy consumed by nodes for transmitting, sending, receiving and forwarding packets between them. Nodes consume energy for receiving, for sending and nodes consume energy in idle state. In general energy consumed is the summation of all those energy consummation of node activities.

4.3.2 Degree centrality

Degree in centrality refers to the number of neighbors to the node. It is one of the Parameters that we consider during cluster head selection, it is number of neighbors to the node. In our work we consider which node is with the highest degree. In other word, the node having the highest degree is located at the center. Degree in centrality is the number of neighborhood of node n, and we can compute as follows.

$$d(v) = N.$$

$$N\_- > (n, distance(v, vi) < R)$$

Where d(v) stands for degree centrality, node n is mobile node, distance (v,vi) is the distance between two mobile nodes, R is transmission range, and N stands for Neighborhood.

After the cluster head is selected the next process is answer the question of how member node is join to the cluster. Several algorithms has been proposed that used to form the cluster. According to our knowledge our algorithm is the first algorithm that tries to create stable cluster by using distance, and relative mobility behavior of each node (speed, and direction of node). The average number of mobile nodes that handle by each cluster head decided based on distance and mobility behaviors of each node till it reaches its maximum value- based on energy levels of the cluster head.

4.3.3 Parameters that used to group mobile nodes

The following metrics are parameters used to know which mobile node is a member of a specific cluster head.

4.3.4 Relative mobility

Speed of node is the movement of node. Due to the mobile nature of node the node in and out from the network. Mobility is the combined functions of movement patterns of node, relative mobility of node, movement direction and a node have the same relative mobility, speed and direction with CH is best to become the same cluster member. To overcome the problem that is faced by mobility we consider mobility behavior of node. It is one metrics used to form stable cluster member.

4.3.5 Distance of mobile node

Distance is one parameter that we used to create clustered network. Distance between mobile nodes is calcualted by using euclidean distance formula between the node i and j. Since, in mobile ad hoc network node i and j cordnates of daynamic topology is created.

Distance $->$ sqrt (((xi-xj) *(xi-xj)) + ((yi-yj) *(yi-yj))).............eqn(4.3)

Generally, in our system each cluster head knows how many clusters is available in the given network. During member joining every node broadcasts a hello message to know the mobility behavior, the CH and its members and to know link status. When cluster head fails the backup node replace the cluster head and do the tasks of the cluster head, during this period, the backup node sends a hello message within its own cluster head ID informing to other CH a new cluster head is selected and the old CH is replaced. That a cluster head can handle to manage in a given network to limit the minimum and maximum number of members in a cluster this reduces the energy consumption and to utilize bandwidth properly.

4.4 Optimal number of node in a cluster member

The life span of network is increased by distributing the load based on energy among all CH. Optimal number of node is used to reduce the energy consumed in side a cluster or reduce the communication between a cluster head and member node. And optimal cluster is used to reduce the energy consumed during inter cluster communication and minimize routing overhead. In general optimal number of node is used to increase throughput of node. And optimal number of node degree is used to avoid MAC layer problem. Since if the number of nodes in a cluster increase the network performance and throughput of node decrease. Since we calculate optimal number of nodes in a given cluster based on energy model. Mobile ad hoc network is represented as an-undirected graph G (Vi, Ej) where Vi represents a set of vertex (set of mobile nodes) and Ej represents a set of edges or links connecting to other nodes.

$$Copt < -(|\ \alpha\text{-}deg(vi)\ |)/deg(vi))..................eqn(4.2)[25]$$

Where Copt stands for optimal member node, α=2 $* ln(n), n$=| V |

$Inotherwordsitissetofmobilenodes.//$

4.5 Flow charts of proposed clustering algorithm

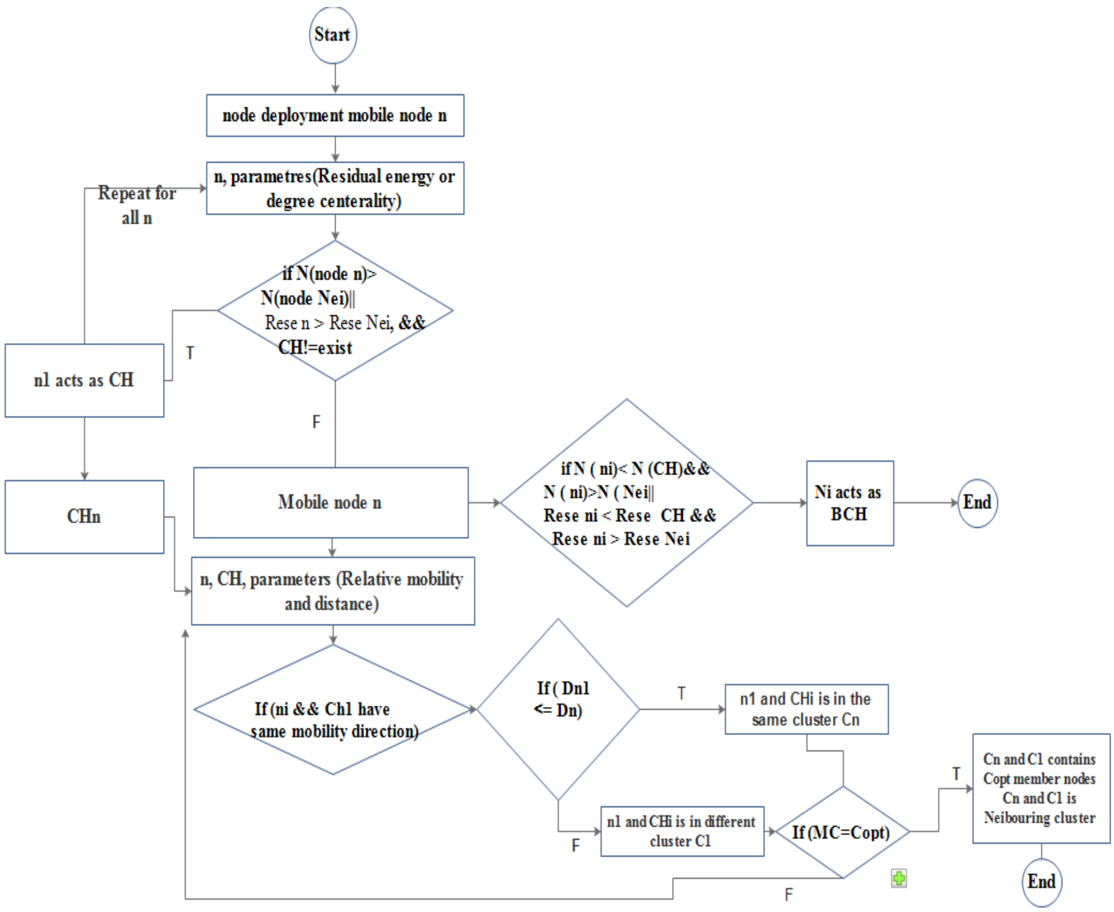


Figure 4.2. Flow charts of proposed clustering algorithm.

Figure 4.2, shows the flow charts of the proposed algorithm. First mobile node is deployed and considers parameters to assign cluster head. After that, CH is selected, if it has high degree in centrality or residual energy. After CH head is selected member node joins to a specific CH based on the parameters that clearly shows in the figure above. Mobile node joins to the CH until it reaches its optimal value.

4.5.1 Proposed algorithm

Algorithm 1 : For cluster formation

Input:

(i) initial energy,

(ii) node n,

(iii) R(transmission range),

(iv) position of node,

(v) node n,

(vi) Distance,

(vii) $\alpha, deg(vi)$.

$Output : clusterhead, backupclusterhead, andclusterednetwork.$

1. For i < − to every node
2. **WHILE** node is not neighbor **do**
3. compute its residual energy, distance and N(node n)
4. N_(node n)− > (node n, distance(v, vi) < R)
5. Residual_energy_N − > initial_energy_N-Energy_consumed_N
6. Distance − > sqrt (((xi-xj) *(xi-xj)) + ((yi-yj) *(yi-yj)))
7. END WHILE
8. Node n broadcasts a hello message to all its neighbor nodes with its residual energy and N(node n)
9. Each node compare the value of Residual energy with neighbor
10. IF(N_(node n)> N_(neighbor)‖ Residual_energy_n > Residual_energy_Nei&& CH=exist)
12. Declare it self as CH
13. END IF
14. IF(N_(node ni)< N_(CH)&& N_(node ni)>N_(Nei)‖ Residual_energy_ni < Residual_energy_CH && Residual_energy_ni > Residual_energy_Nei)

```
15.             Declare it self as BCH
16.         ELSE
17.             Mobile node.
18.         END IF
19. END FOR
20. Each node broadcasts a hello message //to know the mobility behavior of each node.
21. FOR i <- to every node
22. Each CH calculates optimal member node // ideally a CH can handle
23.         Copt <- (| α-deg(vi) |)/deg(vi))

24.         IF(ni && Ch1 have same mobility direction)
25.         IF(Distance_n1 <= Distance_n)
26.             ni is member of CH1
27. Until member node == Copt
28.         ELSE
29.             ni doesn't member of CH1, it performs with other ni nodes
30.           END IF
31.         END IF
32. END FOR
33.         IF(node N1 is neighbor of two or more CH && Distance_ni <= Distance_n)
34.             Declare it self as gateway node
35.         END IF
36. END
```

4.5.2 Algorithm description

At line 1 and 2, tells the execution is repeated for all node n until the mobile node n is neighbor node. From line 5-7 node n computes its residual energy, distance and N(node n), at line 8 the while loop is end. At line 9 node n broadcasts a hello message to all its neighbor nodes with its residual energy and N(node n). Line 11 and 13 each node compare the value with neighbor and if it has the first large value it acts as CH and if it has the second large value it acts as BCH. Line 18 tells executing if the first condition is not satisfied it is a mobile node until the member is join to the CH. When we look line 20, 21, and 22 ends the else, if condition, and for loop respectively. At line 23 a node broadcasts a hello message to tell the mobility rate of each node to its neighbor. At line 24, tells the execution is for all node and at line 25 each cluster head calculates its optimal member node based on energy model to restrict its member node by using the formula. When we restrict the number of nodes to be handled by the cluster head is used to avoid MAC layer problem or it does not have degraded the MAC functioning. At line 27 and 28 check the relative mobility behavior of ni and Ch1 within specific distance respectively. if the condition at line 27 and 28 ni is member of CH1 until member node is equal to Copt. Due to mobility of node or battery drainage a cluster head leave the cluster or die. At this time backup node take responsibilities of cluster head and select its backup node by using priority factor in the next algorithm. Line 31 executes else condition. Line 33, 34, 35, and 36 end else condition, if condition, if condition and for loop respectively. Line 37 checking other conditions to select gateway node. And the node which hears two or more cluster head is considered as gateway node.

4.5.3 Cluster maintenance

In order to reduce re clustering cluster maintenance algorithm is needed. Cluster maintenance algorithm is used to avoid the immediate call of cluster formation algorithm. Instead of this the backup node elect a new backup node by calculating the priority factor. Cluster maintenance or backup cluster head selection algorithm is performed by CH.

Algorithm 2 : For cluster maintenance

Input:

(i) CH,

(ii) node n,

(iii) residual energy,

(iv) speed

Output:Backup cluster head.

```
 1.  If (CH && n is in the same cluster)
 2.  compute priority factor of CH, n and n1
 3.         CH_PF < − Residual_energy_CH − speed_CH
 4.          n_PF < − Residual_energy_n − speed_n
 5.          n1_PF < − Residual_energy_n1 − speed_n1
 6.  If (CH_PF >n_PF)
 7.  If (CH_PF > n1_PF)
 8.          CH is CH
 9.  ELSE
10.          n1 is CH
11.      END IF
12.  END IF
13.  If (n_PF > n1_-PF )
14.         n is CH
15.  ELSE
16.          n1 is CH
17.      END IF
18.  END IF
```

4.5.4 Algorithms description

At line 1 check the existence of a cluster head and a mobile node is in the same cluster member to calculate the priority factor.At line 2 -5 calculate the priority factor of the cluster head, mobile node n and mobile node n1 by using remaining energy and speed of mobile node. At line 5, 11 and 13 compare the priority factor of CH and priority factors of mobile node n and mobile node n1.And decide the CH based on the condition. This algorithm is used to perform cluster maintenance.

4.6 Summary

To achieve the specified objective we use different techniques and methods to create stable mobile ad hoc network by prolonging the network lifetime by using residual energy of node , and degree centrality during cluster head selection and we use relative mobility of a node, distance between CH and member node and by specifying the number of mobile nodes that a cluster head can handle and by specifying the number of optimal cluster heads in given network during cluster formation. And writing the new proposed algorithm by accommodating the new algorithm to the existing protocol and designing a new flow chart for cluster head selection, and cluster formation.

Chapter 5

SIMULATION RESULT AND EVALUATION

5.1 Introduction

In this section, we discussed the general concepts of simulation and performances of our modified algorithm. The simulation environment was used to implement our modified algorithm. Network simulator is useful to test new networking protocols or modifications in the existing protocols. The network simulator have different type of tools such as OPNET, QualNet, NS 2, Ns3, OMNET++, NetSim, REAL, J-sim, GloMosim etc [28]. Those network simulators are categorized based on some criteria such as if they are open source, simple and if they are closed and complex. One simulator is different from other simulator based on the language support, platform support, its license, GUI, animation support, etc.
The simulation of our proposed work is implemented on open source software which is called network simulator version 2 (ns2.35). It is an open-source event-driven simulator designed specifically for computer communication network [28]. It used to investigate network performance, to configure a network and to observe the results of the simulation generated by the simulator.
Ns2 is open source and event-driven network simulator and it is a simulation tool designed specifically for communication networks. The main functionalities of NS2 are to configure a network of connecting nodes and to pass packets from one node (which is a network object)

to another. Ns2 uses 2 languages as a result simulator has two completely different varieties of things it must do. On one hand, detailed simulations of protocols needs a systems programming language which can efficiently manipulate bytes, packet headers, and implement algorithms that run over large data sets. For these tasks run-time speed is very important and turn-around time (run simulation, find bug, fix bug, recompile, re-run) is a smaller amount necessary. On the opposite hand, a large part of network research involves slightly varied parameters or configurations, or quickly exploring a number of scenarios. In these cases, loop time (change the model and re-run) is more important. Since configuration runs once (at the beginning of the simulation), run-time of this part of the task is a smaller amount necessary.

The two languages are C++ and OTcl. C++ is quick to run but slower to varies, making it suitable For detailed protocol implementation. We use C++ to change the behavior of an existing C++ class in ways that werent anticipated and for processing each packet of a flow. OTcl runs much slower but can be changed very quickly (and interactively), making it deal for simulation configuration. We use OTcl for configuration, setup, and one-time stuff and to manipulating existing C++ objects. OTcl (a frontend) and C++ (a backend) interact with each other through TCl/C++ interface which is known as Tclcl. NS (via tclcl) provides glue to create objects and variables appear on both languages. The major advantages of ns2 is used to simulate various types of a wired and wireless local and wide area network, to implement difference types of protocols such as FTP, telnet, TCP, UDP and, etc. Ns2 is an associate object oriented simulator, written in C++, with an OTcl interpreter as a frontend. The simulator supports a class hierarchy in C++ (also called the compiled hierarchy), and a like class hierarchy in the OTcl interpreter (also called the interpreted hierarchy). After simulate our proposed algorithm, ns2 outputs our result in network statics or text based, animation based simulator result. In order to view this results graphically we use a tool which is called X graph, and to view this result interactively we use network animator (NAM visualization) and we use AWK files to deliver the simulation result in text based. [29].

The general overview of how our proposed system is simulated is shown by the following architecture.

5.2 Simulation parameters

Table 5.1. List of simulation parameters

Parameter	Value
Simulator	NS2(2.35)
Channel type	Wireless channel
Radio propagation model	Two ray ground
Network interface type	Wirelessphy
Link layer type	LL
Antenna model	Omni antenna
Maximum packet	500
Routing protocol	CBRP
X and Y dimension of topography	2000 *2000
Time of simulation end	5.0 sec to 50 sec
Mobility model	Random point group mobility model

5.2.1 Simulation parameters descriptions

In our proposed algorithm simulation we use channel type is wireless channel, because our network is mobile ad hoc network two ray ground propagation (it is also large scale model). This model is used to predict the received power in a given distance or the path lose more accurately than another propagation model, and we use Wirelessphy network interface type and 802.11 to implement our proposed algorithm. And also we use interface queue type to schedule, and we use omniantena radio wave. The other simulation parametres we used to simulate our proposed algorithm is the maximum packets sent in the protocol, number of mobile node that used to evaluate the performance difference between existing CBRP protocol, mobility model is used to know the group movement behavior of mobile node , energy model is used to tell the energy levels of mobile node in our simulation we simulate our network scenario 2000*2000 X and Y dimensions of topography and equate with different simulation clock to arrive the best performance of network.

5.3 Protocol implementation

Before we patched our proposed algorithm we patched the existing CBRP protocol in ns2.35. The implementation of our proposed algorithm has done by ntable.cc and ntable.h for cluster head, backup cluster head, cluster formation and cluster maintenance functions. And we write .tcl file extensions it consists of a serious of command invocations. That used to analyse and integrate the result to other text files.

In mobile ad hoc network the movements of each mobile node creates topology re connection. To control this topology re connection and the communication overhead during re clustering we apply optimal cluster head selection for mobile ad hoc network for intra cluster and inter cluster communication management. Since clustering is one method that used to control the topology of mobile ad hoc network by selecting best CH.

5.4 Simulation results and analysis

The results of our proposed work is evaluated with the results of existing CBRP protocol by using text file and Xgraph used to view and analyze the simulation result. The parametres that we consider to equate the performance of our proposed system with the existing CBRP protocol is throughput of the network, and protocol energy consumption. And we couch the graphical analysis of performance results of our system and CBRP.

5.5 Performance metrics

To get worthful information about our system during simulation we use different performance metrics. In our system we use the following performance metrics.

5.5.1 Total energy consumption

Mobile ad hoc networks downs energy for several aspects. I.e. Downs energy when it is idle state, when a data is transmitted and when a data is received. And also consumes energy at top layer, middle layer and at bottom layer which means application layer, network layer and MAC layer during simulation time. One of the major challenges of MANET is energy consumption of node, since each mobile node have limited battery resource. In our system better energy consumption is performed by selecting optimal cluster head that used to manage inter cluster and intra cluster communication. In general total energy consumption of our proposed protocol is the overall energy consumption of all mobile node. I.e. when it is idle the device is free, but it listen the channel(carrier sensing). In our simulation scenario total energy consumption is evaluated by using different simulation time, to know how much we reduce our total energy consumption during simulation process.

Table Total Energy consumption of modified CBRP (MCBRP) and existing CBRP protocol

Table 5.2. Simulation results of CBRP and MCBRP in terms of energy

Simulation time	Total energy consumption of MCBRP	Total energy consumption of CBRP
5	9.6560	10.0
10	9.85431	10.2
15	9.92861	10.321
20	10.0	10.41230
25	10.190	10.41230
30	10.2	10.59230
35	10.48912	10.80

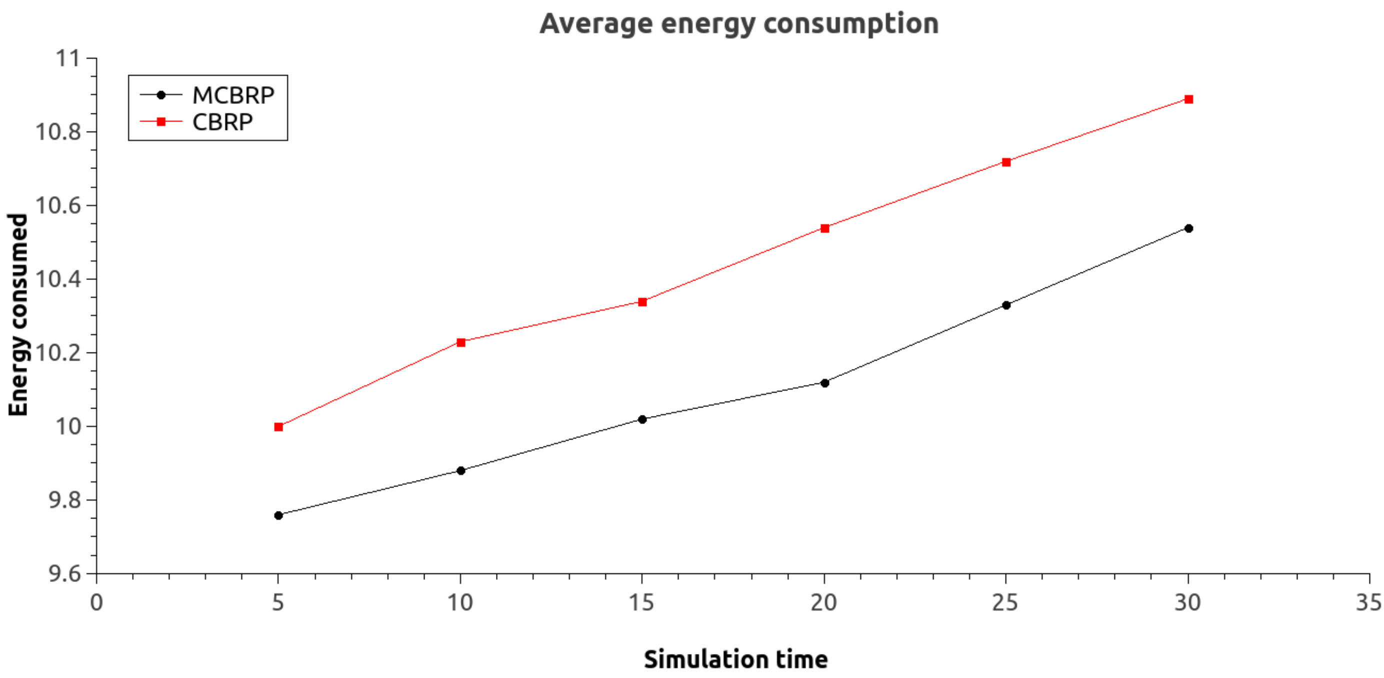


Figure 5.6. Evaluation of energy consumption

As depicted in figure 5.6 shows average energy consumption of both existing OSCA clustering algorithm and modified CBRP clustering algorithm as simulation time increases. As clearly shown from the graph the average energy consumption of modified clustering algorithm for CBRP proportionally lower than that of the existing clustering algorithm. Hence, the proposed clustering algorithm is energy efficient than the existing one.

5.5.2 Throughput of the network (KBPS)

Throughput of the network is the total number of data delivered over the time taken.

Table 5.3. Simulation results of CBRP and MCBRP in terms of throughput

Simulation time	Throughput of of MCBRP	Throughputof of CBRP
5	0.39120	0.2567
10	0.5102	0.28912
15	0.5612	0.35012
20	0.56781	0.39145
25	0.59167	0.44312
30	0.721	0.4798

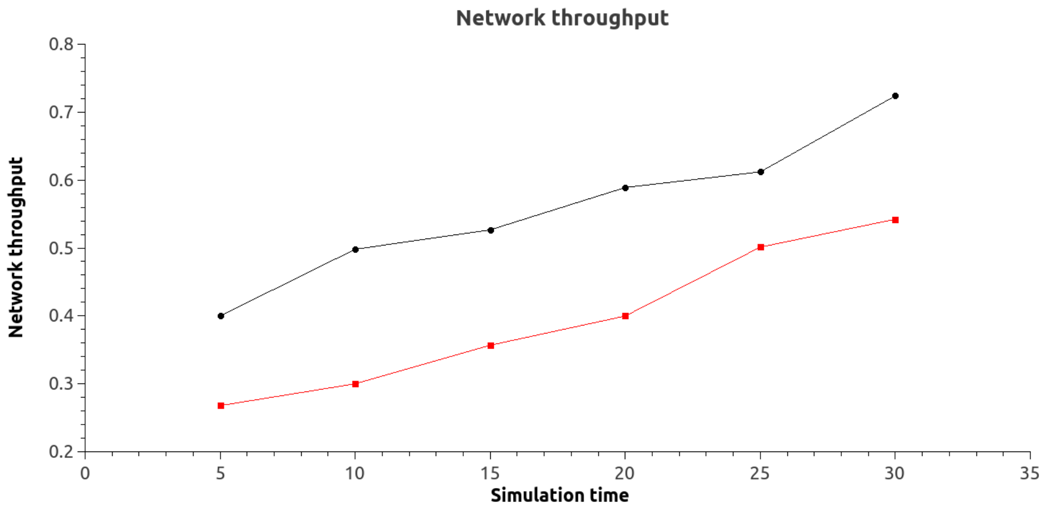


Figure 5.7. Evaluation of throughput

As depicted in figure 5.9 throughput of the network increase as simulation time increases. As the graph shows the proposed clustering algorithm performs better than that of the existing OSCA clustering algorithm.

Chapter 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

Wireless networks are computer networks that forms networks without the aid of wired materials or cables for communication purpose. It is omnipresent, we can communicate by the network anywhere at any time, and portable devices needs an access point or base station. Wireless networks are computer networks that forms networks without the aid of wired materials or cables for communication purpose. It is omnipresent, we can communicate by the network anywhere at any time, and portable devices needs an access point or base station. However, clustering in ad hoc network is difficult because the network topology may change throughout a time. In this work, approaches that used to improve CBRP in MANET were discussed. In order to minimize inter cluster and intra cluster communication energy consumption we have implemented our modified clustering algorithm. Our modified clustering algorithm takes the following approaches in to consideration such as relative mobility, distance and residual energy or degree centrality and optimal member joining is limited. In mobile ad hoc network energy and relative mobility is an important parameter in order to maximize the life time of mobile node.

Our proposed system creates an improved cluster based network on self-configuring and self-manageable network, which manages intra cluster and inter cluster communication by assigning better cluster head by using our proposed algorithm. In our system we select the cluster head before the clustered network is formed by using parameters (residual energy, or degree centrality). And the cluster is created based on parameters distance and relative mobility behavior. And optimal node degree a cluster head can handle is limited, to create stable, to consume energy efficiently we use those parameters. And we need optimal member node to avoid the load difference of cluster head. I.e. a cluster head with high member node is overcome with processing and communication load, and consume its resource (quickly) than that CH which have low member node. So, we need optimal distribution of member node for each cluster head. In our proposed work there is no calling of clustering again or there is no re affiliation. Because the cluster maintenance algorithm is developed when CH fail due to some reasons BCH replace CH and select its BCH. In general this work puts an improved CBRP protocol to minimize energy consumption and to increase network throughput. Enhancement is applied on cluster head selection of CBRP protocol, cluster formation and cluster maintenance. Our system is implemented and evaluated the modified CBRP clustering algorithm is evaluated with existing OSCA clustering algorithm using ns2.35 on cluster based routing protocol. Since, OSCA clustering algorithm was develop to improve CBRP.

6.2 Future work

Our proposed system tries to solve the problem that exists in CBRP, and we evaluate our modified protocol regarding energy consumption and network throughput. Simulation result shows that, it has better performance in terms of network throughput and reducing energy consumption. Even though, we have those improvements, we recommend the following points for future work. Tries to evaluate the result with different algorithms that already done to improve CBRP protocol.

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