Energy Efficient Routing in Clustered Mobile Ad Hoc Network (MANET)

Project submitted in partial fulfillment of the requirements for the degree of

Bachelor of Technology

in

Computer Science and Engineering

By

ASHOKESHWER GODARA

(111cs0617)

Under the guidance of

Prof. Suchismita Chinara

Department of Computer Science and Engineering

National Institute of Technology Rourkela

Rourkela, Orissa, 769008, India

May 2015

Department of Computer Science and Engineering

National Institute of Technology Rourkela

Rourkela-769 008, India. www.nitrkl.ac.in

Dr. Suchismita Chinara

Assistant Professor

May 11, 2015

Certificate

This is to certify that the work in the project entitled Energy Efficient Routing in Clustered Mobile Ad Hoc Network (MANET) by Ashokeshwer Godara is a record of an original work carried out by them under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering. Neither this project nor any part of it has been submitted for any degree or academic award elsewhere.

Suchismita Chinara

Acknowledgment

This project would not have been possible without the help, support, and cooperation of many. I express my gratitude and deep regards to **Prof. Suchismita Chinara** for her valuable guidance, constant encouragement and kind co-operation throughout period of work. As my supervisor, she has constantly encouraged me to remain focused on achieving my goal. Her vast knowledge and expertise in the area of networking was immensely helpful. Her observations and comments helped me a lot

I am highly indebted to Prof. Santanu Kumar Rath, Head-CSE Department, for his continuous encouragement and support, as he has always been eager to help. I am also thankful to Prof. A. K. Turuk, Prof. S. K. Jena, Prof. B. Majhi and all the faculty members and staffs of the department for their support.

I must acknowledge the academic resources that we have acquired from NIT Rourkela. I also want to say thanks to the administrative and technical staff members of the department who have been kind enough to advise and help in their respective roles.

I feel proud to acknowledge my parents for their support and motivation in my career for whom I am today and always.

ASHOKESHWER GODARA

(111CS0617)

Abstract

Mobile ad-hoc network (MANET) comprises of indistinguishable nodes that moves freely and communicate wirelessly. Mobile ad hoc network (MANET) is system without any kind of fixed base where the correspondence abilities of the system are constrained because of battery power of the nodes. Since all nodes can move arbitrarily and there is no fixed base, it causes different sorts of issues, for example, energy efficient routing. Conventional protocols like proactive (DSDV etc.) and reactive (AODV etc.) routing protocols are not suited for such type of networks it is essential to introduce another protocol to work in MANET. MANETs are becoming popular now because of simple deployment and it's cheapness.

Clustering is a proven efficient solution to save the battery power of certain nodes in a network. Nodes in a network are progressively sorted out into subgroups called clusters. In the process of clustering, there exists a cluster head (CH) in every cluster which works similar to a base station in the cellular architecture.Lowest id and highest connectivity algorithms are proposed for forming cluster and for cluster head selection in network and ESAR is proposed as energy efficient routing in flat structure for routing [8]. ESAR consider minimum available battery power of a node in the i^{th} path, and actual distance between the source and the destination in the i^{th} path, Distance(i) and on the basis of these values routing path is selected .This proposed algorithem selects path the best path for packet transmission till any node in the path exhausts battery power beyond a threshold value. The process is repeated till all the paths from the same source to destination are exhausted with their battery power. If there are n nodes in network and m (m<n) are selected as cluster head & energy associated with each node is E(i) then those m cluster heads will send data to base station and other cluster member will send data to cluster headsIn clustered MANET factors DE(i) is decresed as CH sends data and network is in distibuted manner .Here it will choose path in network based on Energy efficiency and distance factor between cluster heads.

Keywords: Mobile Ad-hoc Networks; Wireless, Multipath Routing; Clustering; Routing Protocols; Energy Efficiency; Network Life Time.

List of Figure :

Contents

Chapter 1

Introduction

Chapter 1

Introduction :-

Over recent years there has been a progressive change in the territory of telecom brought by various types of new innovation and devices. Organizing deviceses i.e. Tablets, mobile phones etc. are getting smaller with expanding versatility and network to web cloud. In this situation dependency on hard wired system is no more of our concern. Due to such unpredictable development of wireless devices the quantity of wireless internet users is increasing exponentially than that of the wired internet users within couple of years. For such advanced communication system where devices can be connected via wireless technologies. There are many wireless network technologies like WPAN, WLAN and MANET etc.

1.1 MANET :-

Mobile Ad hoc Networks (MANET) comprises of indistinguishable nodes that go around independently and communicate wirelessly. Every device in a MANET is allowed to move autonomously in any direction, and will subsequently change its connections to different devices regularly. As MANETs (Mobile Ad hoc Networks) comprise of wireless hosts that communicate with each other without of a fixed infrastructure. The hosts in the MANET have a constrained battery power.

MANET can be deployed in any area where there is requirement of cheap, fast and direct communication such as military service, PDAS, Group communication etc. Irrespective of it's attributes of easy deployment, no need of infrastructure there are few challenges while implementing Mobile Ad-hoc Network like it's dynamic topology (node links are

connected for less time),topology maintenance, energy efficiency, transmission quality etc.

1.2 Clustering :-

Clustering is division of network into different groups, based on certain rules in order to differentiate the nodes allocated to other sub – network. Or in other words we can say that clustering in MANET is virtual partitioning of nodes into sub networks according to geographical area [3]. The objective of clustering is to enable maximum of the nodes in a network to remain connected while consuming minimum energy

Clustering in MANET is shown in figure 1

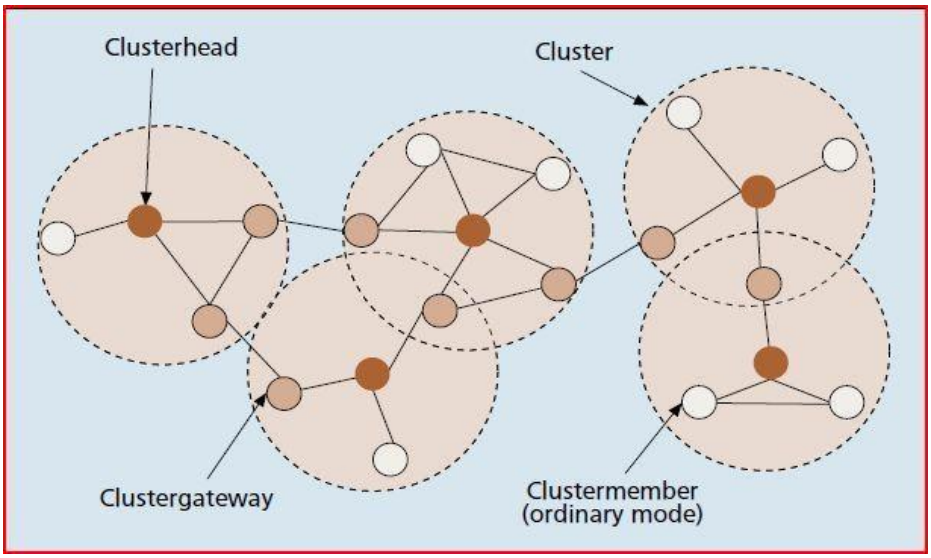

Fig 1 : SIMPLE CLUSTER SCINERIO WITH CLUSTER HEADS AND CLUSTER MEMBERS

Cluster head :- It is a local co-ordinator of a cluster in netowrk. it is important for packet forwarding from one cluster to another. A Cluster head does the resource management for its cluster member and perform inter-cluster and intra-cluster communication.

Cluster member :- A cluster member is a node which is note a cluster head and is in the transmission range of at least one cluster head.

1.3Routing :-

Routing is the process of choosing a optimal path in a network for transferring packets form source to destination. The main issue of ad-hoc networking is how to send a packet from one node to another node without any kind of direct link. And this problem becomes more complicated when topology changes frequently. Because the nodes moves randomly in the network, that are directly linked together are changing all the time. This means that the topology of an ad-hoc network changes continuously and this makes routing more difficult. Routing basically consider following into consideration :

- hop count
- bandwidth
- Delay
- Load
- Maximum Transmission Unit (MTU)

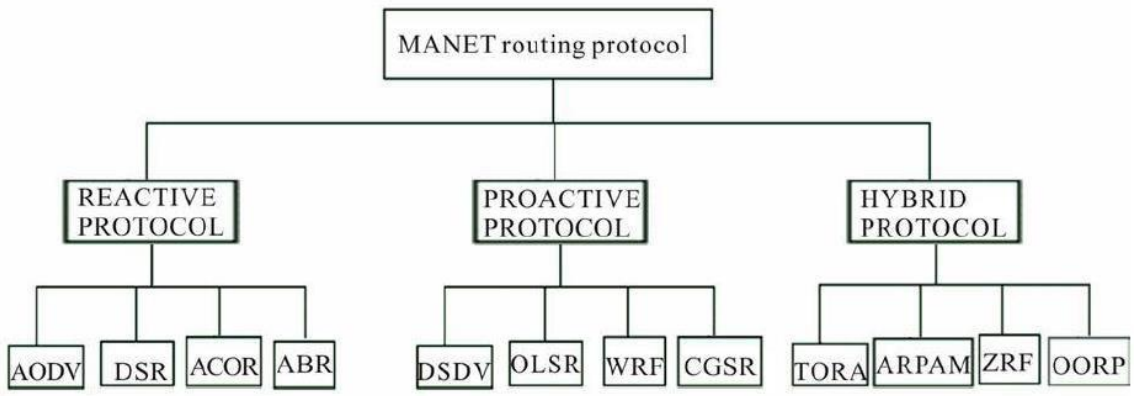

Fig 2: Routing protocols

Main protocols used in MANET [1] are listed in figure 2. Proactive Protocols are basically table driven and uses periodic protocols, that means all the nodes have tables with routing information which are updated at some intervals. The other type of protocols are Re-Active protocols, which means every time a packet is sent thes protocols first find a path by searching the entire network. Due to the highly dynamic nature routing is the key issues in MANET.

1.3.1 Energy Efficient Routing in MANET :

Due to the highly dynamic topology of MANET energy efficiency is the key issues. Since mobile nodes are powered by batteries with limited capacity, energy efficient routing is also an important issue for MANET [2].

Establishing correct and energy efficient routes, in mobile ad hoc networks, is not only an important design issue but also a challenging task. Energy efficient routing aims to minimize the energy required to transmit or receive packets i.e., active communication energy [4].

Some of the proposed energy efficient routing protocol are Local Energy-Aware Routing based on AODV (LEARAODV), Energy Efficient Ad-hoc On demand Routing (EEAODR) and Energy Saving ad hoc routing(ESAR) [7].

Chapter 2

Literature Review

Chapter 2

Literature Review

2.1 Cluster Head Selection :-

Since cluster heads decide whole network topology, Hence selection of cluster heads [3] optimally is critical.

There are certain rules and algorithm in order to divide a network into clusters and select a cluster head among nodes.

2.1.1 Lowest Id Algorithm:-

Lowest ID algorithm [3] is the simplest clustering algorithm that basically selects the cluster head on the basis of node's unique ID . A node is selected as cluster head if it has lowest id in it's transmission range. Any other node in that range cannot be cluster head , they work as cluster member.

According to this algorithm-

- Every node broadcasts its own unique ID to all other neighbouring node periodically.
- Nodes which are in the transmission range of its neighbouring node compare their unique Ids with each other and the node with lowest ID becomes a cluster head for the cluster and other become cluster member.
- If a node is in the transmission range of two cluster head become Gateway node.

Disadvantage:-

Overhead may occur if number of nodes in a cluster increases.

Since it is more biased towards nodes with lower id, so leading to more battery drainage.

It does not attempt balance the load across all the nodes.

2.1.2 Highest Connectivity Algorithm:-

This is based on connectivity of node with other nodes in the network. This algorithm is purely based on degree of connectivity [4]. A node is selected as cluster head if it has maximum connectivity in it's transmission range. Any other node in that range cannot be cluster head and they work as cluster member.

According to this algorithm

- Each node broadcasts value of its degree of connectivity (i.e. no. Of neighbours connected to that node).
- A node with highest value of degree in the neighbourhood is selected as cluster head and all other neighbouring nodes becomes cluster member.
- The procedure is repeated until each node is assigned with a cluster head. And any tie is broken with lowest ID.

Disadvantage:-

There is no bound on no. Of nodes per cluster head so cluster heads become overloaded.

Due to change in network topology, this approach gives high turnover of cluster heads as the connectivity changes.

Figure 3 describes the cluster head selection :

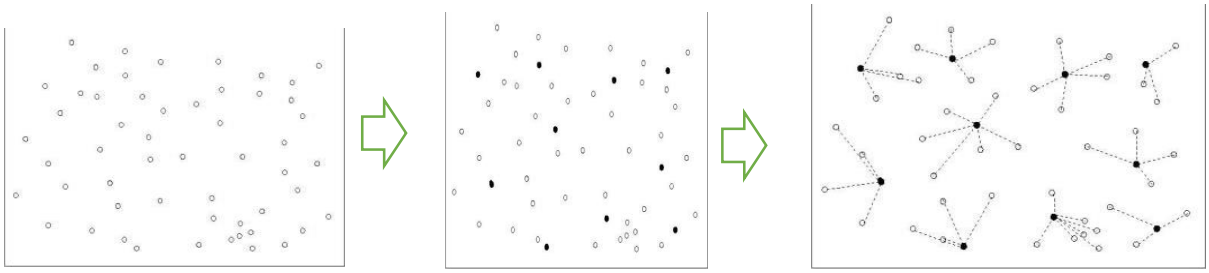

Fig 3: Cluster head selection on the basis of cluster head selection algorithm

2.2 Routing Protocol in Mobile Ad-Hoc Network :-

In wireless Ad-hoc networks, nodes send packets using multi-hop links. These lack any fixed infrastructure or base station for communication. Each node is capable of exchanging packets from other nodes, and acts as a router. The various routing protocols are proposed for routing in a network [1]. Some of important routing protocols are Dynamic Source Routing (DSR) Protocol, Ad Hoc On-demand Distance Vector Routing (AODV) protocol, Destination Sequenced Distance Vector(DSDV) protocol, Temporally Ordered Routing Algorithm (TORA) etc. These protocols are used for sending packet from source to destination but these protocols mainly focus on delay , throughput etc , but as energy efficiency is also a important factor to be considered in MANET so some new algorithms like Local Energy-Aware Routing based on AODV (LEARAODV), Energy Efficient Ad-hoc On demand Routing (EEAODR) and Energy Saving ad hoc routing(ESAR) etc are proposed and implemented and from the simulation results it was clear that they give better result in case of energy efficiency [6].

2.2.1 AODV :

The AODV protocol is a reactive unicast routing technique for mobile ad hoc networks and therefore AODV only has to maintain the routing information about the active routes. In AODV, in absence of available route, a source node initiates a route discovery procedure before sending a packet.The route discovery phase involves broadcasting of route request (RREQ) packets which contain addresses of source and destination , broadcast ID, which acts as its identifier, the last visited destination's sequence number as well as the source node's sequence number. ALL packets follow the same route for every packet transmission till any of the node dies out. The criteria for selecting the path for packet transmission from source to destination is it will select the path with minimum hops .

2.2.2 EEAODR: An Energy Efficient Ad-hoc On demand Routing Protocol for Mobile Ad-hoc Network:-

EEAODR [7] is an improvisation on *AODV* protocol that calculates the routing path by considering energy level of all the nodes in the network. Main motive of this protocol is to increase the network life of the network.

EEAODR uses an equation that considers all the optimality factors for the network like time to send packet from source to destination, minimum battery power of node required in route and number of hops in route to decide the best path (in terms of cost) among all the possible routes.

Cost = σ × time + μ × 1/minimum battery power of node in route + τ× 1/ number of hops

EEAODR makes use of the alternate paths to increase the network life. EEAODR chooses alternate path for each packet based on minimum cost by above equation.

The advantage of EEAODR over conventional routing protocols is that EEAODR increases the network life as it considers the alternate paths for each packet.

Limitation of EEAODR is since the destination nodes need to wait for δt time before calculating the best route, and hence the network delay increases. As EEAODR focus on energy so delay increases here.

2.2.3 ESAR: Energy Saving ad hoc routing Algorithm:-–

The EASR [8] algorithm targets to achieve better energy efficient routing algorithm with a longer network life time. The shortest path in terms of minimum hop counts is chosen by AODV for packet routing ensures that the transmission delay is reduced whereas the network life time is compromised. For EEAODR network delay increases as the destination node waits for δt *before calculating best route based on the cost equation.*

After storing all the possible paths from the source to the destination, ESAR algorithm considers the following two parameters to select a best path for packet transmission:

The minimum available battery power of a node in the i^{th} path, E_i

The actual distance from source to destination in the i^{th} path, Distance(i).

$$Cost(i) = \alpha * DE(i) + \beta * Distance(i)$$

Where α and β are the weighing factors that decide the priority of the battery power or the distance between the nodes in a network topology.

Hence it uses the strengths of both the AODV algorithm and EEAODR algorithms. It selects a route for routing by considering the actual distance from source to destination along with the minimum available power of a node in the path.

According to Dhurandher et. al., the authors of EEAODR [7], in a network, if there are more number of hops, then the distance between the two hops is more likely lesser. But this is not true for all the time. For example in the following figure 4, the total actual distance of the path 0 → 1 →3 →2 is more than that of the path 0 → 1 → 2.

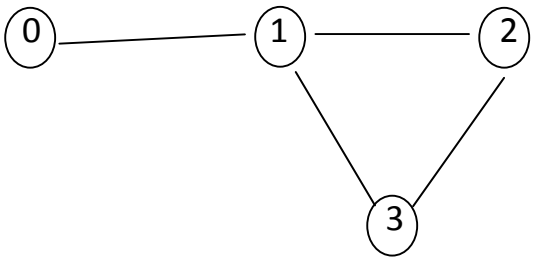

Fig 4 : simple network topology

So the ESAR finds the distances between the hops from the source to the destination instead of finding the number of hops between the source and destination. Similarly, DE(i) is the difference of the minimum available battery power of a node in any path i from a threshold value δ. The value of δ is kept constant for all the paths in network.

2.2.3 Comparison between AODV, EEAODR, ESAR:-

EEAODR increases the network life but compromises with the average energy consumption. ESAR focus on increase the network life by distributing the network load and selecting the routes containing nodes with higher energy levels i.e. the power of the minimum battery node [8].

This energy consumption issue was well addressed by Utkarsh , Mishra Mukesh , Chinara Suchismita, in “ESAR: An Energy Saving Ad Hoc Routing Algorithm” [8].

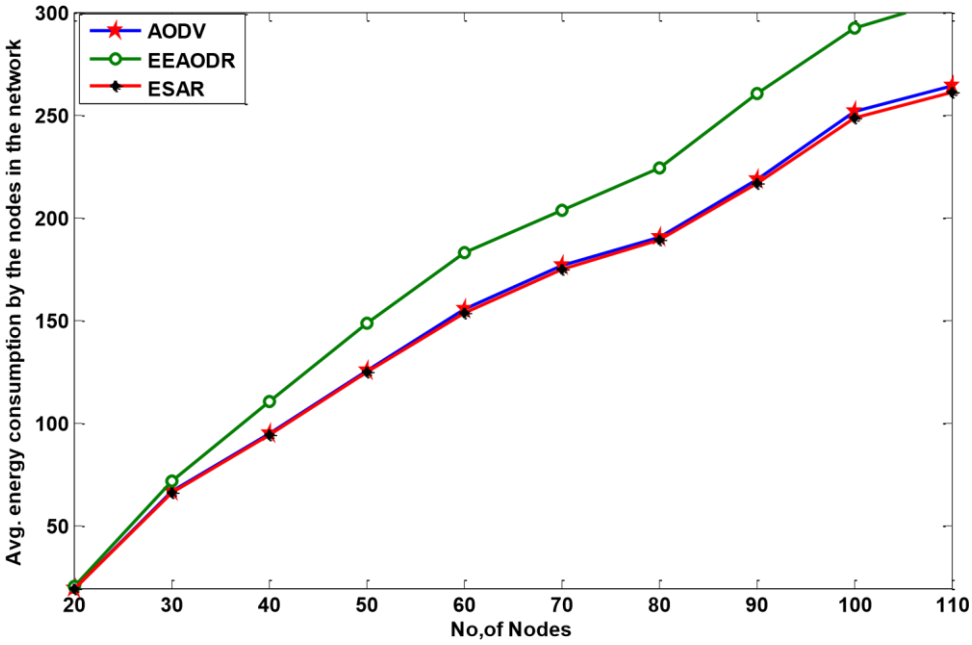

Fig 5 : Comparison Graph for Avg. Energy comparison vs No. of Nodes

The network life time is defined as the time-period since the network is started till the first node in the network dies out. Simulation results of ESAR shows that network life also increased in case of ESAR.

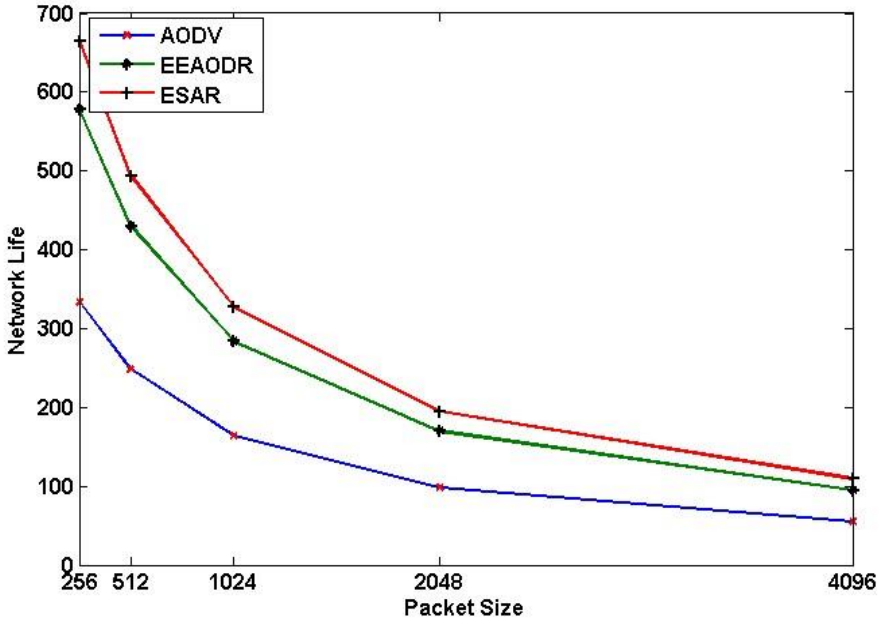

Fig 6 : Network life vs packet size

In case of delay ESAR delay minimum i.e. less than AODV as well as EEAODR. In ESAR every time we select the minimum actual distance path and thus the delay is minimum.

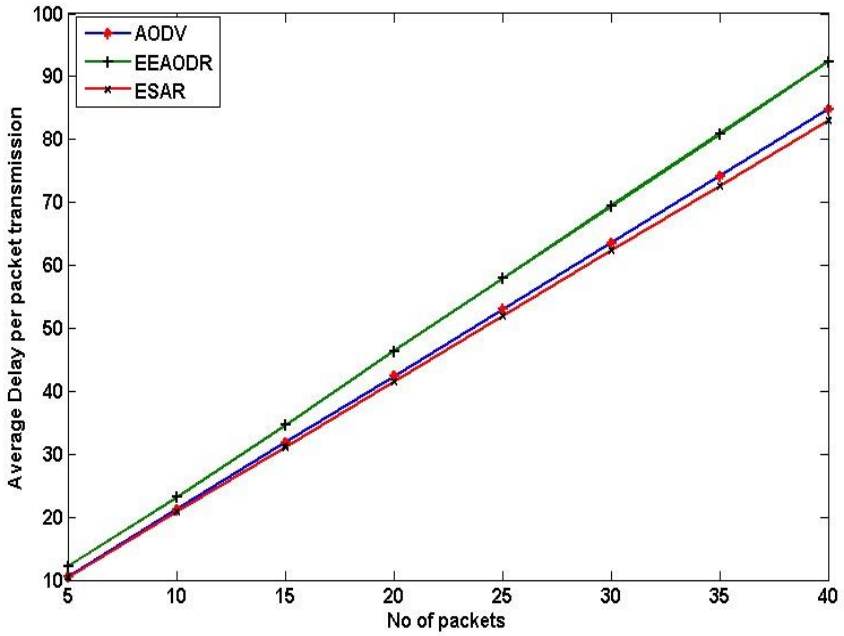

Fig 7: Comparison Graph for Delay vs. No. of Packets

Hence from the simulation results it is clear that ESAR is improved protocol than EEAODR . But if number of nodes increases and if topology change frequently then it becomes more complex as it calculate cost value for each packet.

Chapter 3

Proposed Work

Chapter 3

Proposed Work

Energy consumption at the network interface is an issue for all kind of wireless devices [5]. ESAR works on flat structure ,if number of nodes increases and if topology change frequently then it becomes more complex as it calculate cost value for each packet. , so network can be made distributed by clustering. Suppose there are n nodes in a networks out of which one in source and one is destination .So there will exist $(n-2)^2$ paths between source and destination. If we use clustering and if there exist m cluster heads where m will be less than or equal to n so network will become easy to handle and and energy efficient.

The results like energy consumption and bandwidth utilization by protocols can be improved by clustering in network so that energy can be utilized in distributed manner [3].

Lowest id and highest connectivity algorithms are proposed for forming cluster in network and ESAR is proposed in flat structure for routing. Now new algorithm can be implemented using ESAR routing with clustering.

If there are n nodes in network and m ($m<n$) are selected as cluster head & energy associated with each node is E(i) then those m cluster heads will send data to base station and other cluster member will send data to cluster heads. For such distributed and utilized network routing in clustered ad hoc network is good solution and based on such clustering better results obtained in MANET.

In ESAR we considered that

$$Cost(i) = \alpha * DE(i) + \beta * Distance(i)$$

here in clustered MANET factors DE(i) is decresed as CH sends data and network is in distibuted manner .Here it will choose path in network based on Energy efficiency and distance factor between cluster heads.

EXAMPLE

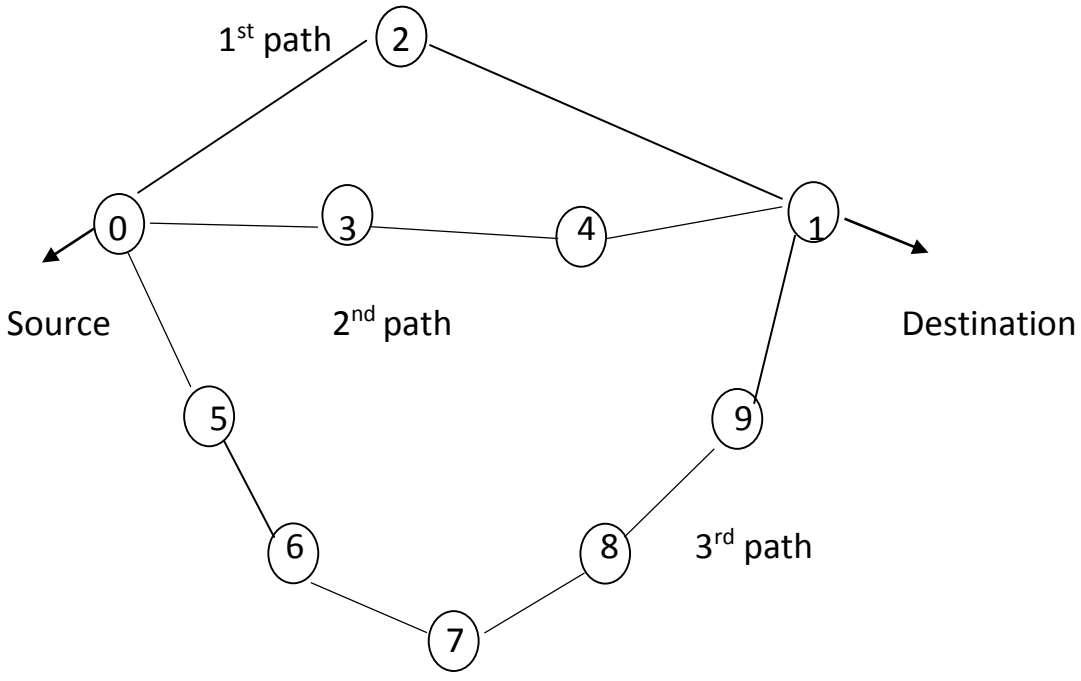

Fig 8 : packet transmission in different routing protocols

In the figure 8, source is 0 and destination is 1. Now we will see how AODV, EEAODR and ESAR and the proposed algorithm work.

AODV:

Every time for packet transmission from source to destination the 1st path will be selected i.e. the selected route will be 0→2→1 for every packet transmission till any of the node dies out. The criteria for selecting 0→2→1 as the path for packet transmission from source to destination is it will select the path with minimum hops and the 1st path have minimum number of hops i.e. 2.

EEAODR:

Here for each packet transmission from source to destination EEAODR may select same path may or may not select depending on the cost value of each path. Optimal cost value path is always selected, cost depends on three factors i.e. no. of hops, time taken and minimum battery power . When the 1st packet is sent, we calculate the cost value of the 3 paths and select the path with optimal cost value and send 1st packet through that path suppose path 2 is selected for 1st packet . Now when the 2nd packet is sent we again calculate the cost value and the path with optimal cost value is again selected, now this path may be 1st, 2nd or 3rd depending on cost value. whenever a packet has to be transmitted, the cost value for each path is calculated and the path with optimal cost value will be selected.

ESAR :

Same as EEAODR in ESAR for each packet transmission from source to destination it may select same path may or may not select depending on the cost value of each path. Here cost is calculated as

$Cost_i = \alpha * D_{Ei} + \beta * Dist_i$

Where Disti is the actual distance of the i^{th} path, For example in the above figure we will calculate the actual distance between 0(source) and 1(destination) going through each path i.e. 1^{st} path, 2^{nd} path and 3^{rd} path.

When the 1^{st} packet is sent, we will calculate the cost value of the these 3 paths and select the path with optimal cost value and send 1^{st} packet through that path suppose path 3 is selected for 1^{st} packet . Now when the next packet is sent then we again calculate the cost value and the path with optimal cost value is again selected.So whenever a packet has to be transmitted, the cost value for each path is calculated and the path with optimal cost value will be selected for packet transmission in ESAR.

ESAR in Clustered MANET :

This proposed algorithm applies ESAR with clustering in network. Same as ESAR for each packet transmission from source to destination this protocol may select same path may or may not select depending on the cost value of each path.

Here in the above example suppose all the nodes are wireless and by cluster head selection algorithm node 6 and node 8 are selected as cluster heads and node 5, node 7, node 9 are cluster member of clusters. Now as cluster heads works as local co-ordinators and send data to other cluster heads or destination. so here 3^{rd} path will be like 0→6→8→2 . so the whole topology becomes distributed and packet transmission will be easy in such network .Here distance factor is decreased in route 3.

When the 1^{st} packet is sent, we will calculate the cost value of the these 3 paths and select the path with optimal cost value and send 1^{st} packet through that

path suppose path 3 is selected for 1st packet so packet will be sent through 0→6→8→2 . Now when the next packet is sent then we again calculate the cost value and the path with optimal cost value is again selected. So whenever a next packet has to be transmitted, the cost value for each path is calculated and the path with optimal cost value will be selected for packet transmission in this protocol.

Chapter 4

Simulation and Results

4.1 Simulation and Results

Several different approach exist to evaluate the performance of networking protocols including live network test, MATLAB, and mathematical models etc. For a detailed discussion about performance and to visualize discrete event network simulators ns-2 is used.

NS-2 :

-Discrete event simulator for networking research

-Simulate both wired and wireless networks

-provide substantial support to simulate bunch of protocols

-Primarily unix based

- scripting language used in ns2 is tcl

-Protocol design, traffic studies

-Nam – visualize ns output

NS-2 can support a considerable range of protocols in all layers. For example, the ad-hoc and WSN specific protocols are provided by NS-2.

Table :

Parameter	Value

Number of nodes	10 - 100
Simulation Area	1000*1000
Speed	10 - 50
Transmission Range	100 -999
Data Packet size	512byte
Data packet interval	4 packets/sec
Initial Energy	100 J

Inputs :

Number of nodes and transmission range will be given by user for cluster head selection :

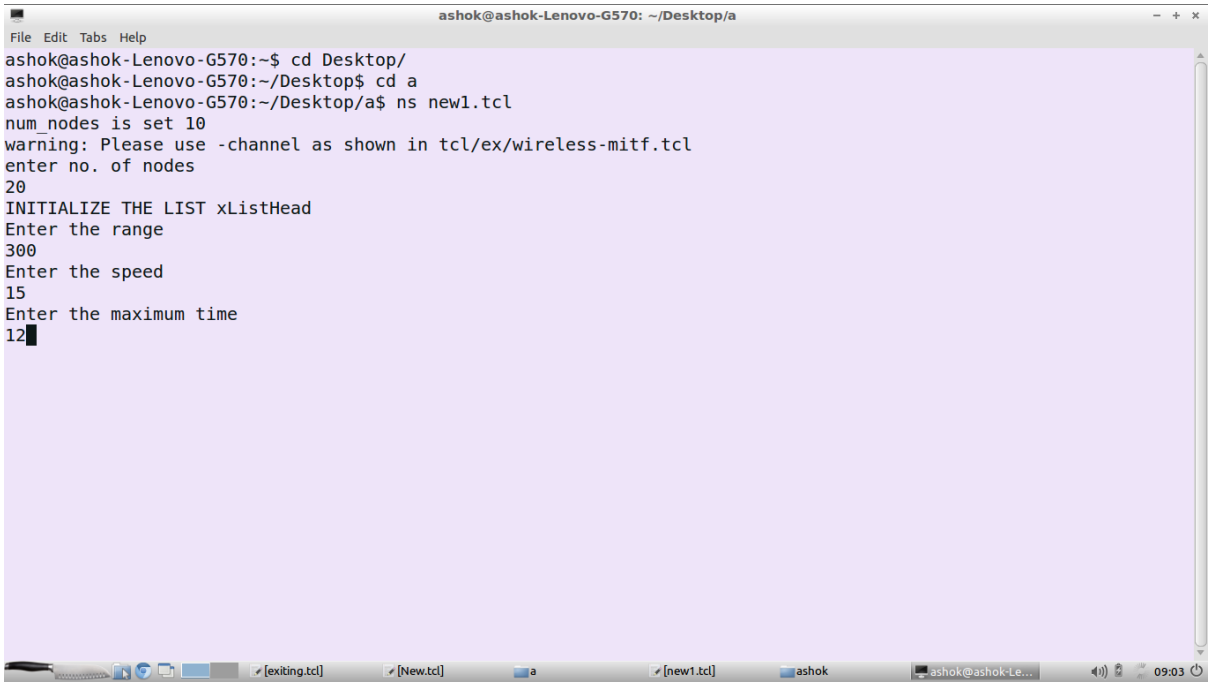

Fig 9 : inputs for cluster head selection

For cluster head selection Calculation of nodes in range

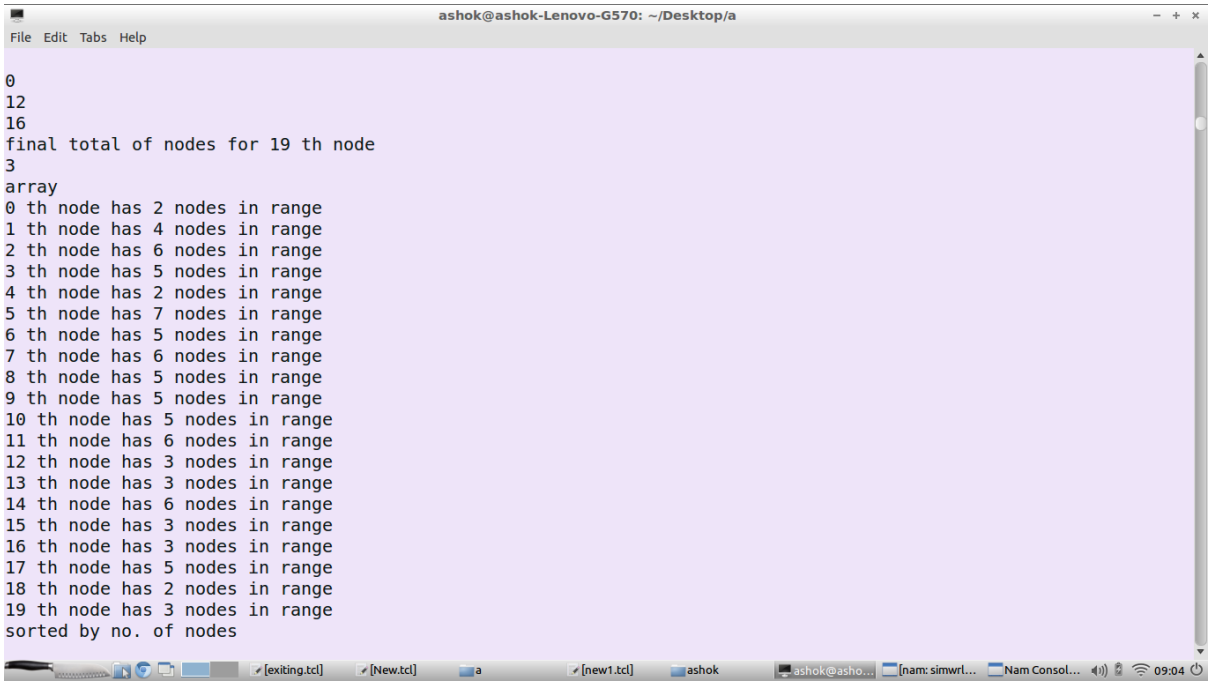

Fig 10 :calculation of nodes in transmission range of a node

Cluster heads will get selected on the basis of no. of nodes in range (highest connectivity) :

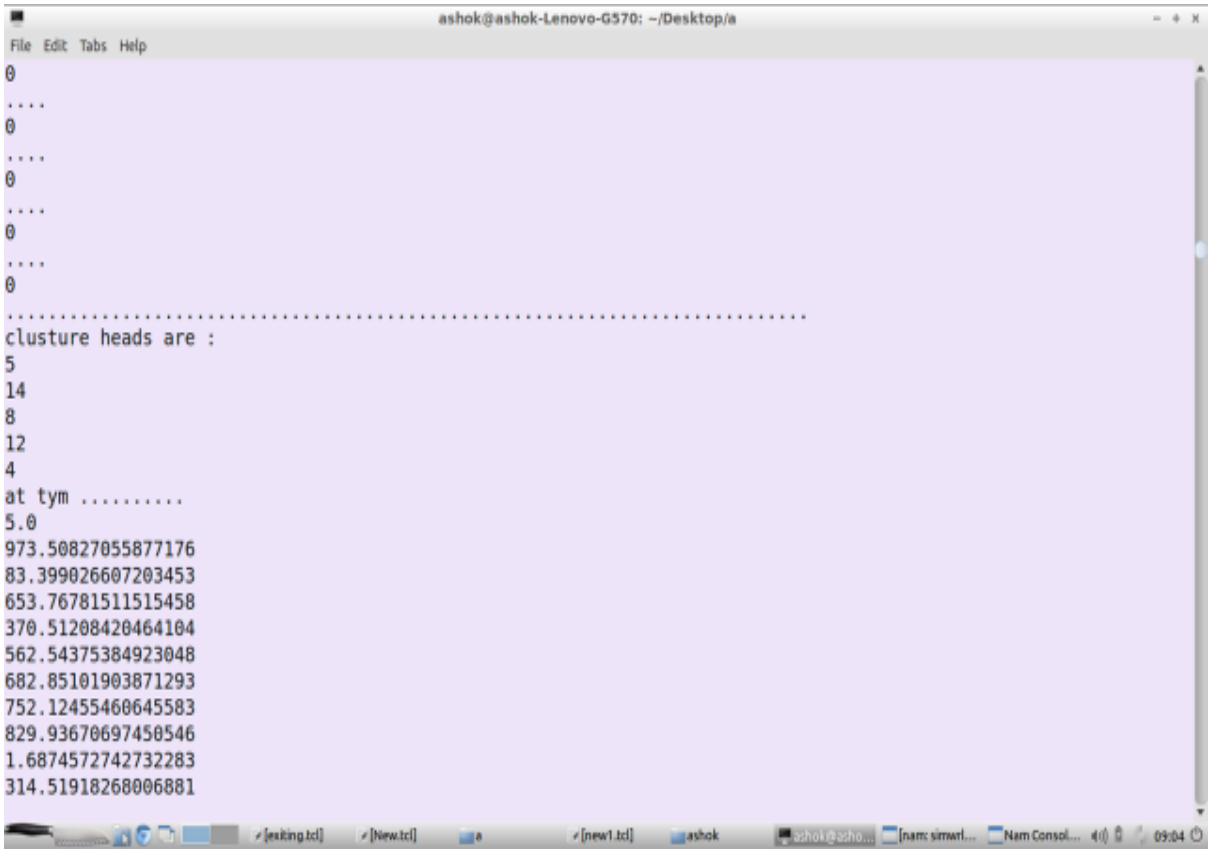

Fig 11 : cluster head selection

NAM simulation at time 0.1 :

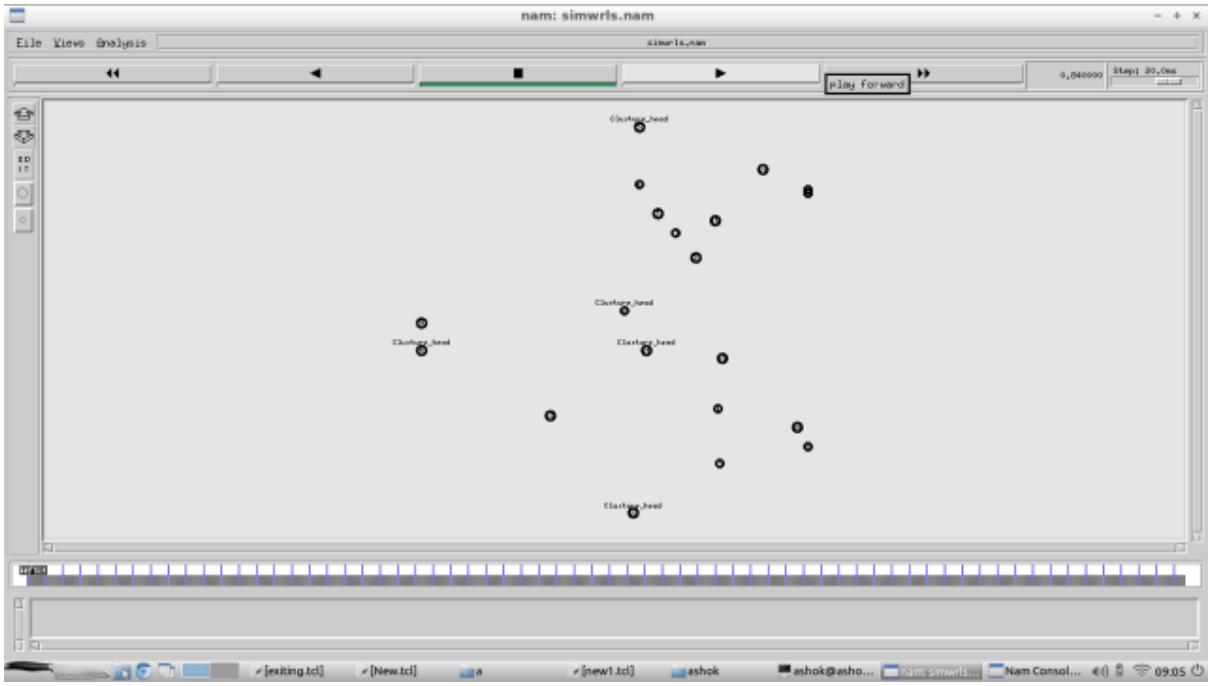

Fig 12: nam simulation at time 0.1

Now as in MANET topology changes frequently so after time 5.0 cluster heads will be again selected on the basis of new positions of nodes

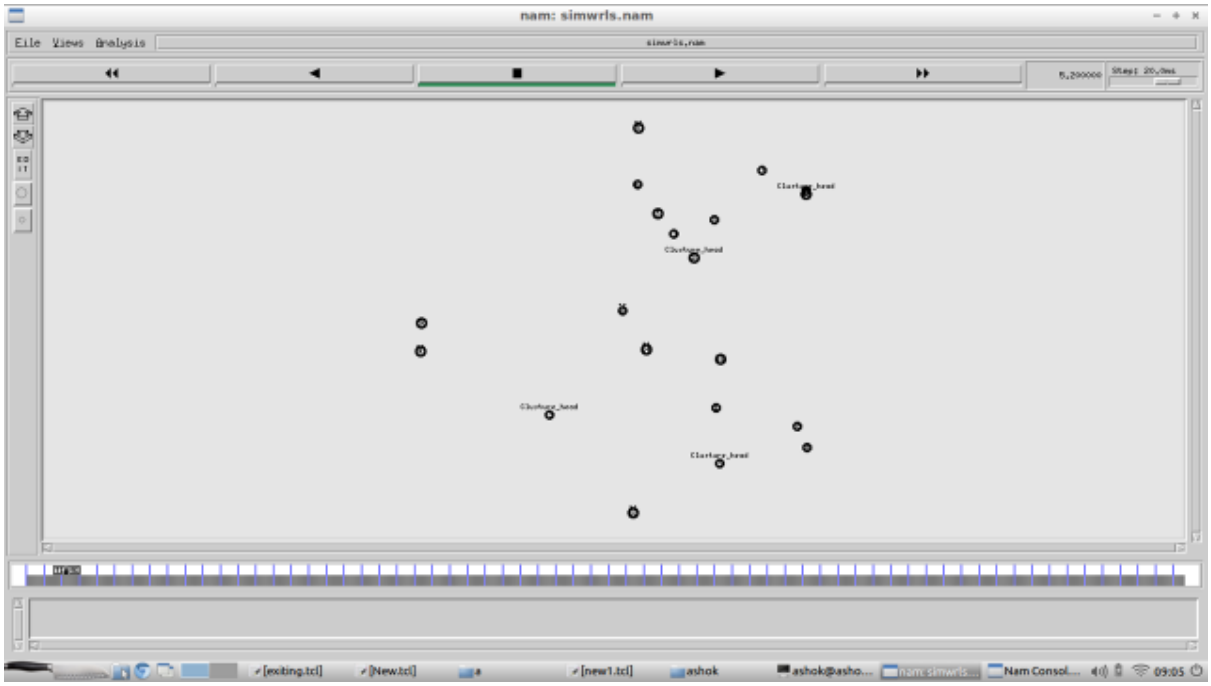

Fig 13 : nam simulation at time 5.1

Energy consumed by cluster heads :

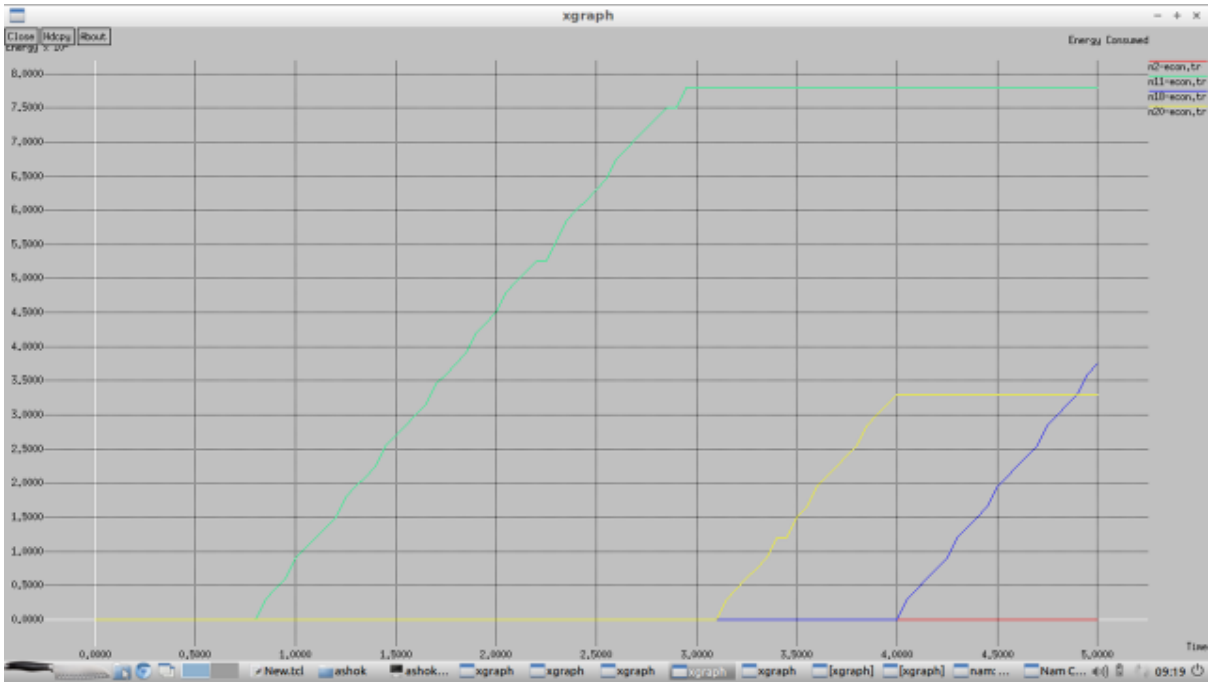

Fig 14 : Energy consumed by cluster heads

Cluster packet delivery ratio :

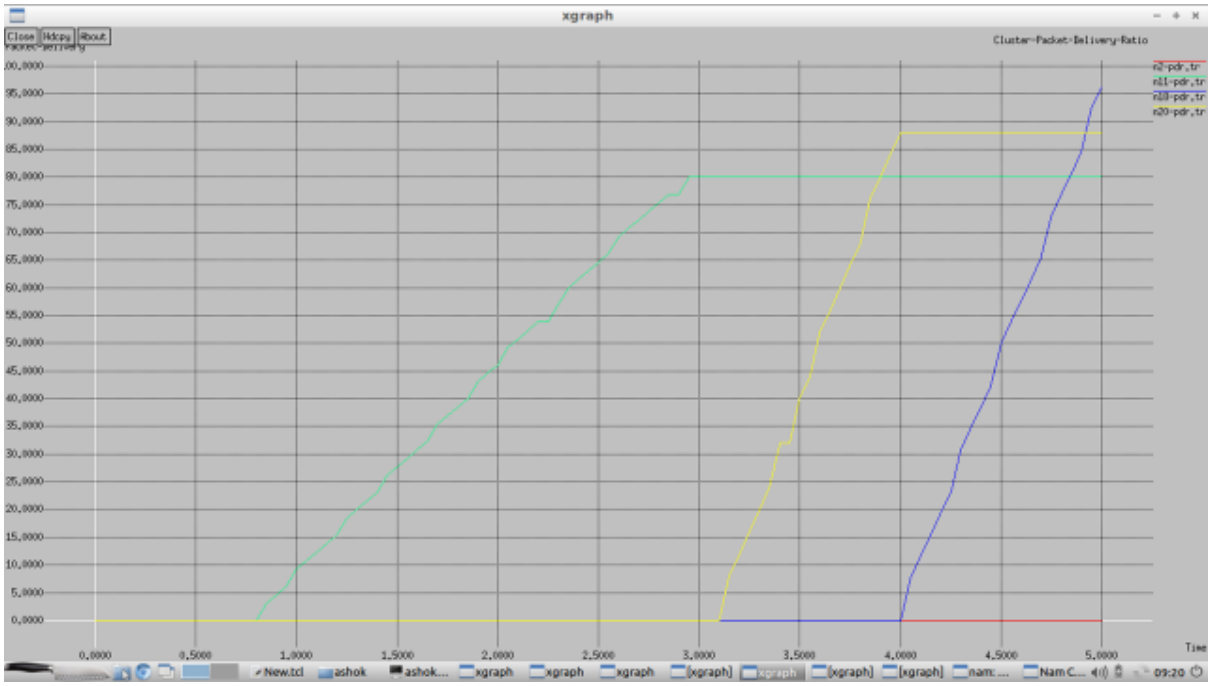

Fig 15 :Cluster packet delivery ratio

Chapter 4

Conclusion

Conclusion :-

This paper discusses how energy is one of the important factor for MANET and how clustering can be a efficient solution for this problem in MANET. So Energy efficient protocol is proposed using clustering in ESAR protocol. Since cluster heads decide network topology, so election of cluster heads optimally is critical. So using clustering energy efficient solution can be provided for routing in a network.

Hardware and software implementation can be done in future for this proposed algorithm to get results.

Refrence :

1. M. Abolhasan, T. Wysocki, E. Dutkiewicz, “A review of routing protocols for mobile ad hoc networks”, International Journal of Ad Hoc Networks, Vol. 2, pp. 1-22, 2004

2. L.M. Feeney, “An Energy Consumption Model for Performance Analysis of Routing Protocols for Mobile Ad Hoc Networks”, Mobile Networks and Applications , Kluwer Academic Publishers, vol. 6, pp. 240-250,2001.

3. Chinara S., Analysis and Design of Protocols for Clustering in Mobile Ad Hoc Networks., Ph. D thesis, National Institute of Technology, March 2011.

4. C.J. Hwang, A. Kush, and S. Taneja. Making manet energy efficient. In *Mobile Congress (GMC), 2011 Global*, pages 1–6, 2011.

5. J.H.Chang and L.Tassiulas, “Energy conserving routing in wireless ad hoc networks”, Proceedings of INFOCOM 2000, Tel-Aviv, Israel, March 2000.

6. A. Muquattash and M. Krunz, A distributed transmission power control protocol for mobile ad hoc networks, IEEE transactions on mobile computing, pp. 113-128, vol. 3, issue 2, April 2004.

7. Dhurandher S.K., Misra S., Obaidat Mohammad S., Bansal V., Singh P.V., Punia V. “An energy efficient ad hoc on demand routing protocol for mobile ad hoc network” , International Journal of Communication Systems 2009; vol. 22: pp. 789-817

8. Utkarsh , Mishra Mukesh , Chinara Suchismita, “ESAR: An Energy Saving Ad Hoc Routing Algorithm”, Advanced Computing (ICoAC), 2012 Fourth International Conference; pp.$1-5$, Dec. 2012