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A Link Capacity & Energy Aware based Multipath Route Selection Protocol for Mobile Ad hoc Network

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Abstract: *MANET (Mobile Ad hoc Network) is a collection of battery-powered nodes that form dynamic network topology. As a result, energy consumption is a critical factor to increase the lifespan of mobile nodes. The link capacity of mobile nodes is also fixed and it is also not very easy to enhance the bandwidth of wireless medium. A key problem is the energy-based multipath routing in traditional ad hoc networks. If a single route in standard energy- based routing fails, it result is significant packet loss because connection failures occur unexpectedly or without warning and neighbors are unaware from this situation. To fix this problem, we proposes Link Capacity & Energy Aware based Multipath route Selection (LCEAM) scheme for enhance routing performance. LCEAM is a multi-path minimum bandwidth energy-based routing scheme that eliminates congestion while also improving energy quality and data transmission reliability. The multipath protocol eliminates the probability of congestion in this scheme, and energy aware routing often chooses the node/s which energy is/are more than the threshold energy level. In this research each data packet is transmitted to the neighbor by one or more different paths based on dynamically changing metrics. The equilibrium of multiple paths that considers the energy consumption at neighbors is further considered in path selection, which contributes to efficient use of the relay nodes and prevents early death of heavily involved nodes. The simulation results show that the LCEAM scheme performance is more better than the performance of AODV and AOMDV protocol. The LCEAM reduces the energy consumption across nodes, which contributes in a longer network life time.*

Keywords: Multipath, Routing, LCEAM, Energy, Bandwidth, MANET.

Introduction

That can refer to the ad hoc [1] under which the numbers of the nodes are less constrained, which allows greater numbers of mobile devices to connect and communicate without oversight from any authority. This node type relies on the deployment using mobile nodes and doesn't have a network infrastructure to rely on. There are no hard-wired connections or distribution points, or routers. Thus, the nodes in MANET do not have to remain in one place for long periods of time but can change their locations from time to time. It's possible for each connection to be either a sender or a recipient, as well as for either of them to perform some number of routing tasks. Expanding this indicates that it will forward packets to other nodes. M meeting consists of multiple-related applications and current exercises that include tactical situations, and is being used in such settings as battlefields, the point of origin of no matter, and search and rescue. If we use AODV or DSR [2, 3] after the path sends data but only on one of the several shared links, excessive sender burden may occur on the network. Controlling traffic congestion is the major challenge in ad hoc networks the ability to monitor traffic flow of various into a

telecommunication network is related to limiting the increase in traffic. Applying methods, the packets with intermediate nodes and links can be avoided or, rather, avoiding it at or using all costs, leads to greatly reducing the number of sent packets with congestion management. There are several researchers who have written papers on the subject of minimizing network congestion in that part of the research area. In this paper, we study MANET ad hoc networks and the transport layer to solve the problem of congestion minimization, which route has the least congestion in the multi-diverse access strategy. Even where the sender's data rate exceeds the maximum data rate of the single path techniques are used, the control link's output is taken into consideration in the multipath approach.

II. Related Work

In this section describe about existing work in the field of WDM optical network, virtual topology management, light path identification and quality of service in WDM network.

Deepak Sharma, Suresh Kumar, Paya,[1] "Performance Evaluation of MANETs with Variation in Transmission Power using Ad-hoc on-demand Multipath Distance Vector Routing Protocol" in this title they discuss With the evolution of dynamically changing network applications, for efficient, seamless and last mile connectivity Mobile Ad-hoc Networks (MANETs) provide a cost effective solution. The mobile nodes in MANETs are randomly connected and their location and functioning keeps on changing based on the situation and network application requirement. However, the nodes in MANETs are battery powered which is one of the limiting factors in their performance. However, seamless and longer duration connectivity depends upon the lifetime of individual nodes. The power consumption during transmission is the critical design issue in MANET's. This work involves the performance evaluation of a designed MANET scenario with variation in transmission power using Ad-hoc On-Demand Multipath Distance Vector (AOMDV) Routing Protocol (RP) at variable node configuration.

Kamlesh Chandravanshi, D. K. Mishra [4] In this article we develop the combined AOMDV-Dream protocol method, which balances the network load with multipath routing. Dream technique to estimate the destination and transmit the sender information for the route regularly Network flood reduction, so that our network Overhead routing may be reduced and performance can be increased. We use the -2 network simulator and evaluate the Both AOMDV and AOMDV-Dream studies are being conducted.

Yi, J., Adnane, A., David, S. and Parrein, B. [6] in his work titled "Multipath optimized link state routing for mobile ad hoc networks" The algorithm gains great flexibility and extensibility by employing different link metrics and cost functions. In addition, route recovery and loop detection are implemented in MP-OLSR in order to improve quality of service regarding OLSR.Multipath routing protocols for Mobile Ad hoc Network (MANET) address the problem of scalability, security (confidentiality and integrity), lifetime of networks, instability of wireless transmissions, and their adaptation to applications.

Natarajan Meghanathan and Leslie C. Milton [7]' A Performance Analysis of Mobile Ad Hoc Networks Stability, Load-Balancing and Power-Aware Routing Protocols' is a detailed simulation-based performance comparison in this title of three distinct classes of mobile ad hoc network routing protocols: stability-based routing, power-aware routing, and load-balanced routing. As part of the stability-based routing, load balancing, and power-aware routing protocols, we choose the Flow-Oriented Routing Protocol (FORP), the Load Balancing Routing (LBR) based traffic disruption protocol, and the Min-Max Battery Cost Routing (MMBCR). FORP has the least number of route transfers out of the three routing protocols, while LBR has the smallest hop count and the lowest end-to-end delay per data packet. Energy

per node, led closely by LBR, is the least consumed by MMBCR.

Alghamdi Saleh A. [8] "Load balancing maximal minimal nodal residual energy ad hoc on-demand multipath distance vector routing protocol (LBMMRE-AOMDV)" is an acronym for "Load balancing maximal minimal nodal residual energy ad hoc on-demand multipath distance vector routing protocol." In this title, we have discuss a load balancing (LB) multipath routing protocol in the ad hoc on- demand multipath distance vector (AOMDV) protocol based on maximal minimum nodal residual energy (MMRE). The proposed LBMMRE-AOMDV protocol evaluates created paths based on the maximum nodal residual energy and the actual number of packets that can be transmitted without depleting the nodes' energy. The proposed protocol's performance was measured and analyzed using various scenarios and performance measures, and it performed well as compared to MMRE-AOMDV and AOMDV. The proposed approach, in particular, will improve packet distribution while lowering the number of dead nodes, decreasing the likelihood of network portioning.

Narendra S Chaudhari and Rakesh Kumar Sahu [8] "Energy Reduction Multipath Routing Protocol for MANET Using Recoil Technique" is a title published in the journal "Energy Reduction Multipath Routing Protocol for MANET Using Recoil Technique Energy Reduction Multipath Routing Protocol for MANET using Recoil Technique (AOMDV-ER) is a novel protocol proposed in this title that conserves energy while providing optimum network lifetime, routing overhead, packet distribution ratio, and throughput. It outperforms all other AODV-related algorithms since the nodes in AOMDV- ER use changing recoil off time technique based on their geographical position to intelligently relay packets to their destination. This definition limits the number of transmissions, which extends the lifespan of the network. Furthermore, road management at the local level eliminates additional routing overhead. Finally, each node's prediction- based connection lifetime is predicted, which aids in packet loss reduction in the network. This protocol is divided into three sections: an optimal route discovery algorithm combined with the residual energy and distance mechanism; a coordinated recoiled nodes algorithm that reduces the number of transmissions to reduce data redundancy, traffic redundancy, routing overhead, end-to-end delay, and network lifetime; and a last link reckoning and route maintenance algorithm to maintain the network lifetime. The AOMDV-ER protocol saves at least 16 percent energy, 12 percent routing overhead, and significantly more network lifetime and packet delivery ratio than Ad hoc on-demand multipath distance vector routing protocol (AOMDV), Ad hoc on-demand multipath distance vector routing protocol life maximization (AOMR-LM), and Source routing-based As a result, the AOMDV-ER algorithm outperforms these newly created algorithms.

Anbarasan M. Anand M. Sasikala [10] "A handheld ad hoc network energy-efficient channel conscious multipath routing protocol" in this title we discuss Energy-efficient channel aware ad-hoc on-demand multipath distance vector routing (EECAAOMDV) is a new energy-efficient channel aware routing algorithm for mobile ad-hoc networks. EECAAOMDV outlines three critical requirements for mobile ad hoc networks: energy efficiency, unwavering quality, and device longevity. To select the safe route for way revelation, the proposed energy-efficient channel conscious AOMDV (EECAAOMDV) uses the channel standard non-fading time and nodal residual energy as steering metrics. The convention's main idea is to find average channel non-fading duration and overall nodal residual energy as routing metrics for each course during the time spent selecting a path, and then sort the multi-course by slipping channel non-fading duration and nodal leftover energy.

Omar Smail Bernard Cousin, Rachida Mekki & Zoulikha Mekkakia [11] "A multipath energy-conserving routing algorithm for improving the

lifespan of wireless ad hoc networks" In this article, they suggest ad hoc on-demand multipath routing with lifetime maximization (AOMR-LM), an energy-efficient multipath routing protocol that saves node residual energy while balancing consumed energy to extend network lifetime. They calculated the node energy level using the residual energy of nodes to achieve this objective. This energy level is used by the multipath selection system to distinguish the directions. The energy threshold and the coefficient are also investigated. These parameters are needed to distinguish nodes and ensure that node energy is preserved. By extending the lifespan of mobile ad hoc networks, our protocol enhances their efficiency. The ad hoc on-demand multipath distance vector (AOMDV) and ZD-AOMDV protocols were compared to this novel protocol. In terms of network lifespan, energy usage, and end-to-end delay, the protocol's efficiency has been assessed.

Hongqiang Zhai et al [12] proposed "a novel rate based end-to-end Congestion Control scheme (RBCC)". Based on the novel use of channel busyness ratio, which is an accurate sign of the network utilization and congestion status, a new rate control scheme has been proposed to efficiently and reliably support the transport service in MANET. In RBCC, a sub layer consisting of a leaky bucket is added under TCP to control the sending rate based on the network layer feedback at the bottleneck node.

Yuedong Xu et al [13] proposed "A fully distributed congestion control algorithm to balance throughput and fairness for TCP flows in multi-hop ad hoc networks". The interactions between the hidden nodes and network congestion are mainly focused. A distributed algorithm to improve the end-to-end throughput, and at the same time, provide per-flow fairness by exploiting cross-layer information is proposed. In the link layer, each node uses a proportional controller to determine the ECN marking probability for the purpose of notifying incipient congestion. Then the rate based TCP sender adjusts its sending rate according to the feedbacks from the link layer.

Yuanyuan ZOU, Yang TAO at el [14] proposed a "A Method of Selecting Path Based on Neighbor Stability in Ad Hoc Network" in this title they studies about routing algorithm based on the stability in mobile Ad-Hoc network and presents a routing mechanism based on neighbor stability.

M. Ali, B. G Stewart et. al.[15] In his work titled "Multipath Routing Backbones for Load Balancing in Mobile Ad Hoc Networks" this title presents a new approach based on multipath routing backbones for enhanced load balancing in MANETs. Nodes in MANETs greatly differ with each other in terms of communication and processing capabilities. In the proposed approach, multiple routing backbones are identified from source to destination using intermediate nodes that have better communication and processing capabilities to take part in the mobile routing backbones and efficiently participate in the routing process. This work use multipath technique but not execute multipath simultaneously that case use alternative base load balancing technique.

K. M. Mahesh, and S.R. Das [16] "On-demand Multipath Distance Vector Routing in Ad Hoc Networks" and propose an improved routing algorithm NBS-MAODV which is based on MAODV algorithm. NBS-MAODV algorithm sends data according to the neighbor stability metric in the path construction process. It can reduce the times of link fracture caused by network mobility and increase the total overhead of network.

Ashish Bagwari et al [17] proposed "Performance of AODV Routing Protocol with increasing the MANET Nodes and its effects on QoS of Mobile Ad hoc Networks" In this paper they are analyzing the performance of reactive routing protocol via enhancing number of nodes and observe how it effects to QoS of existing mobile Ad-hoc network. Here Mobile ad-hoc network are dividing into clusters. Each cluster has MANET node with CHG.

From one cluster to another cluster or within the cluster we applied reactive routing protocols specifically AODV to evaluate AODV protocol behavior and performance and check what kind of effect made by particular protocol on QoS. Finally, they concluded results that confirm AODV giving better performs under such types of circumstances, providing better QoS based on good throughput and acceptable End-End Delay, less data drops. One of the notable features of this AODV protocol strategy is that, it reduces our network load which can be responsible for congestion at the time of communication. Therefore it can be used to extend the network coverage.

S.Karunakaran et al [18] proposed a "cluster based congestion control (CBCC) protocol that consists of scalable and distributed cluster-based mechanisms for supporting congestion control in ad hoc networks". The clusters independently and proactively monitor congestion within its localized scope. The present approach improves the responsiveness of the system when compared to end-to-end techniques. After estimating the traffic rate the length of a path, the sending rate of the starting place nodes is adjusted accordingly. Thus this protocol look forward the injection of dynamic flows in the network and proactively adjusts the rate while waiting for congestion feedback.

Soundararajan et. al.[19] in his titled "Adaptive Multipath Routing for Load Balancing in Mobile Ad Hoc Networks" they propose congestion controlled adaptive multi-path routing protocol to achieve load balancing and avoid congestion in MANETs. The algorithm for discovery of multi-path routes computes fail-safe multiple paths, which provide or give every intermediate nodes on the primary path with multiple routes to destination. The fail-safe or reliable many paths include the nodes with least load and more battery power and residual energy. When the average or normal load of nodes along the route increases beyond a threshold then Node distributes the traffic over disjoint multipath routes to reduce the traffic load on a congested link.

Fubao Yang in [20] proposed work on title Network Coding-based AOMDV Routing in MANET. This paper proposes a Network Coding-based AOMDV routing algorithm in MANET (NC-AOMDV). It is typically proposed in order to increase the reliability of data transmission, and by applying network coding, which allows packet encoding at a relay node. Because the encoding packet is generated by a relay node, the source node does not need to encode the packets, and sends only data packets to each route.

Nitin Goel, et.al. in [21] proposed Efficient Weighted innovative Routing Protocol (EWIRP) to Balance Load in Mobile Ad Hoc Networks (MANETs). The EWiRP proposed in this paper is a load balancing technique which can also be viewed as an efficient routing approach, improves delivery ratio, reduces end to end delay, efficiently exploits the resources like available bandwidth, node energy, queue space, without affecting the network's vital assets. The weight computation process considers not only the necessary parameters but also the service classes of the network.

Shalini Puri, Dr. Satish. R. Devene, in [22] proposed "Congestion Avoidance and Load Balancing in AODV Multipath The proposed protocol (AODV-Multipath) preserves the higher hop count routes in the routing table and utilizes it as alternate path as link failure occurs. AOMDV does not provide any means to avoid congestion and load balancing in the network. Queue Length detects congestion in the network. Queue Length and Hop Count value are together used to select a route from source to destination that avoids congestion and load balancing. Tuan Anh Le [23] in his work titled "ecMTCP: An Energy-Aware Congestion Control Algorithm for Multipath TCP" they build up an energy-aware congestion control algorithm for multipath TCP, called ecMTCP (energy congestion multipath TCP). In ecMTCP moves traffic from the high congested

paths to the more lightly loaded paths, as well as from higher energy cost paths to the lower ones, that node achieving load-balancing and energy-savings. In this title, they develop ecMTCP. This title focus congestion control with the help of energy base load balancing mechanism, this work also modified via multipath routing technique for end-to-end delay minimization.

III. Proposed Work

Route decision is optional property for communication but in recent advancement of technology heterogonous devices capable to provide communication. Due to unlimited device existence route decision functionality is important for efficient path selection for real time communication. Mobile ad hoc device are self configure, movable and limited resource contain devices those limitation treated as challenge for route decision. In the past research various routing algorithm are develop and found that ad hoc on demand distance vector routing AODV and their multipath routing AOMDV is more appropriate for the ad hoc communication.

In our dissertation proposed a link capacity with energy aware multipath routing technique which increase the percentage of data receive and provide reliable path from source to destination. In the proposed routing methodology enhance the working of AOMDV routing with the help of energy aware and link capacity based node selection method. Node energy utilize by various parameter such as data transmission, receiving, sleeping and sensing etc. all those parameter consider during route selection process. Similarly node to node link bandwidth capacity is varied that variation important to selection of route between source to destination. In the route discovery process enhance multipath route is executed, during this process acquire the recent energy of node (threshold energy is 10 joule) as well as available bandwidth and forward route packet to next hop till the destination is found. Multipath routing select best three route on the bases of available link bandwidth and current energy is higher, energy is also calculate based on discharging value. While expected time of node energy discharging is lower and link bandwidth is higher than we select best three routes for the communication. After selection the route actual data are transmitted to intended receiver node and provide reliable communication. Multipath routing provide all time connectivity without interruption, because its uses the three path out of those path at least one path is alive which increases percentage of data receiving and decreases the overhead of network. Proposed approach simulated by network simulator-2 which is three tire architecture, internal module contain implementation of layer protocol and their connectivity, second module is interface and network architecture designing module which contain node deployment, initial node configuration such as energy, routing protocol, mac layer protocol, propagation module, channel bandwidth etc. In the last module data are acquire in trace file or generate animation data in nam file which contain discrete event of network. Trace file pass to analyzer and retrieve the network impact which is represented by graphical format using gnuplot. All the three modules collectively work and simulate proposed methodology, simulated result conclude that proposed link capacity with energy aware multipath routing provide efficient and reliable route for communication.

IV. Proposed Algorithm

Proposed link capacity with energy aware multipath routing implement by network simulator-2, in the multipath routing formal description of algorithm is incorporate which provide reliable and efficient path. In this section algorithm are describe in formal way where all the required data and parameter is define and get the output in terms of network parameter.

Algorithm: Link Capacity & Energy Aware based Multipath Route Selection (LCEAM)

Input:

N: Set of nodes in network
Rt: AOMDV routing protocol
Er: Remaining energy of node

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S: Source node ∈N
D: Destination node ∈N
I: intermediate node ∈N
Th: Threshold energy (10 joule)
γ: radio range 550m2
Ba: available bandwidth
Ln: needed bandwidth
Output: Packet Delivery Fraction, normal routing load, data drop, throughput, energy consume, delay.

Procedure:
N deploy in network
S← call-route-f_n(S, D, R_t)
S← Broadcast route(S, D, R_t)
While (I_i in γ & $E_r \geq T_h$ & $B_a \geq L_n$) **do**
I ← receive routing packets
For each I in γ
While I ≠ D **do**
Store the S address and forward to next hop
hop = hop++;
End do
If (I== D & Path ≥ 1) **then**
Receives route packets
Select three route (max E_r)
Send Ack to S node
Call data_pkt()
Else
R not in zone
End if
End do
// Data Sending Module
Data_pkt(S,D,pkt)
If path is available & $E_r \geq T_h$ **then**
S Generate data packet
Forward data by established path
Er = (Er- Trans_Power* Trans_time)
D receives data Packet
Send Ack to S node
Else
Path not available
Call Route-fn();
End if

V Proposed Architecture

. Mobile ad hoc network designing is dependent on routing decision, bandwidth and node capacity (energy, processing and speed).

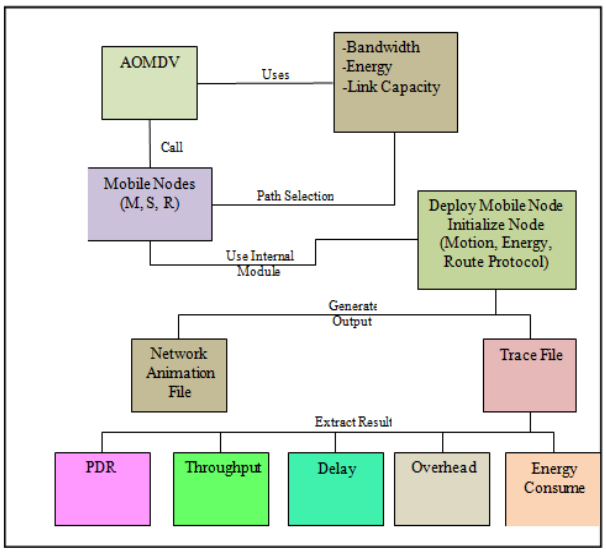

Figure 1: Proposed Enhance Routing Architecture

In this section design the architecture to select the best route for communication. Ad hoc on demand multipath distance vector routing uses the criteria of energy and bandwidth for selection the best three routes. Mobile node uses enhance routing protocol AOMDV and select the route after that send the using TCP/UDP based technique. Simulated output data carried into trace file and nam file, trace file pass to awk programming and analyze the result in terms of energy consumption, delay, PDR, throughput etc. those result compare with exiting system. nam file useful for animation purpose which shows the node position, motion, radio range, routing, data transmission etc.

VI. Simulation Tool

A network simulator is a programmed or hardware that predicts the behavior of a computer network without a particular network being in existence. Typically, machines are modeled on the data network;

traffic in simulators, etc., and performance is assessed. Users would then normally customize the simulator to meet their individual testing specifications. Simulators usually support today's more common protocols and networks, such as WLAN, Wi-Max, TCP, WSN, cognitive radio, etc.

- **Simulation Parameters**

We present simulations using network simulator 2 (NS2-2.31) to assess the performance of the propose LCEAM protocol. The operating system is Windows 10. If your NS-2 does not support Windows, you can also install 'cygwin' for provide Linux environment in Windows. The hardware requirements: are 1.86GHz CPU, memory is 4GB, hard disk is 1TB. Table 1 shows the simulation parameters used in the tests. NS-2 users can run experiments in an ad hoc network without physically moving the nodes by modifying the network's logical topology. Ns-2 monitors the test scenarios using a wired interface, while the ad hoc nodes connect via a wireless interface.

Table 1: Simulation Parameter for Deployment of MANET

Parameters	Configuration Value
Simulation Tool	NS-2.31
Routing Protocol	AODV, AOMDV, LCEAM
Simulation Area	1000m*1000m
Network Type	MANET
Number of Nodes	40,80.120
Physical Medium	Wireless, 802.11
Simulation Time (Sec)	550Sec
MAC Layer	802.11
Antenna Model	Omni Antenna
Traffic Type	CBR, FTP
Propagation radio model	Two ray ground

- **Result Analysis**

This section evaluated the results in case of previous AODV, AOMDV case and proposes LCEAM. The performances of propose scheme is better because of better proper bandwidth utilization and energy aware route selection.

- **Network Architecture for 120 Nodes**

The topology depicted in Figure 2 that shows 120 mobile nodes. The nodes are continuously moved in a limited area. Each node detects its neighbors and sends data to its next node or destination using the shortest multiple path. First, produce test traffic on the network. Nodes are first sense nearby node/s for route establishment. The blue circles in figure 2 show the process of sensing. The trigger process starts by categorizing incoming and outgoing traffic into two types: broadcast and non-broadcast packets. After completion of routing procedure data transmission will start in between sender and receiver.

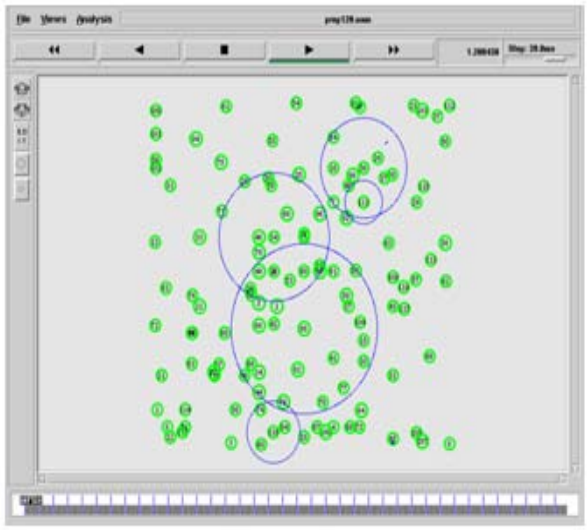

Figure 2: Simulated Architecture in 120 Nodes

- **Packet Delivery Fraction Analysis**

The better PDF performance means the better data packets receiving in network. The Packet Delivery Ratio (PDR) is the ratio of packets received to packets sent in a network. This efficiency metric is critical for analyzing the packet percentage successfully obtained in the network.

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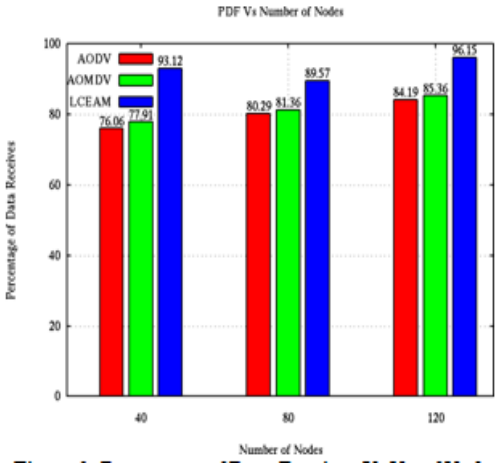

Figure 3: Percentage of Data Receives Vs No of Nodes

The proposed LCEAM protocol performance is better than the standard AODV and AOMDV routing protocol. In the case of standard multipath routing, the packet delivery fraction is around 85 percent highest in case of 120 node density, but in the case of the proposed scheme, the PDF value is more than 96 percent. The packet transmitting differences in the previous and propose schemes are almost identical, but the receiving gap in the proposed scheme is greater due to the PDF value more is more in LCEAM. The performance in different node density scenario is also mention in table 2.

Table 2: Percentage of Data Receives

No of Nodes	AODV	AOMDV	
40	76.06	77.91	
80	80.29	81.36	
120	84.19	85.36	96.15

- **Analysis of Normal Routing Load**

The routing load is defined as the number of routing packets delivered in the network to establish a connection with the recipient.

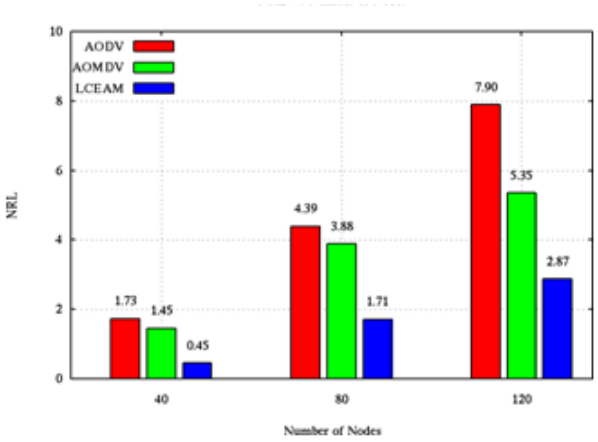

Figure 4: Normal Routing Load Vs No of Nodes

The routing packets are also known as' Hello 'packets. In this figure, the routing load is lower in propose LCEAM scheme as compare to previous AODV and AOMDV scheme. The routing overhead of AODV routing is highest in 120 nodes density scenario. The overhead of AOMDV is less as compare to AODV. The increased routing load means more flooding in the network as well as energy waste, but the energy factor has been included in the proposed work and also increases the routing efficiency of the multipath protocol, so that the routing process is improved and energy consumption is reduced. The overhead performance in different node density scenario is also mention in table 3.

Table 3: Analysis of Routing Load

No of Nodes	AODV	AOMDV	LCEAM
40	1.73	1.45	0.45
80	4.39	3.88	1.71
120	7.90	5.35	2.87

- **Data Drop Analysis**

The efficiency of packet transmission and receiving is mainly dependent on network conditions. This graph presents the packet drop analysis in case of propose LCEAM scheme, standard AOMDV and AODV routing protocol. The packet drop in the proposed scheme is only about 438 packets, while in the previous schemes packets dropping is high in 120

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node density scenarios. The routing efficiency of the AOMDV protocol can accommodate the risk of congestion, but propose LCEAM provides energy efficient routing which improves network performance and also resolve the problem of suddenly link breakage. The data drop performance in different node density scenario is also mention in table 4

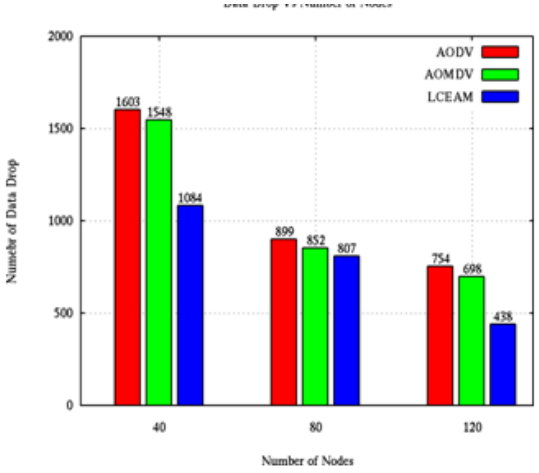

Figure 5: No of Data Drop Vs No of Nodes

Table 4: Analysis of Number of Data Drop

No of Nodes	AODV	AOMDV	LCEAM
40	1603	1548	1084
80	899	852	807
120	754	698	438

- **Throughput Analysis**

The number of packets transmitted and received in per unit of time is known as throughput. In this figure, the throughput of standard AOMDV routing is lower than that of propose LCEAM routing. The propose LCEAM routing strategy reduces the nodes energy wastage and increases the performance of the bandwidth estimation based multipath routing. The throughput of AOMDV is only 3.2 Mbps but the throughput of the propose LCEAM routing protocol gradually increases until the end of the simulation. Standard multipath routing offers an alternate route, but not handled load and energy consumption efficiently. In proposed multipath routing, load distribution occurs appropriately, so the efficiency of multipath routing is increased with minimal energy consumption or a limited life time factor. The throughput performance in different node density scenario is also mention in table 5.

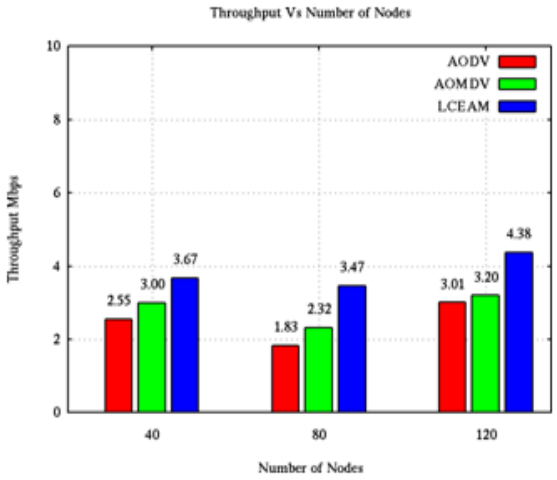

Figure 6: Throughput in [Mbps] Vs No of Nodes

Table 5: Analysis Network Throughput [Mbps]

No of Nodes	AODV	AOMDV	LCEAM
40	2.55	3.00	3.67
80	1.83	2.32	3.47
120	3.01	3.20	4.38

- **Average End to End Delay**

The Average End to End Delay (AEED) analysis is measure by calculates the average extra time taken by packets to reach in destination. The routing packets in a network are used to create a link between a sender and a recipient, and the less the routing packets, the better the network delay results. In this figure, the delay performance of propose LCEAM protocol measures with the previous normal

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AOMDV and AODV routing protocol. The time is calculated in seconds in all node density scenario. It means that data packets retransmission also impacted on the routing performance. The propose bandwidth estimation based scheme showing less delay as compare to rest of two protocols. The AEED performance in different node density scenario is also mention in table 6.

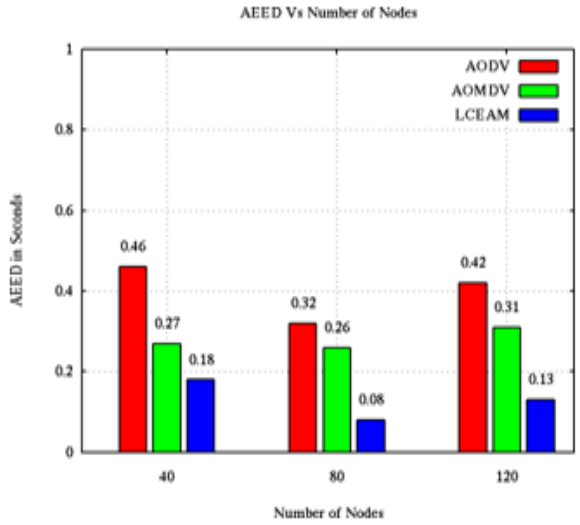

Figure 7: Analysis of AEED Vs No of Nodes

Table 6: Analysis of Average End to End Delay [Second]

No of Nodes	AODV	AOMDV	LCEAM
40	0.46	0.27	0.18
80	0.32	0.26	0.08
120	0.42	0.31	0.13

- **Energy Consumption Analysis**

The energy source is the limited source available for communication in mobile devices.

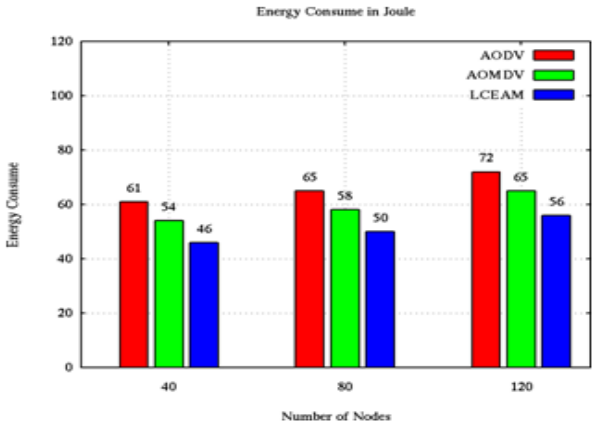

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Figure 8: Analysis of Energy Consumption [J] Vs No of Nodes

The AOMDV and AODV scheme consumes more energy but the LCEAM scheme use battery power more efficiently, which means the load in the propose scheme is manageable, so that in the proposed scheme only more packets are sent because of strong link establishment. In 120 node density scenario only 56 joule energy consumes in case of LCEAM approach and rest of protocols consumes more energy in communication. Now, the propose LCEAM is consumes less amount of energy in communication. It means that the LCEAM handled the load efficiently. If the load is appropriately distributed means power usage reduces and utilization increases. The energy consumption performance in different node density scenario is also mention in table 7.

Table 7: Analysis of Energy Consumption [Joule]

No of Nodes	AODV	AOMDV	LCEAM
40	61	54	46
80	65	58	50
120	72	65	56

VII. Conclusion

In dynamic network line MANET, charging or replacing batteries would be impossible that's why energy aware routing is important to improving the life of mobile nodes. The MANET is the

decentralized network that's why it is also different from other network. Even though a node also work as a sender or receiver or router. it means also forwards data and routes packets to others, which depletes its battery power rapidly. The Link Capacity based Energy Aware Multipath routing (LCEAM) The better link capacity reduces the possibility of packet loss and multipath routing solving the problem of dynamic topology because instantly alternative path available for data transmission. The suggested multi-path routing scheme establishes more than two routes to reduce the risk of link breakage. Each data packet is sent to the number of nodes or neighbors using one of the established minimum more than two routes. The propose LCEAM algorithm establish reliable path that maximizing network lifetime. The propose LCEAM performance also compare to AODV and AOMDV protocol. The less amount of data loss also reduces energy expenditure. The performance of all schemes evaluated in three different node density scenarios. The average PDR performance is about 10% more as compare to AODV and AOMDV. The result is improved in terms of performance metrics, which demonstrate that the suggested scheme outperforms the comparison scheme. The overhead and delay in network also less because of more packets receiving and better throughput. Furthermore, the route is chosen with the balance of multiple routes dependent on available bandwidth capacity. The multi-path and energy conscious multi-path schemes demonstrate tremendous promise in terms of effectively utilizing connecting nodes, evenly reducing energy usage, and having an optimum path. In the future, we will implement the proposed scheme for some location aware protocol, such as DREAM or LAR, and analyze the impact of the location aware protocol on energy consumption. We will also apply the energy efficient routing scheme in WIMAX technology to determine the correct energy utilization.

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