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Guaranteeing Quality of Service and Low Power Consumption in Mobile Ad-Hoc Networks

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***Abstract*— Mobile Ad-Hoc Networks are used widely in these days. It is suitable for emergency situations or disaster areas when existing communication infrastructure is damaged and rapid deployments of a communication networks are needed. In a MANET, power awareness is an important challenge to improve the communication energy efficiency at individual nodes. In this paper authors have proposed and implemented efficient low power consuming routing protocol on top of AODV. The main goal of the proposed routing protocol is increasing the network lifetime of the MANET. Additionally paper evaluates the implemented protocol using the NS2 simulator in different network scales taking the power consumption into consideration. The proposed algorithm reduces for more than 9.8% of the total energy consumption and decreases the mean delay and achieves a good packet delivery ratio.**

***Keywords*— MANET, AODV, Power Consumption, QoS**

I. INTRODUCTION

Mobile Ad-Hoc Network (MANET) provides wireless communication with high degree node mobility without a fixed infrastructure and the union of nodes forms an arbitrary topology. The Ad-Hoc self-organization also makes them suitable for virtual conferences, where setting up a traditional network infrastructure is a time consuming high cost task [1].

MANETs are suitable systems which supports some specific applications as virtual classrooms, military communications, emergency search and rescue operations, data acquisition in hostile environments, communications set up in exhibitions, conferences and meetings, in battle field among soldiers to coordinate defences or attack, at airport terminals for workers to share files etc. In Ad-hoc networks, nodes can change position quite frequently. The nodes in an Ad-hoc network can be laptops, PDA, palm tops etc. These are often limited in resources such as CPU capacity, storage capacity, battery power and bandwidth. Each node participating in the network acts both as a router and as a host and is willing to transfer packets to other nodes. For this purpose, a routing protocol should minimize control traffic. Energy has become an important factor in MANETs. There is a limitation of battery life in an Ad-Hoc environment where battery is most commonly used. The concept of power as one of the deciding factor in route selection can be crucial in route discovery and route repair phase.

Devices in MANETs must able to detect the presence of the other devices and perform necessary set up to facilitate communication and sharing of data and service.[2,3] Ad-Hoc networking allows the devices to maintain connections to the network and easily add and remove devices to and from the network. Due to nodal mobility, the network topology may change rapidly and unpredictably over time. The network is decentralized, where network organization and message delivery must be execute by the nodes themselves. Message routing is a problem in a decentralize environment where the topology fluctuates.

II. RELATED WORK

An energy efficient routing protocol decreases the power consumption of the nodes by routing data on paths that consume the least amount of energy [4]. Some special efficient mechanisms and caching techniques are used for storing information to propose an energy efficient routing protocol.

Many routing protocols have been proposed for MANETs, but none of them has good performances in all scenarios with different network sizes, traffic loads and node mobility patterns. Each of the proposed protocols is based on different principles and has different characteristics. Those proposed routing protocols for MANET have been evaluated their performance in term of energy consumption. It requires reliable power consumption secured protocol to communicate in the Ad-hoc infrastructure.

Existing power saving mechanisms proposed by researches:

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- Controlling transmission power by Minimize signal to interference and noise (SINR) ratio and increasing residual battery power and increase network lifetime.
- Using power management techniques by measuring the performance of metrics such as throughput, latency and delay.
- Power conserving at mobile nodes by considering memory allocation hard disk scheduling and CPU scheduling.
- Constructing a multicast tree rooted at the source and spanning the destination nodes such that the minimum residual battery energy (also referred to the network lifetime) among the nodes in the network[5]
- Propose a set of metrics that associate each link transmission with a cost and consider both the cases of plentiful and limited bandwidth resources, the latter jointly with a set of channel allocation algorithms.

By using existing methodologies and technologies implement a new protocol with an algorithm to overcome issues related to reliability and power consumptions is needed. Power is a scarce and non-renewable resource in wireless sensor networks and energy efficient routing protocol design is a key concern. Compared with the IEEE 802.11 approach, the proposed protocol achieves significant improvement in energy consumption. The protocol relies on dynamic adjustment of the data-packet transmission power, while maintaining a fixed (maximum) transmission power for request-to-send and clear-to-send handshake control (RTS/CTS) packets [6].

III. PROPOSED METHODOLOGY

Maintaining an optimized lifetime of a routing path in MANET is a challenging task because the power or energy of the nodes depends on the size, properties, battery capacity etc. Energy in batteries continuously depletes due to activities of nodes related to data transmission, reception and overbearing. Depletion of energy in nodes, especially the intermediate ones disrupt communication and results in changes to the network topology. Disruption can be minimized through an efficient selection of intermediate nodes in the routing. Selection criteria must be the first step in any route selection process in order to maintain a stable routing of data between the end nodes. Nodes consume energy while transmitting signals to neighbouring nodes for the purpose of detecting their existence or transmitting data to another node. The nodes' residual energy is important in determining the path to successfully completing data transfer without any interruption. A routing protocol that considers the nodes' residual energy will perform better than the existing protocols.

The objective is to provide an energy efficient, more stable and long lasting path from a source to the destination. This goal is achieved by modifying the Ad-Hoc On-Demand Distance Vector (AODV) protocol [7,8].] A new routing scheme has been designed for MANET with a large number of nodes .The new routing scheme has been proposed to make AODV energy efficient and for all practical purposes.

The AODV protocol tries to minimize this traffic by making only the hosts that participates in the communication to periodically send Hello messages with the hop limitation of the one hop. AODV selects the best path only by considering the number of hops/devices between the source and the destination. The selected path may have some nodes which only have a less amount of remaining battery power[9,10]. The existing AODV protocol is modified by considering the remaining battery power also when selecting the best path. The Route Request (RREQ) packet is modified by adding an extra field which will calculate the cumulative existing battery power of the device. When selecting the best path AODV consider about the hop count, sequence number and also the total remaining battery power of the path.

Simulation research tools are used by the majority of MANET community that estimates how event might occur in the real world to evaluate the performance of network in terms of different metrics. Discrete Event Simulation is a software-based method to employ the models of real environment to draw a conclusion from the output and is used in this study [10]. Network Simulator (NS2) is the most widely used Discrete Event Network Simulator in the MANET research [11]. The most important reasons for using NS2 are software availability, large community of developer and also supporting energy model [12].

The proposed and modified AODV protocol is implemented on top of Linux Operating System with NS2 (Version 2.35) to simulation and debugging of the modified AODV protocol [13]. After implementing a perfect protocol the deployment of the protocol to real sensor motes

with debugging and testing is done. Network lifetime is defined as the time from beginning of simulation until first node in MANET runs out of energy. NS2 energy model is used to measure energy consumption of AODV.

TABLE I
PARAMETERS OF NS2 SIMULATOR ENVIRONMENT

Parameter	Value
Area	1000*1000m
Simulation Time	1000s
Channel	Wireless
Propagation Model	Two Ray Ground
Antenna Type	Omni Antenna
Buffer Type	FIFO
Connection Type	TCP/FTP
Number of nodes	5 - 100
MAC protocol	802.11

NS2 is the result of an on-going effort of research and development that is administrated by Researchers at Berkeley. It is a discrete event simulator targeted at networking research. It provides substantial support for simulation of TCP, routing, and multicast protocols. The simulator is written in C++ and a script language called OTcl[11].NS2 uses an Otcl interpreter towards the user. The user writes an OTcl script that defines the network (number of nodes, links), the traffic in the network (sources, estimations, type of traffic) and which protocols it will use. This script is then used by ns during the simulations. The result of the simulations is an output trace file that can be used to do data (processing ,calculate delay, throughput etc..) and to visualize the simulation with a program called Network Animator (NAM).NAM is a perfect visualization tool that visualizes the packets as they propagate through the network.

IV. RESULTS AND DISCUSSION

The results have been derived and graphs are generated by carrying out experiments over network simulator NS2. TCL scripts, trace files and AWK scripts are used to obtain and analyse data. The performance evaluation for large number of nodes in a network of modified AODV and existing AODV has been done on the basis of average End-to-End Delay, Average Throughput and Average Packet Delivery Ratio. Routing packets including Hello messages which have higher priority always transmitted firstly and data packets are queued at nodes. With the AODV routing protocol, when the traffic is low in the network, no matter which route the traffic flow chose, the route chosen can provide enough data rate at most of the time.

In general, the Average End-to-End Delay is the average amount of time taken by all the packets to reach the destination node after they have been transmitted by the source node. In MANET, the End-to-End Delay is the delay encountered by a packet which is measured from the time the packet is generated to the time the source node receives an ACK packet indicating successful reception of the packet by the destination node. This includes the route discovery time, the queuing delay at node, the retransmission delay at the MAC layer and the propagation and transfer time in the wireless channel. Ad hoc networks provide quality of service (QoS) support in terms of bandwidth and delay.

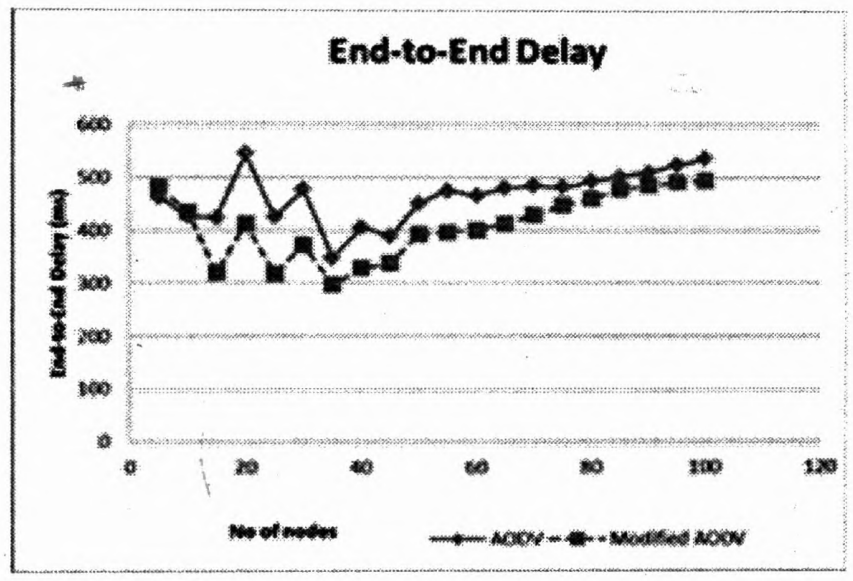

Fig. 1 Average End-to-End Delay

The obtained graph (Fig. 1) indicates that the Average End-to-End Delay is a lower value than the values of existing AODV. As the wireless Ad-Hoc networks provide QoS by considering the bandwidth and delay, the modified AODV provides a higher QoS.

According to the graph obtained by simulation results it is observed that the delay of improved AODV do not indicate a big difference than the existing AODV after the number of nodes in the simulation area is more than 70. When the existing wireless node density increases they need more time for the route discovery and data transmission

process and the End-to-End Delay gradually increases.

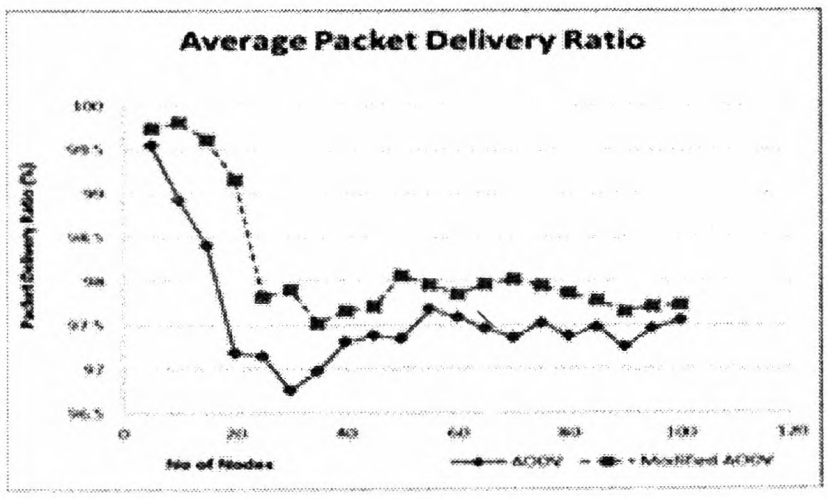

Fig. 2 Average Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the fractions of packets sent by the source to that are successfully received by the receiver. The PDR should be high in a reliable, highly performing routing protocol. All the packets which are sent are more likely to be delivered than in regular AODV. The simulation results of PDR up to 100 nodes for existing AODV and modified AODV are given in Fig. 2. When the numbers of nodes are increasing the PDR gradually decreases in both existing and modified AODV due to the dynamic nature.

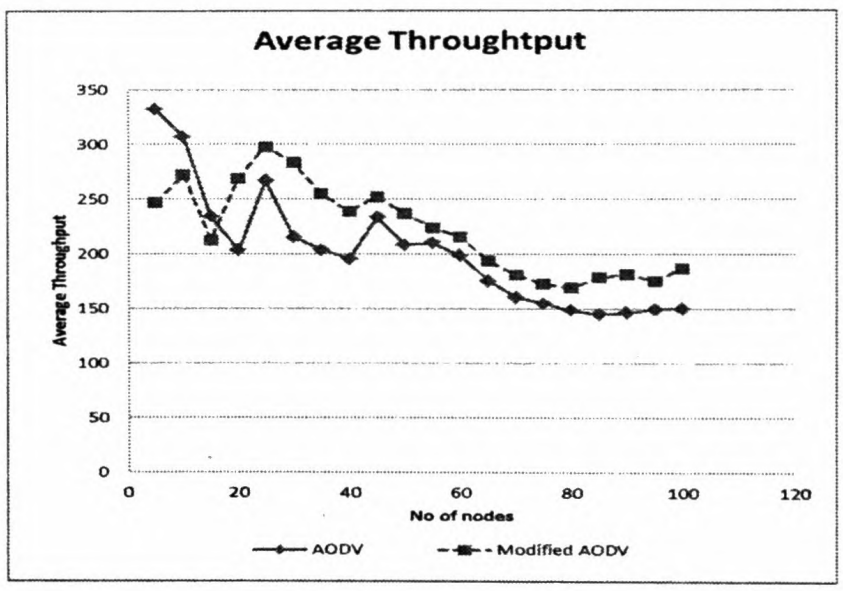

Fig. 3 Average Throughput

Network throughput is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second and sometimes in data packets per second or data packets per time slot [15].It is one of the dimensional parameters of the network which gives the fraction of the channel capacity used for useful transmission. The throughput should be a higher value to have a better performance of a routing protocol.

The graph (Fig. 3.) is obtained by calculating the aggregate of all the received packets in the network within a particular defined time period. The Average Throughput of the modified AODV is higher than the Average Throughput of the existing AODV.

Simulation results indicate that the proposed scheme provides robustness to mobility and enhances protocol performance. The modified AODV protocol shows average improvements. The scenarios are randomly generated and their topology can vary immensely from scenario to scenario, the performance of the new protocol may differ significantly from scenario to scenario.

V. CONCLUSIONS

The energy consumed by the mobile nodes in MANET is mostly dependent on the using routing protocols. The Ad-hoc routing protocols determine which nodes will forward packets and the amount of routing overhead each node needs. Efficient battery management, transmission power management and system power management are the major factors of increasing the life of a node. The shortest routes do not always provide the best performance, especially when there are congested nodes along these routes. By considering the remaining battery power of the existing nodes in the ad-hoc network when selecting the most reliable/best path the performance on the data communication of the ad-hoc network can be improved.

This research proposes a modified AODV algorithm solution for MANET with additional mechanism that consumes low energy in packet routing. The newly implemented, modified AODV routing protocol performs well on assessment of energy consumption for the MANETs with high node mobility. Nodes in MANETs are battery operated that have access to a limited amount of energy. In this research the energy based Ad-hoc On-Demand routing algorithm balances energy among nodes and a minimum energy level is maintained among nodes and the lifetime of the nodes are increased. This paper presents an idea to determine the best path based on the cumulative residual energy available in nodes.

According to the results that have been obtained from simulation of the modified AODV gives significant variation of the AODV protocol in terms of PDR, End-to-End Delay and Average Throughput. It has demonstrated excellent energy and delay assurance while at the same time achieving higher packet delivery ratio and lower packet loss than the existing protocol.

When the existing wireless node density increases the nodes need more time for the route discovery and data transmission process and the end-to-end delay gradually increases, PDR decreases and throughput decreases. Another major considerable issue is the decrement of node energy. The remaining energy of the wireless nodes discharges a lot when the node density increases because the nodes need more energy for route discovery process with lots of nodes in the area with their random position changes.

Ad-Hoc networks provide QoS support in terms of bandwidth and delay. The modified AODV provides a high QoS be providing a higher throughput, lower delay and a higher PDR.

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