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Achieving Energy Efficiency in MANETs by Using Load Balancing Approach

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ABSTRACT

Mobile Ad Hoc networks have no base station and use multihop routing for transmission of data from a source node to its destination node. To make this multi-hop routing mechanism possible we need a routing protocol. We have adopted load balancing technique that can improve the overall performance for communication in a network. We have presented optimum performance for our novel protocol i.e. Energy Efficient Load Balanced (EFLBAODV) and compared it to the traditionally existing reactive routing protocol Ad Hoc on Demand Distance Vector (AODV) thus using the load balancing technique to improve the node to node communication in our network. Also our routing protocol will be energy efficient as it will minimize the communication time and overheads thus utilizing the energy resources. Some important metrics like route discovery time, route errors, MAC delay, network load, end-to-end delay and throughput have been taken to evaluate the overall improvement in the novel protocol.

Keywords: *MANET; Ad Hoc On-demand Distance Vector (AODV), Multi-hop Routing, Load Balancing, Energy Efficiency, Energy Efficient Load Balanced AODV (EFLBAODV).*

1 INTRODUCTION

A special network containing mobile nodes in a wireless network is known as a mobile Ad Hoc network (MANET). A MANET does not need any sort of infrastructure or any centralized administration for its communication between nodes. This type of network is very useful in some emergency or urgent requirement of a temporary network. MANETs can play an important role in some war between two countries or some disaster struck areas where infrastructure cannot be provided. Also MANETs can be implemented and be useful in everyday mobile nodes in any mobile network. MANETs use multi hop system for communication from a source node to a destination node. But in such a case we have limited resources which mainly include the battery timing and bandwidth required for communication. Another issue in MANETs is the continuously changing mobile topology which causes many hazards and links are lost very quickly in many cases. We need a mechanism is our routing to transmit data quickly and efficiently so minimum time will be required to transmit data between a source and a destination and we will get an optimized result and also energy consumption will be reduced as well as our performance will increase[1][2]. Many reactive, proactive and hybrid approaches are used with MANETs but the ultimate goal is to increase the efficiency of a network and increase the performance. Throughput is a measure of successful packet delivery in a network [3][4].

2 MANET ROUTING PROTOCOLS

Routing protocol is the basic feature for performance evaluation in mobile adhoc networks. Many reactive, proactive and hybrid approaches have been developed and are being used. Over the years the protocols which have been implemented include AODV, DSDV, OLSR, DSR, GRP, TORA etc for communication. We have used the scenarios employed by AODV for overall performance evaluation and comparing it with the novel protocol Energy Efficient Load Balanced AODV (EFLBAODV)

2.1 Ad Hoc on demand distance vector (AODV)

AODV is reactive routing protocol [5].By reactive we mean AODV searches its paths on demand. Reactive approach is considered better than proactive approach as no signaling information is required in route maintenance. Only signaling is done on demand when we need a path from source to destination. AODV uses different message types route request (RREQ), route reply (RREP), route error (RERR) and acknowledgement message (RACK) [6]. Initially RREQ messages are broadcasted on demand and when destination is found the destination unicast's a RREP message [7] back to the source, and then a route is created for communication. Destination asks for acknowledgement from source if there is some doubt in the path being used. In case of link breakage AODV returns a RERR message [6], [7] to the destination. AODV uses sequence number with its routing packets to avoid loops in a network that were a big hazard in legacy routing algorithms. Figure 1 below shows general working of AODV i.e. initially the source node broadcasting a route request throughout the network with the help of intermediate nodes. When request reaches the desired destination it unicasts a route reply and a path for communication is established. Also a broken link is shown in Figure 1 and the node that comes before the broken link sends back a route error message to the source node [7].

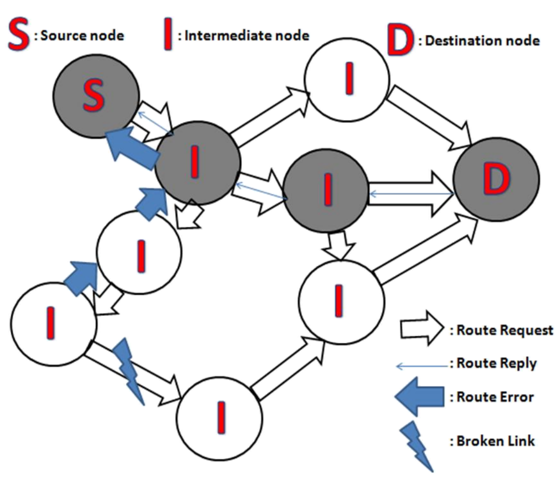

Fig.1. Working mechanism of AODV

2.2 Energy Efficient Load Balanced AODV (EFLBAODV)

When multiple paths are available for routing network traffic then using them for communication can bring some useful results. Load in a network leads to congestion and more routing errors are generated which leads to data and communication losses [8]. EFLBAODV uses multiple paths to reduce congestion and routing hazards. EFLBAODV uses the same reactive routing approach similar to AODV with slight changes. The difference comes when EFLBAODV uses multiple paths for transmission of data across the network making the overall progress better and more efficient than AODV. EFLBAODV will initially broadcast route request (RREQ) packets across the network to find routes to the desired destination. Now the route reply(RREP) instead of coming by a single path will be coming by multiple paths. Routes for data transmission will be selected with same number of hops and same bandwidth. Route error (RERR) message will be generated if a path is lost during communication. By use of multi paths EFLBAODV reduces communication time increases throughput and saves energy in a network during data transmission by shortening the battery time required for communication. Figure 2 shown below shows working mechanism of EFLBAODV by using multiple paths work load is being divided into multiple paths and highlighted nodes show paths being used for communication. By this division of work load between multiple nodes saves times as data transmission is much quicker between a source and destination and link breakages do not affect the entire transmission so by consuming less energy source time this routing mechanism becomes more energy efficient than the original AODV.

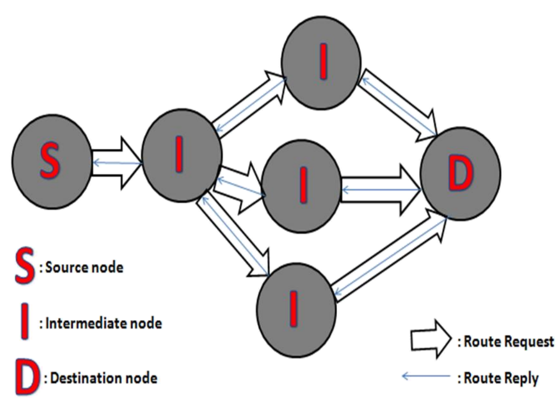

Fig. 2. Working mechanism of EFLBAODV

3 SIMULATION RESULTS AND COMPARISONS

In this portion, we will simulate both AODV and EFLBAODV and then make comparisons and analysis to prove that load balancing can make AODV working more efficient. We have chosen OPNET modeler 14.5 for our analysis which can produce very efficient and good results. We selected an area of 100 meter x 100 meter with 30 mobile nodes with vector trajectory dealing with various applications as discussed below in application parameter table. First we will set some parameters to simulate our desired results [9]. Simulation parameters and applications running in the network are given below with their respective values used.

3.1 Simulation parameters

The parameters considered in our scenarios for simulation environments as in Table 1.

Table 1: Simulation Parameters

Environment parameter	Value
Medium Access Control Protocol	IEEE 802.11 b
Area Size of Environment	100m X 100m
Number of nodes (N)	30
Bandwidth	1 Mb/sec
Node Transmission Range	1500 meters
MANET Trajectory	Vector
Transport Layer Protocol	TCP
Mobility Model	Random Waypoint
Simulation Time	1800 seconds

3.2 Application parameters

We have considered the mentioned applications for different types of corresponding traffic as given in Table 2.

Table 2: Application Parameters

Application	Traffic
FTP	High Load
Video Conferencing	High resolution video
Voice	GSM Quality
Http	Image Browsing
Database	High Load
Printing	Color prints
Email	High Load
Remote Login	High Load

3.3 Route Discovery

The total time required to discover a route for communication is known as the route discovery time. By total time we mean the time taken by source node to broadcast its request up to the time when source receives a route reply from destination.

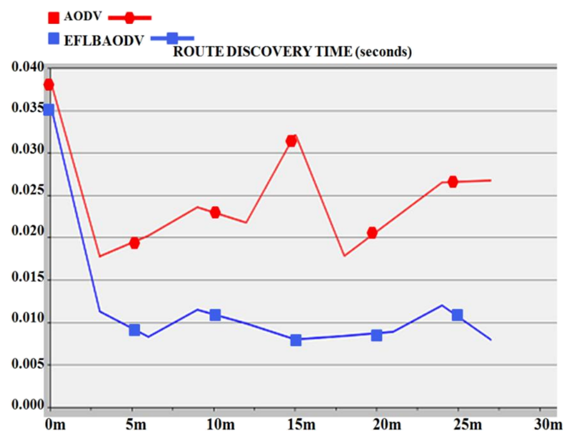

Fig.3. Route discovery time AODV vs. EFLBAODV

In the above figure 3 we observe that route discovery time for EFLBAODV is clearly less than AODV. If we analyze after every 5 minute interval we see that after 5 minutes time EFLBAODV takes 9 milliseconds to discover a new route whereas AODV takes 19 milliseconds. Then after 10 minutes we see that EFLBAODV takes 11 milliseconds to discover a route and AODV takes about 23 milliseconds, then after 15 minutes EFLBAODV takes 9 milliseconds and AODV takes 32 milliseconds, after 20 minutes time EFLBAODV takes 9 milliseconds and AODV takes 21mili-seconds and after 25 minutes time EFLBAODV takes 11 milliseconds and AODV takes 27 milliseconds to discover routes for communication. Hence when we take an approximate average value for route discovery time from the above results we observe that EFLBAODV takes 9.8 milliseconds and AODV takes 24.4 milliseconds approximately. This clearly shows that EFLBAODV is much better approach than AODV as EFLBAODV searches paths much quicker for communication than AODV and this quality makes it more energy efficient than AODV as less signaling overhead is required for discovering new routes for communication and battery time is saved as compared to AODV.

3.4 Route Errors

Every node sends signaling information to its neighbor when discovering a route or for checking connectivity when a node does not get a response from its neighboring node it generates a route error message.

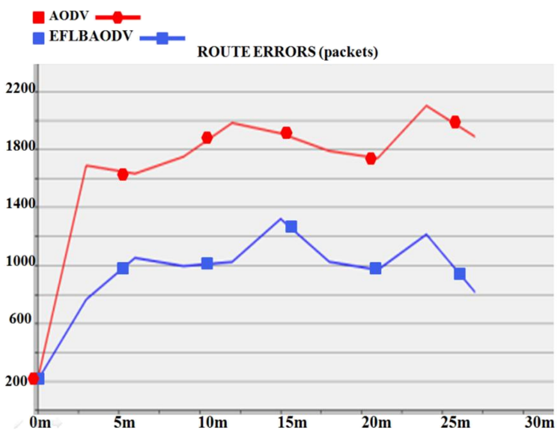

Fig.4. Total route errors EFLBAODV vs. AODV

Figure 4 shows route errors send during the communication due to broken links or lost paths. We exclude the initial result at 0 minutes. When we analyze the graph we see that after initial 5 minutes EFLBAODV has sent 1000 route errors and AODV has sent 1650 route errors, after 10 minutes time EFLBAODV has sent 1025 route errors and AODV has sent 1900 route errors, after 15 minutes time EFLBAODV has sent 1300 route errors and AODV has sent 1950 route errors, after 20 minutes EFLBAODV has sent 1000 route errors and AODV has sent 1780 route errors, after 25 minutes time EFLBAODV has sent 980 route errors and AODV has sent1900 route errors. When we take an average value from these results EFLBAODV produces 1061 route error packets and AODV produces 1836 route error packets approximately. From these results we can conclude that EFLBAODV is more reliable that AODV as it has generated lesser errors than AODV.

3.5 Delay

By delay we mean End-to-end delay of MANET packets which are used in communication [4]. The time during which a packet is created at the source and reaches destination is known as End-to-end delay. This can also be said the total time required by a MANET packet to communicate successfully in a network is its delay time. End-to-end delay is a combination of various other types of delays including propagation delay, processing delay and transmission delay.

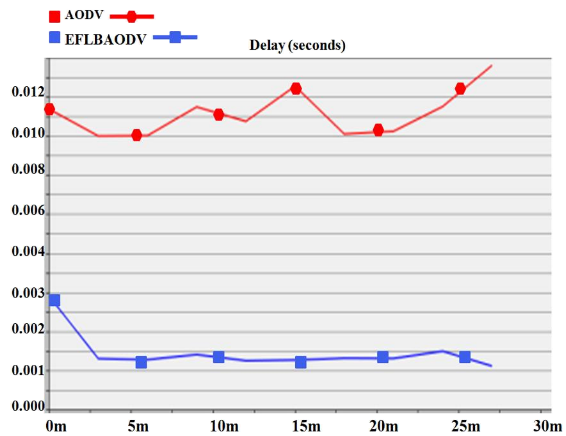

Fig.5. Delay EFLBAODV vs. AODV

In the above Figure 5 we can see delay curves for EFLBAODV and AODV. When we analyze it we see that initial delay is 3 milliseconds EFLBAODV and 11milliseconds for AODV, after 5 minutes we see EFLBAODV has delay of 1.4 milliseconds and AODV has 10 milliseconds, after 10 minutes we see that EFLBAODV has delay 1.4 milliseconds and AODV has 11mili-seconds, after 15 minutes EFLBAODV has 1.4 milliseconds delay and AODV has 12.5 milliseconds delay, after 20 minutes EFLABAODV has 1.4 milliseconds delay and AODV has 11 milliseconds delay, after 25 minutes time EFLBAODV has 1.4 milliseconds delay and AODV has 13 milliseconds delay. On average EFLBAODV takes 1.6 milliseconds and AODV takes 11.41 milliseconds. So it is quite clear from these observations that EFLBAODV has relatively quite smaller delay time as compared to AODV. So EFLBAODV uses minimum time for communication as it uses fewer resources and utilizes energy source for less amount of time and is more energy efficient.

3.6 MAC delay

MAC delays are responsible for representing the total of queuing and contention delays of the data, management, delayed Block-ACK and Block-ACK Request frames transmitted in the network. Delay is calculated as the duration from the time when it is inserted into the transmission queue, which is arrival time for higher layer data packets and creation time for all other frames types, until the time when the frame is sent to the physical layer for the first time.

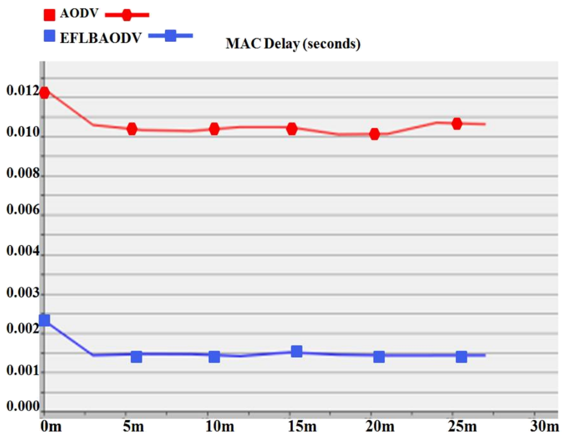

Fig. 6. MAC delay EFLBAODV vs. AODV

In the above Figure 6 we can see the comparative MAC delays for AODV and EFLBAODV. If we observe the simulation results at different intervals we see that initially EFLBAODV gives a MAC delay of 2.5 milliseconds and AODV gives about 12.2milliseconds. After 5 minutes EFLBAODV gives MAC delay of 1.5milliseconds and AODV gives 10.5 milliseconds. When 10 minutes pass EFLBAODV gives 1.5milliseconds and AODV gives 10.5 milliseconds and after 15 minutes EFLBAODV gives 1.5 milliseconds and AODV gives 10.5 milliseconds. After 20 minutes time EFLBAODV gives a MAC delay of 1.5 milliseconds and AODV gives 10.2 milliseconds. When 25minutes pass EFLODV gives a MAC delay of 1.5 milliseconds and AODV gives 10.4 milliseconds. On average EFLBAODV gives an approximate MAC delay of 1.6milli-seconds and AODV produces a MAC delay of 10.7 milliseconds. So it is evident from these results that EFLBAODV has minimum MAC delay as compared to AODV which is a proof of its node to node communication efficiency.

3.7 Network Load

Efficient networks can easily handle large traffic being communicated. But when it becomes difficult to handle traffic for a network then the condition of high network load occurs. When network load is high MANET communication is badly affected as communication packets slow down and collisions between control packets start which initiates another hazard. Network load is expressed as number of bits/sec being transmitted.

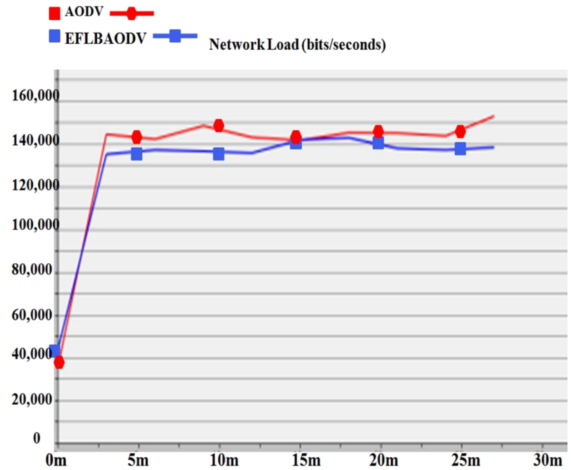

Fig.7. Network Load EFLBAODV vs. AODV

Above Figure 7 shows a simulation comparison of network load represented in bits/second for EFLBAODV and AODV. Initially EFLBAODV has a load of 40,000 bps and AODV has 39,000 bps, after 5 minutes time EFLBAODV has a load of 138,000 bps and AODV has a load of 142,000 bps. After 10 minutes EFLBAODV has a load of 138,000 bps and AODV has a load of 148,000 bps, if we check after 15 minutes we see that EFLBAODV has a network load of 150,000 bps and AODV has a load of 142,000 bps. After 20 minutes we see that EFLBAODV has a load of 150,000 bps and AODV has a load of 145,000 bps and after 25 minutes time EFLBAODV has a load of 139,000 bps and AODV has a network load of 146,000 bps. To conclude this graph we take an average value from these readings EFLBAODV gives an approximate network load value of 1, 25,833 bps or 0.125 mbps and AODV gives 127000 bps or 0.127 mbps. So it can be concluded from these results that EFLBAODV has lesser network load than AODV.

3.8 Throughput

Throughput can be defined as the ratio of total data sent from source and received by the destination [4]. Throughput can be defined as bytes/second (bytes per second) or bits/second (bits per second). Throughput is definitely affected by randomly changing topology or sudden changes made in short time intervals, also if we have limited bandwidth that also affects the overall throughput of our system. Similarly if we have some energy issue in the network that also is a hazard for the final resulting throughput of a certain network.

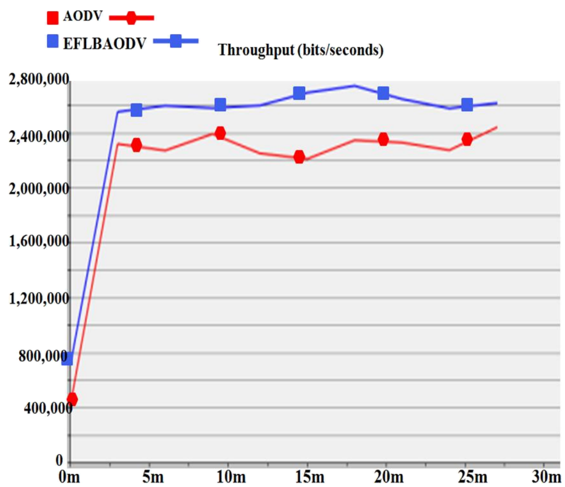

Fig..8 Throughput EFLBAODV vs. AODV

In the above figure 8 we can see the comparative throughputs of EFLBAODV and AODV. Initially EFLBAODV shows throughput of 0.75Mbps and AODV has 0.48 Mbps. After 5minutes time we see that EFLBAODV has a throughput of 2.58 Mbps and AODV has 2.3 Mbps, after 10 minutes time EFLBAODV has throughput of 2.6 Mbps and AODV has 2.4 Mbps. If we see after 15 minutes time we observe EFLBAODV throughput is 2.7 Mbps and AODV has 2.2 Mbps, after 20 minutes time EFLBAODV has a throughput of 2.7 Mbps and AODV has 2.37 Mbps. After 25 minutes time EFLBAODV has a throughput of 2.6 Mbps and AODV has 2.37 Mbps. If we calculate an average value for both we get EFLBAODV has a throughput of 2.32 Mbps and AODV has 2.02 Mbps approximately, so we can conclude from these results that EFLBAODV performs better than AODV.

4 CONCLUSIONS AND FUTURE WORK

In this paper we discussed energy efficient AODV which used load balancing. Load balancing itself used multiple paths to divide the workload. By this concept of workload division we have seen that efficiency of AODV increased to a certain level and we got the desired optimization in EFLBAODV. When we compared different metrics EFLBAODV proved to be better than AODV in route discovering EFLBAODV took only 9.8 milliseconds to find new route for communication whereas AODV took 24.4 milliseconds to discover a new path for communication on average. When we checked route error packets EFLBAODV produced 1061 route error messages and AODV produced 1836 route error messages. When we compared end-to-end delay we observed EFLBAODV had a delay of 1.6 milliseconds and AODV had 11.41 milliseconds delay time in communication. When we checked MAC delay time for node to node communication we observed EFLBAODV had a MAC delay of 1.6 milliseconds and AODV produces a MAC delay of 10.7 milliseconds. In network load EFLBAODV gave an approximate network load value of 1, 25,833 bps or 0.125 Mbps and AODV gave 127000 bps or 0.127 Mbps and finally for throughput EFLBAODV had a throughput of 2.6 Mbps and AODV had 2.37 Mbps. Hence we concluded from these results that EFLBAODV proved to be better than AODV in all aspects and transmitted data over the network quickly, effectively and efficiently by using multiple paths, saved time and resources and produced energy efficient results than AODV. If we implement this technique in AODV protocol and make it a standard for it then AODV can produce much better communication results then it is producing at present. EFLBAODV can be very useful in heavy traffic applications using video conferencing on Skype or some live streaming on YouTube or any other streaming source or downloading data from the internet using any download manager e.g. IDM (Internet download manager) as quick transfer of data on multiple paths will increase performance as data will be transmitted quickly from source to destination and reduction is transmission time will lead to energy efficiency as less power would be consumed.

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