Indian Journal of Science and Technology, *Vol 10(10), DOI: 10.17485/ijst/2017/v10i10/100498, March 2017*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Energy Efficient AODV for Backup Route Selection in MANETs

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Abstract

Objectives: In this paper, a backup routing solution in which routes are selected based on their energy efficiency is presented. **Methods:** The selection of nodes is based on energy efficiency. Nodes that are nearest to the failed node are found out and checked for their energy efficiency. Depending on whether nodes are energy efficient or not, they are classified as alive or dead. The selected node is then used for data transmission to the destination. Backup routing is done with the help of alive or energy efficient nodes. These nodes are first chosen based on how close they are from the failed node and then the energy available with them is checked. It is shown through experimental results that the obtained QoS parameters are better than the traditional routing protocols. **Findings:** It is found that after 6000 rounds of transmission, in a MANET of size 100 nodes, throughput obtained with energy efficient AODV BR protocol is 107800 bits. Also, PDF obtained is 0.187 and end to end delay is 0.05422 secs after 6000 rounds. **Applications:** MANETs find use in education purpose like e-classrooms, in war zones, in disaster affected areas or even in places where the cost of establishing a setup needs to be minimized. MANETs have diverse applications such as in warfare, earthquake or disaster stricken areas etc. and require good Quality of Service (QoS) parameters. The existing work provides QoS parameters when the link is not broken. However it is desirable to provide a system that continues to provide good QoS parameters even when the existing link fails. In this paper efforts have been made to provide for such a system that searches for an alternate link on failure of the main route based on certain energy efficiency criteria such that the network provides good QoS parameters in various applications.

Keywords: AODV, AODV BR, DSR, Energy Efficient, Routing Protocols

1. Introduction

MANETs are a network of self-configuring nodes that can be dynamically established. Support of any fixed infrastructure is not needed in setting up of MANETs. The nodes in MANETs themselves act as router to send and receive data or multimedia packets. Since any fixed infrastructure support is not needed, the cost of setting up of MANETs is tremendously reduced. Also, MANETs can be easily setup during an emergency situation, disaster and relief operations, in difficult terrains etc. The ease of setting up of MANETs and minimal requirement of infrastructure during setup and operations has made MANETs quite popular.

MANETs can be classified as either single-hop or multi-hop. In single-hop MANETs, only nodes that are in broadcast range of each other can communicate. Information exchange through packet transmission has

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become imminent with increasing number of users in MANETs. Moreover, since people using MANET technology has increased rapidly, it has become necessary to develop devices that can communicate with other nodes not in communication range of each other. Multi-hop communication is important in vehicle-to-vehicle communication, smart phone ad hoc networks (SPANs), military as well as tactical setup etc. To support various applications it is required that MANETs must be supported by efficient routing protocols. MANET routing protocols should also provide good QoS parameters. They are table driven or proactive routing protocols and reactive routing protocols. In proactive routing protocols network information is maintained in the form of routing tables. However, in a dynamic changing system it is not possible to save information of all nodes. Moreover, bandwidth consumption and resource constraints are also very high. Reactive routing protocols only start a search for new routes when it is demanded. This means alternate paths are found out in the absence or in the case of breakdown of the existing link. This type of a system saves up on resources as well as bandwidth and thus suits MANETs.

Ad Hoc On Demand Distance Vector (AODV) protocol and Dynamic Source Routing (DSR) protocol are the ones that are most popular or quite commonly used for ad hoc networks[1]. Although AODV and DSR protocols perform better than proactive routing protocols but they do not find any solutions to route failure. In AODV as well as DSR protocols, main route failure leads to loss of packets and in turn poor QoS parameters.

It is imperative for MANETs to have good QoS parameters to support applications like video conferencing, multimedia transmission etc[2]. Improved routing protocols and better route selection criteria play a key role in improvement of QoS parameters. Lee had earlier proposed a backup routing scheme called Ad Hoc On Demand Distance Vector Backup Routing Protocol (AODV BR). AODV BR protocol gives the provision of an alternate route that comes into implementation when the originally selected route faces a problem. AODV BR protocol showed improved results than the other reactive routing protocols. However, there was no specific criteria for proper selection of routes. In other words, selection of nodes that can work as backup routes were not based on energy efficiency of the nodes or any such scheme.

The paper is organized as follows: In section 2, existing work on routing and backup protocols are discussed. In Section 3, energy efficient routing proposed in this paper is presented. Obtained results are discussed in section 4. Finally, the conclusion of the paper is presented in section 5.

2. Routing and Backup Protocols

Routing protocols are mainly classified as proactive and reactive. Proactive or table driven protocols require more bandwidth as well as resources. This is because information about routes and nodes are stored in a tabular form. Table driven routing protocol facilitates the provision of routes immediately when data packets have to be transferred. However, in MANETs where position of nodes is not constant, maintaining routing tables also results in high bandwidth consumption as well as overhead[3]. On the other hand, reactive routing protocols maintain information for active routes only. As there is no need of maintaining routing tables, so control overhead is reduced. AODV and DSR are two prominent reactive routing protocols. AODV protocol was inherently derived from Direct Sequence Distance Vector (DSDV) protocol and DSR protocols[4]. DSDV is a proactive routing protocol and an extended version of Bellman-Ford algorithm. AODV protocol uses periodic beaconing and sequence numbering procedure for sending the packets to the destination[5]. Routes are established only when there is a requirement of data transfer[6]. So, bandwidth consumption is reduced drastically. However, backup routes or solutions in case of main route failure was not provided. In DSR protocol route cache is used by intermediate nodes for finding a way o the destination[7]. In DSR protocol also, the routes are established as and when necessary leading to saving of resources and reduction of control overheads. However, maintenance of route cache information is extremely important in dynamic systems like MANETs. Moreover, backup routing provision and other related solutions are not provided in DSR protocol.

AODV BR protocol took the first step in providing backup routes in case of node failure[8]. Here, a mesh like structure is provided wherein neighbouring nodes overhear the packets that are being transmitted and in this way alternate route may be established as and when required. AODV BR protocol provided a better solution than AODV protocol. However, backup nodes are not selected on a distance and energy efficiency criteria. In AODV BR protocol on failure of the backup route packets cannot be delivered to the destination leading to loss and error in the network. Dynamic Backup Routes Routing Protocol (DBR[2]P) reconstructed several routes from source to destination so that on failure of the main route other routes are available for packets to reach the destination. Presence of multiple routes results in less packet loss as apart from the main route there are other paths through which data packets can reach the destination[9]. However, multiple paths leading to the same destination may lead to overflowing of the same information in the system. This, in turn, results in more resource consumption. Another protocol SMORT (Scalable Multipath on Demand Routing for Mobile Ad hoc Networks) provided intermediate nodes on the main path with multiple routes to the destination in case the primary path fails. However, flooding in the network due to the presence of multiple nodes remained a concern when SMORT protocol is implemented for MANETs[10].

3. Proposed Solution

In this paper an energy efficient routing criteria has been proposed for route selection when the main route fails during data transmission in MANETs. The protocol is mainly based on AODV routing. During AODV routing when the main route to the destination fails, the process of finding the backup route starts. Simulation has been performed in MATLAB.

After route or node failure, an alternate active node needs to be found out for transmitting or rerouting data packets. This is done using distance vector calculation[11]. Average distance between the transmitting device and destination is calculated from the following formula

$$D_{bs} = \frac{one\ dimension\ of\ field}{\sqrt{2\pi k}} \quad (k = 1) \tag{1}$$

The node found out using distance vector calculation is then checked for its energy efficiency[12].

$$Threshold\ Distance\ Calculation\ E(c) = \sqrt{\frac{E_{fs}}{Emp}} \tag{2}$$

E_{fs} = amplifier energy consumptions for a short distance transmission

E_{mp} = represents transmit amplifier energy

E_a = represents the average energy of a node after a particular round

$$E_a = E_t \times \left(\frac{1 - \left(\frac{r}{R_{max}} \right)}{n} \right) \tag{3}$$

Following algorithm was formulated and implemented for simulation

3.1 Algorithm

Step 1: Various parameters (n, speed, E_{fs}, E_{mp}) are initialized

Step 2: All nodes are initialized with a certain initial energy

Step 3: Node are randomly placed in a MANET of $100\ m \times 100\ m$ area

Step 4: Set mobility of devices

Step 5: Set source and destination node

Step 6: Distance between nodes is calculated to find the node nearest to the failed node

Step 7: Transmit data packets from source to destination

Step 8: If next node is destination, packets are successfully transmitted

Else

next nearest node is found using distance vector calculation

energy of the node is checked

If energy of the node is less than the set threshold energy,

node is rejected

Return, Else continue step 8 until all packets are transferred

A $100\ m \times 100\ m$ field area has been considered for simulating a MANET setup. The MANET considered here is dense. Number of nodes for simulation can be varied. However, here 100 nodes placed indiscriminately at various points in the setup are considered for simulation. 4000 packets are to be transmitted with initial energy of the nodes being 0.5 J. Table 1 required parameters for simulation are given.

Figure 1 depicts the random placement of nodes before simulation begins. A Graphical User Interface (GUI) is used so that values for simulation can be entered conveniently. GUI also facilitates observing random movement of nodes, distance calculation of nodes and results obtained with different protocols clearly. Figure 1, the red nodes depict the source as well as various intermediate nodes. Blue node is the destination node and is initially paced at the center.

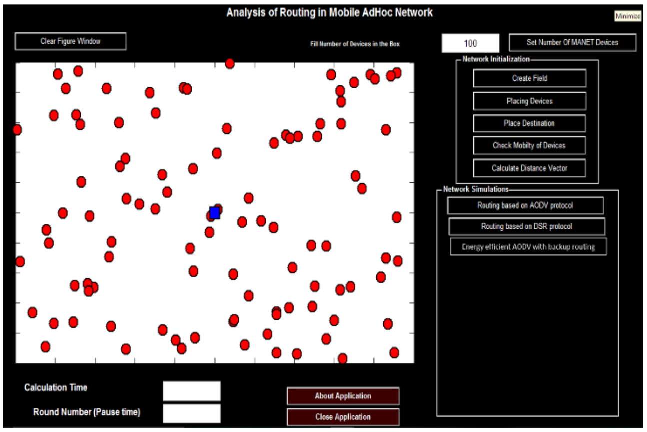

Figure 1. Random Placement of Nodes.

4. Performance Evaluation

4.1 Throughput

Throughput is the units of information that can be processed in a given duration of time[13]. The protocol that processes more number of units in a given time duration is said to perform better. Figure 2 shows throughput obtained when AODV, DSR and energy efficient AODV backup routing protocol is simulated. As can be seen from the graph, throughput obtained is maximum for energy efficient backup routing followed by AODV and then DSR. After 2000 rounds, throughput obtained with DSR protocol is 43060 bits transmitted. With AODV protocol, throughput obtained after 2000 rounds is 74780 bits. However, throughput obtained is highest with energy efficient backup routing, its value being 107800 bits after 2000 rounds, 109800 bits after 4000 rounds and 110700 bits after 6000 rounds.

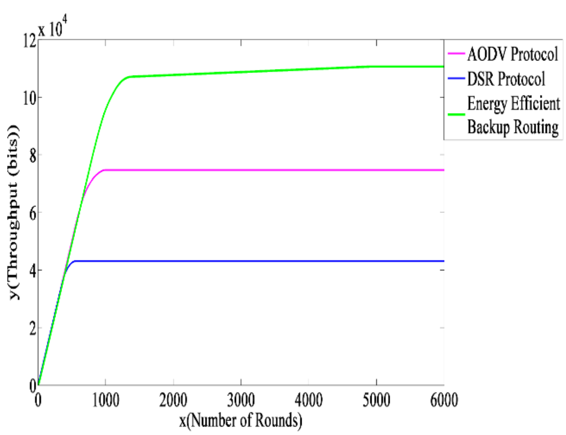

Figure 2. Throughput v/s Number of Rounds.

4.2 End to End Delay

Result obtained after simulation with AODV, DSR and energy efficient backup routing is shown in Figure 3. Delay obtained with DSR protocol is 0.04645 secs after 2000 rounds, 0.0929 secs after 4000 rounds and 0.1393 secs after 6000 rounds. In case of AODV protocol delay after 2000 rounds is 0.02674 secs, after 4000 rounds it is 0.05349 secs and after 6000 rounds it is 0.0813 secs. End to end delay obtained is least with energy efficient backup routing with delay of 0.01856 secs after 2000 rounds, 0.03644 secs after 4000 rounds and 0.05422 secs after 6000 rounds.

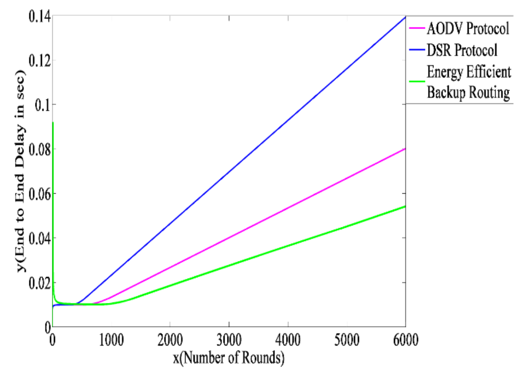

Figure 3. End to End Delay v/s Number of Rounds.

4.3 Packet Delivery Fraction

From Figure 4 it can be observed that highest value of PDF is obtained with energy efficient backup routing. PDF is 0.2694 after 2000 rounds, 0.2744 after 4000 rounds and 0.2766 after 6000 rounds. In case of DSR protocol, PDF obtained is 0.1076 after 2000 rounds and remains constant thereafter. With AODV protocol, PDF is 0.187 after 2000 rounds and remains constant afterwards.

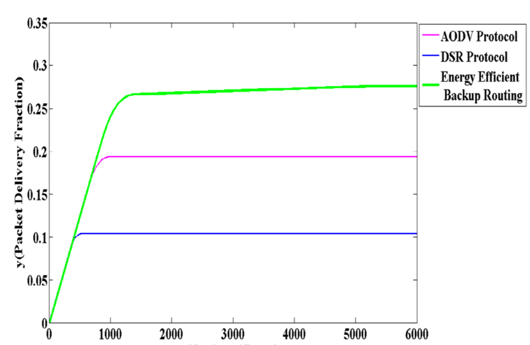

Figure 4. PDF v/s Number of Rounds.

4.4 Lifetime of Devices

Figure 5 shows lifetime of devices. It is the total time duration from start of data transmission till the time node has sufficient energy for data transmission. More the number of nodes available per round, better will be the data transmission. The number of energy efficient or alive devices is maximum in case of energy efficient backup routing and least for DSR protocol.

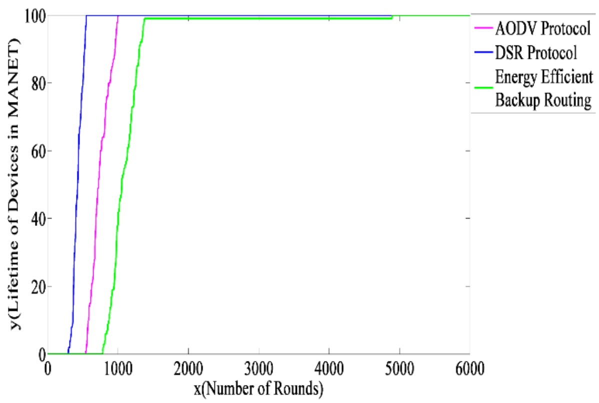

Figure 5. Lifetime of Devices v/s Number of Rounds.

5. Summary

In this paper, an energy efficient AODV backup routing scheme has been proposed. The backup scheme described in this paper helps in searching a node that is efficient enough to carry out data transmission when route failure occurs. The proposed scheme is better than the already existing routing protocols as it provides a backup for packet transfer in case of route failure. Moreover, proper selection of backup node on a distance and energy criteria also minimizes the chances of route failure. It can be deduced that using distance and energy efficient criteria a better backup as well as routing scheme can be obtained for MANETs.

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