Energy Efficient Reliable Routing Considering Drain Rate and Residual Battery Energy in Ad Hoc Networks

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Abstract— Ad-hoc networks has become a hot topic in the research world. Routing in ad-hoc networks has faced so many problems due to the peculiar nature of ad hoc environments. In this paper a new energy efficient routing protocol based on residual battery energy and drain rate is proposed. This paper considers the protocol proposed in [1] as the base protocol and overcomes the problems in that protocol by effectively including drain rate in the calculation of link cost. The simulation results show that the proposed protocol reduces the energy consumption, provides reliable routing as well as increases the network lifetime.

Key words: Drain Rate, Ad Hoc Networks, PDR

I. INTRODUCTION

Ad hoc networks are temporary wireless networks normally formed at emergency situations where there are no centralized authorities like base station or access points. Ad hoc networks have special characteristics. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Ad Hoc networks are used for creating temporary networks. The main application areas of Ad-hoc networks are; Creation of instant infrastructure, Disaster relief, network connection to remote areas where installation of base station is not feasible. An ad hoc network consists of nodes which are free to move. The nodes may be anywhere, in airplane, ships, trucks, cars even on every people. Routing in such a type of network is challenging. The nodes are battery operated, hence a routing protocol designed for ad hoc networks, should not consume more energy. The route selected should include nodes with enough energy so that the data will reach the destination without any interruption. In ad hoc networks failure of a node due to energy loss may create a bad impact on the network performance. Hence designing a routing protocol which reduces the energy cost, increases the reliability and increases network life time is very challenging. This paper proposes a new routing protocol based on drain rate and residual battery power. It considers minute details like energy consumed by transmitter unit, reception unit, acknowledgement, retransmissions etc. for calculating the energy cost. Thus becomes a unique approach as opposed to existing approaches. This paper is organized as follows. Section 2 explains some of the existing approaches to energy efficient routing in ad hoc networks. Section 3 discusses the design of the proposed protocol. Section 4 gives the simulation results and analysis. Section 5 concludes the paper.

II. RELATED WORK

Energy efficient routing in ad hoc networks has been a research topic for long years. Many protocols were proposed during the last 10 years. All the protocols were aiming at reducing the energy consumption [2], [3], [4], [5], [6], [7]).or, reducing the network portioning time [8], [9], [10], [11], [12], [13], [14], [15]).or increasing the reliability of routes[4], [5], [6], [7]. The protocols which aim to reduce energy consumption in the route does not consider reliability of the path or network partition due to over load at some nodes. Protocol which aim to reduce network partitioning and increase the reliability of the route does not reduce the energy consumption. So a new protocol which needs to consider the following factors 1. Reducing the energy consumption 2. Increase the network life time 3. Increase the reliability of the route should be designed.

We propose a protocol based on a energy-aware routing algorithm (RMECR)[1] reliable minimum energy cost routing. RMECR finds energy efficient and reliable routes that increase the operational lifetime of the network. In the design of RMECR, they used an in-depth and detailed analytical model of the energy consumption of nodes. RMECR is proposed for networks with hop-by-hop (HBH) retransmissions providing link layer reliability, and networks with E2E retransmissions providing E2E reliability.

But RMECR has a major draw back. It does not consider drain rate of the battery power of nodes. This paper is based on RMECR, but includes drain rate also in the energy cost model.

III. PROTOCOL DESIGN

A. Assumptions and Network Model:

Network is assumed to be a graph G(V,E) with V- vertices and E- edges. Nodes are uniquely identified by identifiers. Each node is battery operated. The remaining battery energy of the node is say Cu. where u € V. The link between nodes u and v is represented by (u,v).

B. Objectives:

The objectives of the new protocol is

(1) To reduce energy consumption of the nodes
(2) To reduce the network partitioning time.
(3) To increase the reliability of the routes.

In order to achieve the objectives first an energy model is designed considering the following details.

(1) Energy dissipated at transmitter unit,
(2) Reception unit,
(3) Retransmissions,
(4) Acknowledgements,
(5) Residual energy of battery of nodes.
(6) Drain rate

This energy model can be incorporated with any routing protocol which uses Dijkstra’s algorithm. For simulations, we have used DSDV [16] (Destination Sequenced Distance Vector). DSDV selects routes only based on number of hops and sequence numbers. We have included the energy model that we have designed in to the existing DSDV to make it an energy efficient protocol.

C. Design:

The link weight is calculated as per equation (1)

$$W(u,v) = e_{u,v}(L_d) \quad (1)$$

where $e_{u,v}(L_d)$ is the energy consumption for transmitting data of length L_d from node u to v.

Equation 1 can be defined as

$$W(u,v) = \frac{a_{u,v}(L_d)}{(C_u/DR_u)} + \frac{b_{u,v}(L_d)}{(C_v/DR_v)} \quad (2)$$

Where $a_{u,v}(L_d)$ represents energy consumed for transmitting data of size L_d from node u to v by node u and c_u is the remaining energy of node u. DR_u *and* DR_v are the drain rates of nodes u and v respectively. $b_{u,v}(L_d)$ is the energy consumed for receiving data of size L_d from node u by node v and c_v is the remaining energy of node v.

Equation 2 can be further defined as

$$= \frac{(L_d)}{r} E\left[n_{u,v}(L_d)\right]\left(\frac{A_u+\frac{P_{u,v}}{K_u}}{(C_u/DR_u)} + \frac{B_v}{(C_v/DR_v)}\right) + \underline{(L_h)}\, E\left[m_{v,u}(L_h)\right]\left(\frac{A_v+\frac{P_{v,u}}{K_v}}{(C_v/DR_v)} + \frac{B_u}{(C_u/DR_u)}\right) \quad (3)$$

$E\left[n_{u,v}(L_d)\right]$ is the expected number of times that u needs to transmit a packet of length Ld [bit] to deliver it to v (including the first transmission), where $1 \leq n_{u,v}(L_d) \geq Q_u$ is the exact value. Furthermore, we assume is $E\left[m_{v,u}(L_h)\right]$ the expected number of ACKs of length Lh [bit] sent by v for the data packet to u, where $1 \leq m_{v,u}(L_h) \geq Q_u$ is the exact value. Note that Lh and Ld are known constant values. A_u *and* B_v are the power required to run the processing circuit at transmitter node and receiver circuit at receiver node respectively for data packets. $P_{u,v}$ is the transmission power from node u to v. K_u is the power efficiency of the amplifier. For simulations it is kept as 10%. r represents the data rate of wireless physical link. In the same way the next part of the equation are the parameters for transmitting and receiving the acknowledgement packet back from receiver to sending node.

The equation involves the impact of quality of links by considering number of retransmissions, the energy parameter of nodes by considering transmission circuit consumption, reception circuit consumption, the remaining battery power of nodes and drain rate of nodes. Thus equation 3 becomes a complete energy model.

IV. Simulation Results and Analysis

Simulation is done using ns2 [17]. The various parameters used for simulation are given in the Table 4.1

The parameters used for performance comparison are 1. Average energy consumption by all nodes in the network. 2. Packet delivery ratio. Average energy consumption is calculated by adding the energy consumed by all the nodes divided by number of nodes. A perl script is written to calculating the average energy by processing the trace file which we get as output by executing the (scenario).tcl file in ns2. Packet delivery ratio is the ratio of number of packets received to number of packets sent. Figure 4.1 shows the average energy consumption for 10 nodes. It proves that the proposed method is better since it considers drain rate of the nodes also as compared to the existing energy efficient routing protocol without considering drain rate. Figure 4.2 gives PDR packet delivery ratio and it also maintains a rate of 99.99%.

S.No	Parameter	Values
01	Number of nodes	10
02	Speed of nodes	10 m/s
03	Simulation time	200 s
04	Initial Energy	500 joules
05	Type of traffic	TCP
06	Number of connections	1

Table 4.1: Simulation parameters

Various graphs can be taken by changing the simulation parameters. Number of nodes, mobility is some of the example parameters which can be changed.

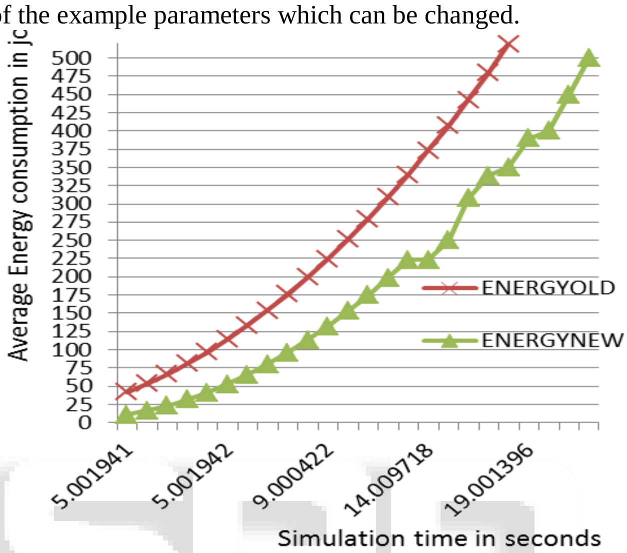

Fig 4.1: Average energy consumption by nodes Vs. simulation time

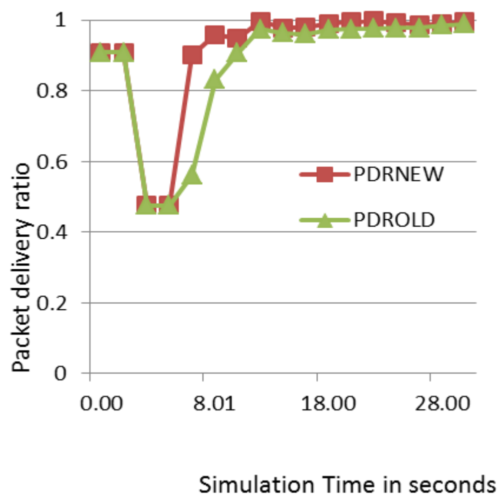

Fig. 4.2: PDR Vs Simulation time

V. Conclusion

This paper proposed a new energy efficient protocol considering both the residual energy and drain rate. It also considers minute details like energy consumption by transmitter circuit, reception circuit, energy consumption by retransmissions, acknowledgement transmissions etc which makes this protocol unique from other existing papers. The results also proved that this protocol outperforms the earlier protocol which is similar to this.

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