A Novel Energy Efficient Network Routing Protocol for Lifetime Improvements in Wireless Sensor Networks

Anil G.L [1] , J L Mazher Iqbal [2]

Department of ECE
Veltech Rangarajan Dr Sagunthala R&D Institute of Science and Technology,
Chennai, India.
Email: [1] anilluciageorge@gmail.com, [2] mazheriq@gmail.com

***Abstract* - We develop an energy efficient routing algorithm for Wireless Sensor Network. Though most of the conventional research work focuses on resource management and security issues, they fail to focus in terms of energy efficient routing protocols. We proposes an Energy Efficient Distribution Diffusion Protocol based A* algorithm which is superior to conventional routing techniques like LEACH, AODV, and RIDSR. Existing routing techniques use *hop-count* as a routing metric to optimize the routing overhead in the network. Our technique avoids choosing nodes with residual energy to join the cluster. For high data rates the hops between the cluster heads follow loop-free shortest path algorithm for the receiver. This transmission time is calculated as the forward and backward link loss rate and throughput of the system is 5-7% higher than conventional techniques. In some cases, when multiple routes traverse through the same node, the node may end up with out-of-energy, which results in detaching the node from the network. To overcome this issue, our proposed work also takes the nodes remaining energy into account in routing selection. With this scope, it is pre-estimated that the proposed routing protocol can optimize the energy efficiency by 20% more than conventional reactive routing protocols. As a future work, with little trade-off factors we can establish security measures to our routing protocols.**

Keywords - Shortest Paths, Hop count, Leach Protocol, Throughput, Energy Efficient

I. INTRODUCTION

Wireless Sensor Networks (WSN) design of a large number of sensor nodes that are mainly used in various applications including agriculture, traffic control, environment and habitat monitoring, object tracking , fire detection, surveillance , home automation, biomedical applications, machine failure diagnosis and energy management. Micro sensing devices, each rigged with low computational capacity processor and a wireless transmitter-receiver is called as sensor nodes. It will be building material of sensor networks. The sensor nodes can collude to collect the data from the sensing area and transfer the data to the sink. It is battery powered and in most cases the sensor nodes cannot be recharged. In data transmission, a sensor node consumes more energy and it is used to design an energy efficient routing algorithm for wireless sensor network [1]. Once a node drains its energy, it is considered as dead which means it is not able to transfer or relay any messages. Thus to improve the lifetime of a sensor network, it is important to design energy-efficient protocols that allow sensor nodes to communicate with one or more base stations.

In this experiment, we try to overcome the restraint of wireless sensor network. The limitations will be named as limited energy resources, changed energy consumption level based on location, transmission cost is high, and limited processing capabilities. The characteristics of WSNs are complete opposition of their wired network counterparts, in that part the energy consumption is not an issue, transmission cost is low and the network nodes have much more processing capability [2]. Figure.1 mentioned as Architecture of WSN and Our routing techniques worked well in traditional networks for over twenty five years will not enough for this new generation of networks.

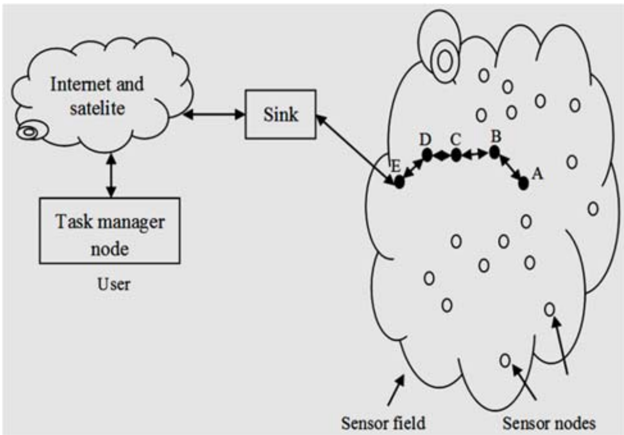

Figure.1. Architecture of WSN

The main purpose of energy efficient algorithm is to increase the network lifetime. The energy consumption is directly propotional to network lifetime of the network. The network lifetime will increase, if the enrgy consumption will decrease in the network. In these algorithms are related to reduce the total energy consumption of the route but also to increase the lifetime of each node in the network to maximize the network lifetime. The energy efficient routing algorithms based on the two metrics: (i) Reducing the total transmission energy (ii) The network lifetime will be increased. The first metric approach on the total transmission energy is used to send the packet from source to destination point by choosing the huge number of hops. The second metric approach on the residual better energy level of full network or individual battery energy of a node.

II. ROUTING

It is the process of fixing path and transfer the packets from source node to the destination node. It is a design of two steps, route selection from many source-sink pairs and transfer of data packets to the correct destination [3]. Different protocols and routing tables are used to meet these two steps. In case of WSN, the energy is a limiting factor. Routing in WSN has some unique characteristics and it has a three basic approaches can show the Figure.2.

(i) Energy of nodes is very essential and depends upon battery which has limited power supply.

(ii) Nodes can change in an unchecked manner so frequent route failures are possible.

(iii) Wireless channels have lower and more variable bandwidth compared to wired networks.

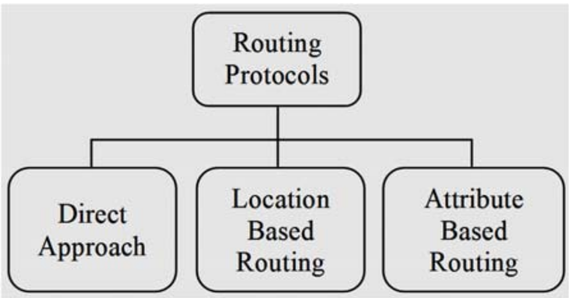

Figure.2. Structure of routing protocol.

A. Energy Efficient Routing Protocols

In WSN, the energy efficient routing may be the most valuable design criteria for MANETs, since mobile will be a charged by a battery with limited capacity. Power failure of a mobile node not only affect the node itself but also able to send packets to other networks which is analyze the network lifetime. A mobile node drains its battery energy not only when it actively sends or receives the packets properly, but also when it stays idle attention to the wireless medium for available communication from other nodes. The energy efficient routing algorithm can be used to decrease communication, energy is needed to transmit and receive the data [4] [5]. The optimal routing path reduces the total transmission energy needs to transfer the data packets to destination point. In the scientific papers Energy Efficient Routing Protocol has analyzed the two approaches: (i) To reduce the activity of communication Energy, (ii) Minimize the inactivity Energy.

To reduce the energy consumption of particular nodes, the main aim of the load distribution method is to balance the energy usage among the nodes and to increase the lifetime of network by preventing over-utilized node when choosing a routing path [6]. In wireless ad-hoc network, the power management approach is used to decrease the energy consumption. Generally, the design of power management policies wants to accurately account for the different performance posed by various application scenarios such as latency, throughput and other performance metrics. Power management approaches have been studied broadly in the context of CPU, memory and disk management in the past. The main concept is to switch devices to the low-power state during periods of inaction as compared with conventional approaches in operating systems, power management of communication devices need to be distributed coordination between two or multiple communicating entities which is having to be in the active mode for a successful communication.

III. PROPOSED WORK

A. Shortest Path Algorithm

Several routing algorithms have been proposed and implemented in WSN, Many routing algorithms are used in today’s computer network are Loop Free Shortest path algorithms that route packets from sources to destinations over paths of minimum cost. The shortest path calculation may be based on hop count, link cost or both. A new loop-free routing algorithm is mentioned, which is easy to update the shortest paths of a distributed network in fully dynamic scenarios. Generally, WSN is a developing network in terms of their applications and design nodes using known routing algorithm. There are many challenges and a model issue which wants to be decision for improving efficiency [7]. In WSN, there are various issues relevant to routing in it and such as having limited battery power, bandwidth and memory. In our research work, we avoid choosing nodes with residual energy to join the cluster. Anyway, for high data rates the hops between the cluster heads follow loop-free shortest path algorithm for the receiver.

In our paper, the shortest path is an optimization problem which gives the minimum cost between two given node pairs. For proposed algorithm is recognized as the most efficient method for shortest path calculation in IP based networks. In the network and number of nodes increases, then it becomes incompetent because of heavy computation involved in it [8]. Also the time needs to get the results is very high and all information needed, then gathering process of finding the shortest path can be initiated. In our algorithm, it is used to estimate the shortest path all nodes want to have a complete view of the network and then operate the calculation locally. The shortest path algorithm is demanding a full view over the network, which form the number of messages and its needed to be sent between all routes relatively high. Our proposed method is used to reduce the complexity of the shortest path problems.

With a large network of nodes, sensors are assigned in close range of each other which monitor the transmission of information and notes. We consider all the nodes are static which later on allows some motion based shortest path detections. These nodes send the packet to some gateway node which is joined to the internet or some other network. In WSN, most of the nodes consume power when they transfer to the data to their neighbor nodes. In this paper, we desire to reduce the power requirements and sustain the load transformation to the packets. Here we chose the routing protocol based on their type of proactive and reactive. In this novel, the Energy Efficient Distributed Diffusion Protocol (EEDDP) based A* algorithm for identifying the shortest path in less consumption through the particular phenomenon was implemented.

B. Proposed Energy-Efficient Routing Algorithm

In this paper, we used A* algorithm to estimate the optimal path from the source node to destination node with regard to the some parameters of sensor nodes such as residual energy, packet reception rate and node buffer state. In order to calculate the optimal path, the sink node should be aware of the criteria of each node. Thus, at the initial stage, each node must forward its previous parameters to the sink node. In the remaining area, if the sensor node has data to forward the sink node. The sink node must be used to find and broadcast the routing schedule to each sensor node. Figure. 3 shows the block diagram of our proposed method. Then our proposed algorithm will search for the optimal path from the source to the destination node [9]. In our technique, we are giving routing to the shortest path algorithm as unique. If the residual energy of the sensor node is less than the energy threshold value (E_{th}), that sink node does not compete in the routing process and hence will not transfer its parameters to the base station. If the threshold value is decreased, does not consider the residual energy of nodes and vice versa as a result, the network lifetime will be improved.

Our proposed algorithm is used to search and find the optimal path from the source node to the destination node. The node has OPEN and closed list, which produces a structure of sensor nodes. The OPEN list is a priority queue and maintains the track of those nodes while the CLOSED list maintain track of nodes which may be already examined [10]. It is used a distance plus cost heuristic node n, f(n) to calculate the some nodes in the tree. We have considered for some example, the sum of two functions which is called the heuristic function.

$$f(n) = g(n) + h(n) \tag{1}$$

where, *g(n)* is the cost from the source node to current node and *h(n)* is allowed a heuristic estimation of the distance from n to the destination node. In our method node cost is equal to the *g(n)*.

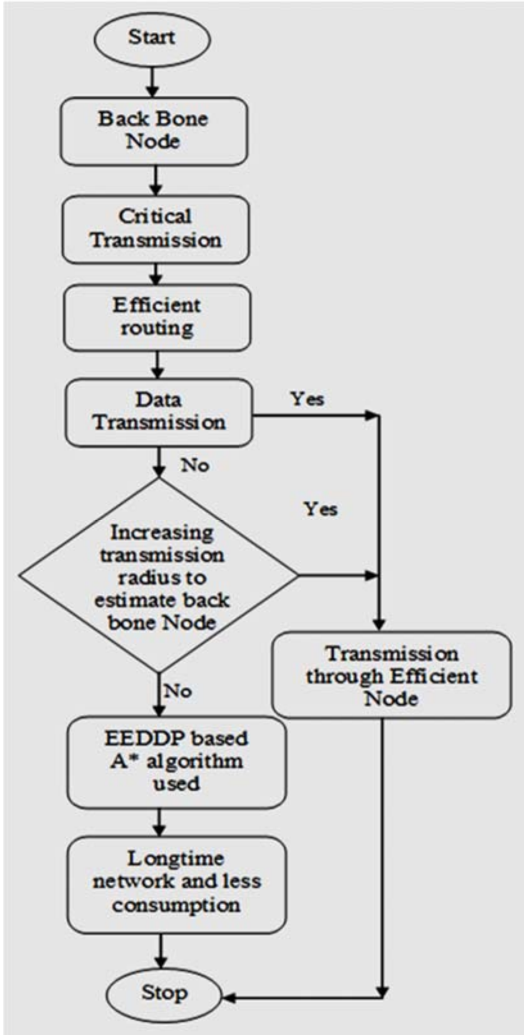

Figure.3. Flow diagram of proposed work

Our aim is to transfer the data packets to the next neighbor node which has higher residual energy, high buffer rate and higher packet reception rate. Here we decide the combined weight of a next neighbor node as the sum of normalized weight of the routing metric as follows:

$$g(n) = Max\left\{\alpha\left(\frac{E_{res}(n)}{E_{ini}(n)}\right) + \beta\left(\frac{N_r(n)}{N_t(n)}\right) + \delta\left(\frac{B_f(n)}{B_{ini}(n)}\right)\right\} \tag{2}$$

where $E_{res}(n)$ and $E_{ini}(n)$ are residual energy and initial energy of node respectively. In addition $N_t(n)$ and $N_r(n)$ are the transmitted and received packets respectively. $B_f(n)$ and $B_{ini}(n)$ mentioned as a number of free and initial buffer of node n respectively. α,β and δ are the weight parameters such as $\alpha + \beta + \delta$=1. We consider above the three metrics

DOI 10.5013/IJSSST.a.19.06.48

ISSN: 1473-804x online, 1473-8031 print

are related to the node parameters. The first parameter contains normalized residual energy which demonstrates the residual energy of the next neighbor node n. The objective of our parameter is that the energy consumptions are balanced. In order to distribute the energy to all the sensor nodes and improve the lifetime of the network.

In our research work, the parameter of node cost is relevant to the linear combination of three normalized metrics. The first parameter contains the normalized residual energy which demonstrates the residual energy of the next neighboring node n. The objective of parameter is that the energy consumptions are balanced in the sensor node. The energy load must be allocated between all the sensor nodes in order to increase the network lifetime. The second parameter is to relate with a received packet in a node n. As a result, increasing this metric is equal to maximize the packet transmission efficiency. The third parameter is mentioned the free buffer at the next neighboring node n and this parameter stands in the stable distribution of traffic load. We assume that the each node knows the position of sink node which may be transfer its position to all sensor nodes in the network. We use EWMA for updating packet reception rate as follows:

$$PRR(t+1) = \theta\big(PRR(t)\big) + (1-\theta)\left(\frac{N_r(t+1)}{N_t(t+1)}\right) \quad (3)$$

where, θ is the mentioned as waiting parameter and the value for the *h(n)* function which can be calculated as:

$$h(n) = \frac{1}{Min(hc_n^s)} \quad (4)$$

where, $Min(hc_n^s)$ denoted as the minimum hop count from node n to the destination node. We estimate the hop count from node n to the sink node and we calculate the node n and sink node via Euclidean distance formula as:

$$d(n,s) = \sqrt{(x_n - x_s)^2 + (y_n - y_s)^2} \quad (5)$$

where, *d(n,s)* is equal to the Euclidean distance between the node *n* and sink node *s*. Equation (6) denoted as the hop count from node n to the sink node can be determined as follows:

$$hc_n^s = \frac{d(n,s)}{avg\big(d(n,j)\big)} \quad (6)$$

The average distance between the node *n* and its one hop neighboring nodes *(j)*. Equ (2) and Equ (6) we can estimate the evaluation cost function *f(x)* for selecting the optimal path. The value of *f(x)* can be used to obtain the optimal path. In order to mention the energy consumption are balanced and prolong the network lifetime.

IV. SIMULATION PARAMETERS

The proposed EEDDP was implemented using Network Simulator (NS-2) software. Generally, NS-2 is the most standard nonspecific network simulator which supports a wide range of protocols in all layers. It uses OTcl as configuration and script interface. NS-2 is the paradigm of reusability. Here, ns-allinone version 2.33 are used to simulate the parameters. The proposed EEDDP algorithm was compared with the existing EEDR, DSDV, AODV [36] in terms several parameters. The parameters used in simulation are shown in table 1. The network size of the proposed simulation model in terrain area is 100 m x 100 m using Adhoc on Demand Vector (AODV) routing protocol for monitoring the important parameters of the networks.

TABLE 1. SIMULATION PARAMETER

Parameters	Values
Number of nodes	100
Network size	100×100 m^2
Node placement	Random
Node mobility	Mobility
MAC layer protocol	IEEE 802.11
Routing Protocol	AODV
Time simulation	150 ms
Dimension of Topography (x,y)	1000, 750
Interface Queue Type	Drop tail/PriQueue
Antenna Type	Antenna/Omni Antenna
Application Layer Protocol	FTP
Channel	Channel/Wireless Channel
Radio Propagation Model	Propagation/Two Ray Ground
Network Interface	Phy /Wireless Phy

V. PERFORMANCE EVALUATION AND ANALYSIS

The proposed technique name EEDDP protocol was compared with existing techniques such as EEDR protocol, DSDV protocol, AODV protocol [36[which is graphically represented in following figures and tabulated in table 2.

A. Energy Efficiency

Energy is the major concern in the WSN, hence to improve the energy efficiency for more throughputs, produce the virtual nodes is the idea. It is moderate to approximately to find the energy consumed according to the data transmission. In our work, the energy is improved according to the data transmission and if the sensor node is in sleep mode it turns off the radios for saving energy. Our proposed protocols the relay nodes which are not selected without knowing any other residual energy has done to other routing protocol in this comparison. In our proposed method, energy consumption for each node occurs for every transmission and reception made. Thus the probability of selecting the same node as the next hop is decreased. Thereby, the energy has been balanced and the efficiency level is higher than the existing scheme is shown as Figure.4.

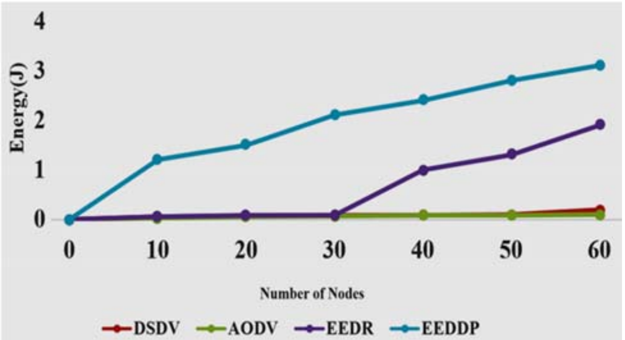

Figure.4. Energy efficiency level

B. Network Lifetime

The backbone nodes accomplish the prolong lifetime of the network. Identical initial energy and imbalanced energies are used as energy configurations [11]. First the transmission range is fixed, later the transmission radius can be lengthened based on the critical transmission and produce the energy uniformly. Figure.5 Shows the achieved network lifetime compared to other protocols.

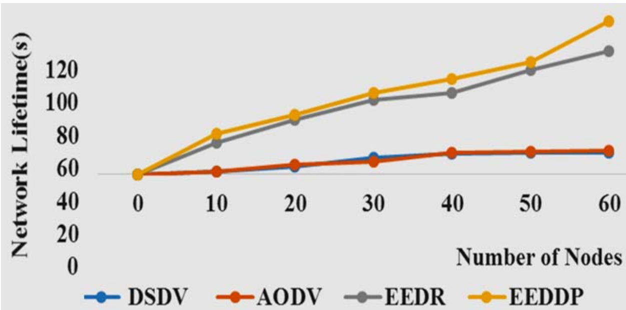

Figure.5. Network Lifetime

C. Run Time

Other protocols are randomly choosing the next hop for the packet and base station has been selected as the next hop in our protocol [12]. Generally, it uses GPS to find the base station. From the results, the time taken to run the whole network in our protocol is smaller than other protocols which is shown in figure 6. For many applications of WSNs, It is important that the delay of the transmissions is not too big. In our paper, the EEDDP protocol is used to reduce the energy consumption but does not affect the delay while getting energy consumption. The protocol conserves the battery power of the nodes by intelligently powering off the nodes that are not actively transmitting or receiving packets. It achieves these power savings without affecting the delay or throughput behavior of the basic protocol.

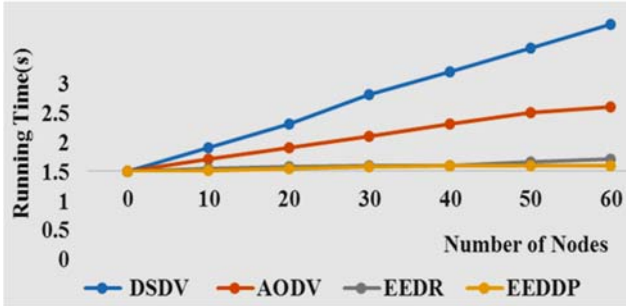

Figure.6. Running Time

D. Throughput

In data transmission, network throughput is the amount of data transmitted successfully from sender node to receiver node in a given time period .The proposed EEDDP achieves higher throughput than existing schemes which is represented in figure 7.

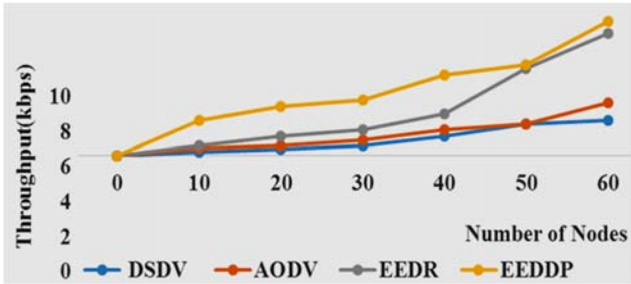

Figure.7. Throughput.

TABLE II COMPARISON OF NETWORK LIFETIME, ENERGY EFFICIENCY, RUNNING TIME AND THROUGHPUT

Sl.No	Parameters	EEDDP	EEDR [36]	DSDV [36]	AODV [36]
1	Energy Efficiency	3.1	1.9	0.2	0.1
2	Network Lifetime	98	79	14	15
3	Running Time	0.1	0.2	2.5	1.1
4	Throughput	7.7	7	2	3

From the simulation, the parameters such as energy efficiency, network lifetime, running time and throughput was calculated and explained in table 2. The results shows that the proposed protocol was efficient than existing protocol.

VI. CONCLUSION

The extreme aim of a routing protocol design is to develop the lifetime of the network by keeping the sensors alive for a maximum time. Generally the energy spent on transmission and it is compared to the sensing and routing technique. In our proposed routing algorithm is designed to reduce energy consumption while transmitting the data. In this paper we analyzed the routing algorithm on the basis of metrics that are used to reduce energy utilization. Our proposed EEDDP based A* algorithm is broad spectrum that this paper covered only a few of them. Our proposed algorithms are used in two types. i) Minimizing total transmission power. ii) Maximizing the network lifetime. Our algorithm produces the best results based on the metrics are used. Our extension approach is compared with some conventional techniques like EEDR, AODV and DSDV. The algorithm has to be additionally investigating in multipath routing for larger number of nodes.

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