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Evaluation of Routing Behavior with Energy Capable Sensor Nodes Based on Dynamic Approach

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Abstract— Efficient use of energy is one of the recent area among researchers of wireless sensor networks (WSNs). Here we have proposed a novel method to use the energy of the sensor nodes optimally. We have merged the AOMDV routing protocol with the particle swarm optimization. This integration shows us that we can increase the lifetime of the network efficiently. This integration resolves the issue of hot spot problems. We have taken six parameters to prove our results. They are throughput, packet delivery ratio, packet loss ratio, average end to end delay, routing overhead and average energy consumption. This ensemble insertion of PSO with AOMDV has enhanced the energy efficiency in WSN.

Keywords— Wireless Sensor Networks, Particle Swarm Optimization, AOMDV, Energy Consumption, Dynamic approach.

I. Introduction

Wireless Sensor Network is a self-configured and infrastructure-less wireless network which consists of a number of sensor nodes which together monitor the physical or environmental conditions, like sound, temperature, vibration, pressure, and jointly pass their data through the network to a main location or base station where the data can be noted and examined [1]-[3]. A base station is an interface between the network and the users. We can get back the required data from the network by inserting queries and getting results from the sink. Usually, a wireless sensor network contains thousands of sensor nodes which communicate among themselves by means of radio signals. A wireless sensor node consists of sensing and computing devices, transceivers and power elements. The nodes in a WSN are constrained by a number of resources. They have restricted processing speed, storage capacity, and communication bandwidth. After the deployment of the sensor nodes, they self-organize themselves in appropriate network infrastructure generally with multi-hop communication between them. After this, the sensor nodes start collecting the required data. These sensor nodes can reply to the queries sent from a control site to perform specific instructions.

All the sensor nodes are operated by batteries and hence they have limited energies. These batteries are not chargeable or replaceable. So, the limited energy is the biggest issue among the researchers. In order to transmit the data, nodes use their maximum energy. So, weightage has been given on designing an optimal algorithm which selects the optimal routes and also optimally use the energies of the nodes so as to increase the lifetime of the WSN [4].

In a WSN, the nodes are scattered over an entire area. Due to the lack of transmission range and due to high power consumption, it is difficult to send the data directly using single hop communication, so multi hop pattern is used [5]. The sensors which belong to the hot spot area reduce their energy very fast and die very frequently as compared to the other nodes in the WSN [6] and hence this reduces the coverage area and divides the network [7].

Many researches have shown that it is possible to reduce the energy consumption of the nodes but they have not effectively increased the life time of the network. Here, we have proposed a novel and robust algorithm to solve the issue of energy and increase the life time of the network. We have combined a routing algorithm with the PSO in order to optimally utilize the energy consumption of the nodes in the network. In each round, we check the residual energy of the nodes and based upon this residual energy, we find the optimal path for sending the data to the destination either by single hop or by multi hop communication.

II. RELATED WORK

Optimal energy consumption is an active area in the wireless sensor networks over a few decades. Many techniques based on clusters are proposed to extend the life time of the network. [5][6]. One of the important method for the cluster based approach is LEACH which is a distributed routing technique [8]. This method selects few nodes randomly with equal opportunities as the cluster head and then rotates this role to balance the energy usage in the WSN. For reliable transmission of the packets and the minimization of the signal, they use the back propagation neural network technique [9]. A multi hop communication and hierarchical based routing algorithm which utilize energy optimally is presented [10]. The cluster head is selected based upon the maximum energy and the node with the highest energy is selected as the head of the cluster. All other nodes are ignored for the cluster head selection. The next cluster head is chosen based upon the weight function and this protocol reduces the energy consumption of the network. An energy efficient algorithm named PERP is proposed which reduces the consumption of energy when the sensor nodes are in the idle state as well as by reducing the communication distance between the nodes [11]. A protocol based on common and adaptive transmit power which uses SINR constraint to optimize the energy resource is introduced [12]. A method known as CMIMO is proposed for optimal consumption of energy in WSN [13]. A novel protocol which is used for both static and dynamic approaches, DEEB is proposed for under water network which balance the energy loads of the nodes [14]. A protocol, CRSN which is used to dynamically access the bandwidth of the channel is proposed [15], implicit cooperation is done and the aggregation is used to reduce the consumption of energy. A protocol in which the area is divided into the number of cells is proposed in which the moving sink node optimize the energy efficiency [16][17]. Zuzhi Fan [18] has proposed a protocol in which the multiplication of energy and the delay is done to evaluate the performance of the protocol. This method reduces the delay time and increases the network lifetime. A V MIMO algorithm is proposed which is used to increase the life time of the network by reducing the communication between the sensor nodes [19]. A GEAHAR protocol is proposed which adjusts the consumption of power based upon the distance of the communication [20].

III. PROPOSED METHODOLOGY

The main objective of our research is to optimize the consumption of energy by the sensor nodes. We have integrated the AOMDV routing protocol with the PSO algorithm and this integration reduces the consumption of energy by the sensor nodes. These improvements are basically based on the adaptive power transmission strategy.

The technique makes use of the remaining battery charge of the sensor nodes. Using this residual energy of the nodes, data transmission is done between the nodes. The nodes having more residual energy will forward the data up to more distance and the nodes with less residual energy will transmit the data within the small distance. The optimal route will be chosen all the time by the integrated approach of AOMDV and PSO. Effective control of transmit power is a critical design issue and improves the performance of wireless sensor networks. Overall network performance can be improved by using variable range transmission control versus common range transmission control. Various network performance metrics, such as network connectivity, traffic carrying capacity, and power saving properties of WSNs are affected when comparing routing protocols based on common range transmission control and variable range.

The performance of the network layer can be improved by transmitting at a higher power directly and indirectly reducing the amount of forwarding. The scheme is based on the control of the variable range transmission. Using variable range transmission power results in lower transmission power levels than the power levels obtained using common range transmission approaches. This is an important finding because it suggests that routing protocols based on variable range transmission can increase the traffic carrying capacity of the wireless sensor network while at the same time reducing the overall transmission power consumption within the network and increasing the network life.

$$Optimized\ route\ 1 = \sum_{k=0}^{n} \binom{V(n) \in rene\ (v(n))}{V \in V\ ene\ (v)} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$Optimized\ route\ 2 = \sum_{k=0}^{n} \binom{E(n) \in rdist\ (e(n))}{e \in E} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The sending and receiving nodes are randomly selected; the sending node initiates the path discovery process and broadcasts the routing packets to all nodes in the network. During this process, the sending node updates the routing table and power state of the nodes. If the energy of the nodes is greater and the distance is smaller within the minimum number of hops; then the source node follows equation 1 and equation 2. If the energy of the node is greater and the distance is also greater, so it would look for another path that has a shorter distance. If the lowest distance is found, the proposed algorithm follows Equation 1 or Equation 2 and ends the path for communication. Also, if the power level of the nodes is exhausted between 20% and 70%, the transmission range of the nodes is adjusted to 200 meters. Furthermore, if the power level of the nodes is reduced below 20%, the transmit power is adjusted to just 100 meters. Then the algorithm follows the beacon message. The periodic path detection process and the forwarding function keeps the updated power of the nodes and stays updated.

A. Transmitter power detail

The transmit power of the node must be modified, to vary the transmission range. Free space propagation has been chosen for simulation. First transmission equation is used to calculate the transmit power of nodes, given as:

$$\text{Pr} = \sum_{1}^{n} \text{Pt. Gr. Gt}\left(\frac{\lambda}{4\Pi r}\right)2 \text{.............................(3)}$$

Pt is the transmit power. Pr is the received power. Gr is the antenna gain of the receiver. Gt is the antenna gain of the transmitter. R is the distance between the nodes. λ is the wavelength.

The main goal of the proposed algorithm is to form the energy conscious network. The protocol is designed by varying the transmission range of the nodes. By variable transmission range we mean the control of the communication level of each packet in a distributed way on each node, which affects the energy consumption of the network. By choosing a better transmission range, the number of nodes required to be successful at the destination is reduced, but it also creates a lot of interference, while reducing the transmission range requires more forwarding nodes, resulting in less power usage. Each node communicates with neighboring nodes during the path discovery phase. Once the path is understood, each individual node controls the transmission range based on the space between the source node and the destination node, so that the optimum energy is used for packet transmission.

B. Route Discovery Phase

When a node wants to send a packet to a destination, it initiates a route detection process, if there is no valid route in its routing table. For route detection, the node creates a Route Request Packet (RREQ) and passes it on to its neighbors. A common transmission range Rmax is considered to take care of the connectivity between nodes. Then the node sets a timer to wait for the response. The timer is set to T_wait time. The node then collects the entire path response (RREP) received until this timer expires.

C. Forward Route Setup

When a node determines that it has a sufficient current route to respond to the RREQ, it creates a route response (RREP). The RREP sent in response to RREQ contains the IP address of both the source and the destination. In addition to these, two other parameters are added to the RREP packet. These parameters are used to specify the exact x-y position of the node sending the path response. These parameters are named loc_X (x-axis position) and loc_Y (y-axis position). In on-demand routing protocols, the first received route response is forwarded and the route is established. But here, "each node waits a while (T_wait) until it receives all" of the RREP messages destined for the node. The node then calculates the distances between the nodes from which the RREP message is received and itself. This is done using final location and the locations of the intermediate nodes. Let the position of a node be (nX, nY) and the position received in RREP be (loc_X, loc_Y), then the distance d between the two nodes is calculated as:

n_hop_X=abs [nX-loc_X]............................(4)

n_hop_y= abs[nY- loc_Y]...............................(5)

Therefore,

Distance, D=$\sqrt[2]{n\_hopY^2 + n\_hopX^2}$*...................(6)*

Equation 6 is used to calculate the distance for all the RREP received. The node having minimum distance is then selected as the next hop and its location is also updated in the routing table as two entries n_hopX and n_hopY.

Select the node with d_{min}

add n_hopX, n_hopY in the routing table.

The d_{min} is the minimum distance between the current node and the next hop node in the algorithm. The power threshold received by all nodes remains constant during the path detection phase. This path between source and destination is maintained for data transfer.

D. Route Maintenance

Once a path has been discovered for a source / destination pair as explained above, the source node maintains it for as long as necessary. The movement of nodes within the network affects only the routes containing those nodes; such a path is called an active path. Path detection restarts if the source node is moved during an active session to establish a new path. If the destination or any intermediate node is moved, a path error message (RERR) is generated. In PSO, the RERR message is handled as in other routing-on-demand protocols.

In this research work, an optimized packet forwarding method is proposed using the PSO algorithm which improves on the existing AOMDV protocol. The proposed method uses the energy consumption of the nodes. The energy transmitted by the nodes is regulated according to the residual energy of the nodes.

If Res_Energy < =100 % && Res_Energy > =70%

Then the transmission distance of the nodes will be equivalent to ***250 meters***.

And;

If Res_Energy < 70 % && Res_Energy >= 20%

Then the transmission distance of the nodes will be equivalent to ***200 meters***.

And;

If Res_Energy < 20% &&Res_Energy >=0

Then the transmission distance of the nodes will be equivalent to ***100 meters***

Also the forwarding function with Residual Energy Status is declared so that every communication of messages between the nodes would be updated in the routing table of Sender node.

IV. RESULTS & DISCUSSION

Nodes are moving randomly in the experimental area of 1000 X 1000 m^2 with the speed of 2 m/s, 4 m/s, 6 m/s, 8 m/s and 10 m/s.

To prove the efficiency of our scheme, performance comparisons between AOMDV routing algorithm and AOMDV integrated with particle swarm optimization are made. Both the methods are simulated using simulation tool NS-2. For simulation and result analysis, it is necessary to set the simulation parameters for the dynamic model. The summarized simulation parameters are shown in the Table 1. Figure 1 to 6 shows the results obtained through AWK scripts for both existing and proposed methods. We have taken six network parameters to compare the results between both protocols. These parameters are throughput, packet delivery ratio, packet loss ratio, average end to end delay, routing overhead and average energy consumption.

TABLE I. PARAMETERS SETTING

Parameters	Values
Simulator	NS-2 (ns-all-in-one-2.35)
Routing protocol	AOMDV
No. of nodes	50
Traffic model	Constant Bit Rate
Simulation time	1000 seconds
Simulation Area	1000*1000 m^2
Packet size	512 Bits
Nodes Velocity	2 m/s, 4 m/s, 6 m/s, 8 m/s and 10 m/s
Simulation Area	1000 * 1000 meter square
Data Rate	2000 bits/sec
Mobility model	Random
Mac Layer protocol	IEEE 802.11

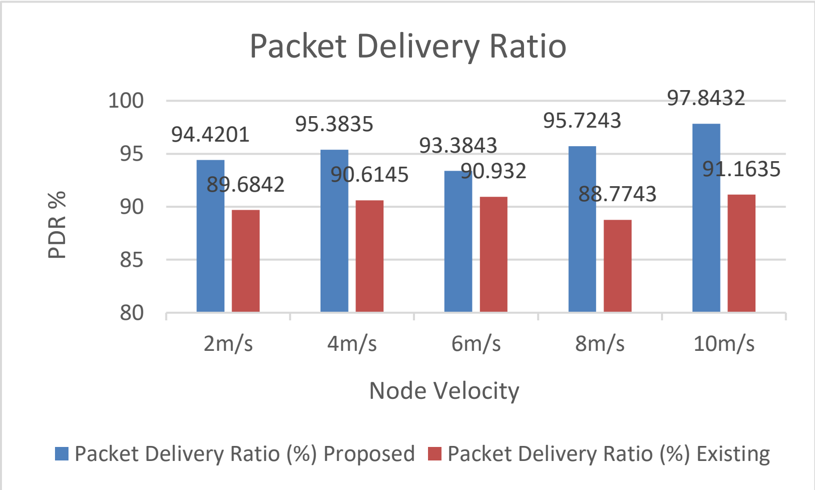

Fig. 1: Packet Delivery Ratio

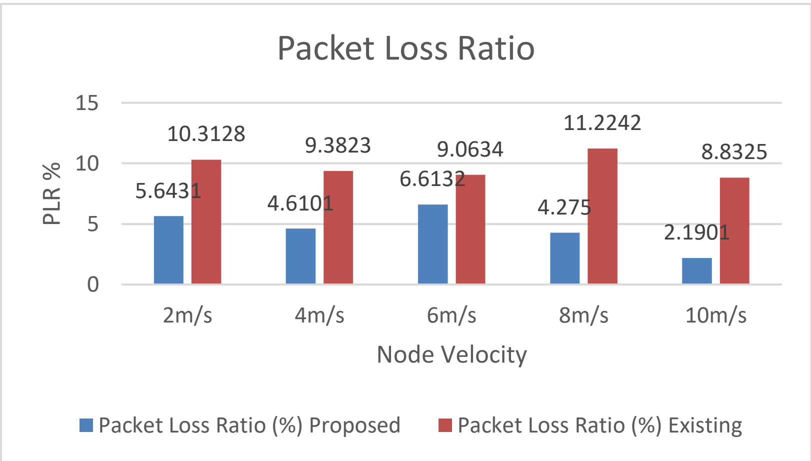

Fig. 2: Packet Loss Ratio

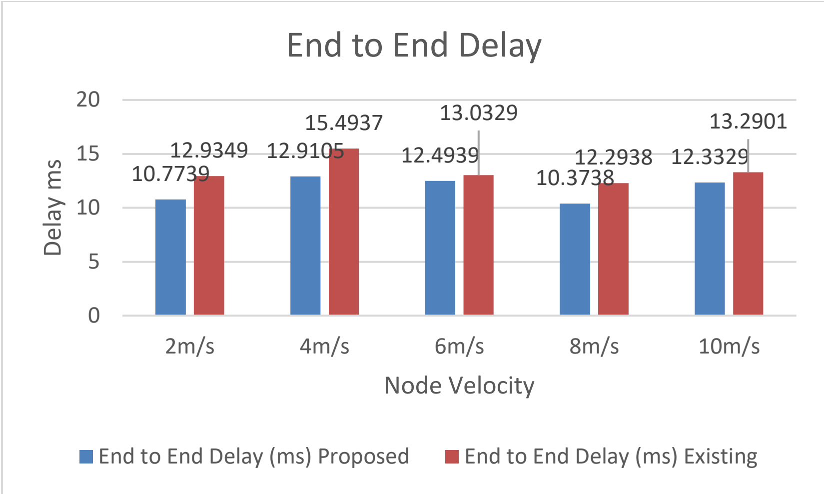

Fig. 3: Average End-to-End Delay

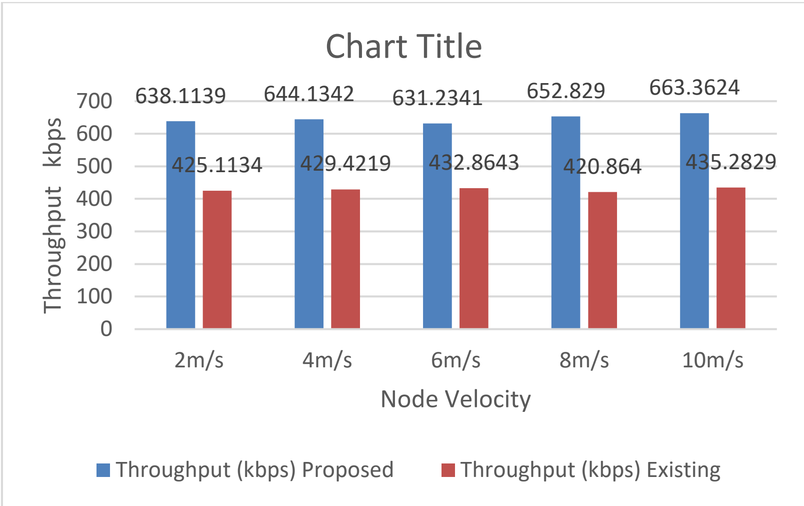

Fig. 4: Throughput of Network

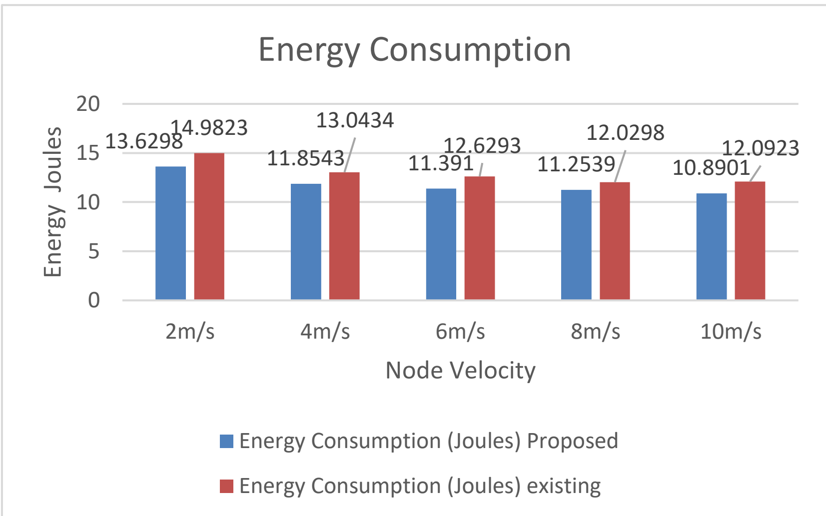

Fig. 5: Energy Consumption

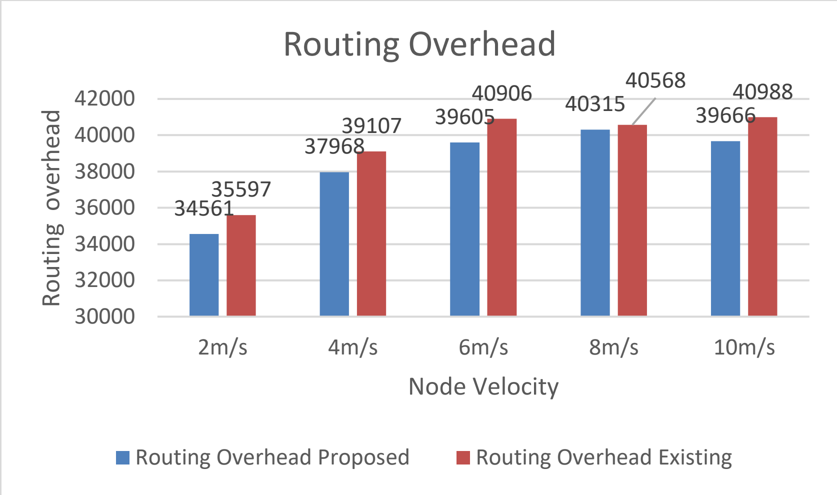

Fig. 6: Routing Overhead

TABLE II. PERCENTAGE OF IMPROVEMENT OF PROPOSED WITH EXISTING SYSTEM

Parameter	**Existing Method**	**Proposed Method**	**Percentage of Improvement**
Packet Delivery Ratio	90.23 %	95.336	5.65%
Packet Loss Ratio	9.76 %	4.656 %	52.29 %
End to End Delay	13.406 ms	11.774 ms	12.17 %
Throughput	428.70 kbps	645.926 kbps	50.66 %
Energy Consumption	12.95 joules	11.8 joules	8.88 %
Routing Overhead	39433	38423	2.56 %

V. CONCLUSION

This paper proposed a novel routing scheme based on the integration of Adhoc on Demand Multipath Distance Vector and Particle Swarm Optimization to optimally utilize the energy of the nodes in WSN. The lifetime of the network is improved by applying PSO. Both AOMDV and AOMDV-PSO are simulated using simulation tool NS-2. The proposed method shows better results than the existing method. The improvements are shown in the Table II. The total energy consumption after implementation of PSO is reduced by 8.88%. Packet delivery ratio is improved by 5.65%. Total packet loss ratio is decreased by 52.29%. End to end delay is decreased by 12.17%. Throughput of the network is increased by 50.66% and the routing overhead is decreased by 2.56%.

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