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AN ENERGY EFFICIENT ROUTING ALGORITHM FOR WSN USING PSO APPROACH

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Abstract: *Wireless sensor networks have become increasingly popular due to their wide range of applications. Energy consumption is one of the main constraints of the wireless sensor node and this limitation combined with a typical deployment of large number of nodes have added many challenges to the design and management of wireless sensor networks. WSN's are typically used for remote environment monitoring in areas where providing electrical power is difficult. Therefore, the devices require to be powered by batteries and alternative energy sources. Energy consumed by nodes should be minimum is to increase lifetime of network. In this paper, enhancement of DSDV protocol by Particle Swarm Optimization (PSO) is done to increase the lifetime of network and the evaluation of proposed algorithm is done on the of performance metrics: Consumed Energy, Packet Delivery Ratio (PDR), and Average Throughput. PSO is a heuristic global optimization method and also an optimization algorithm, which is rely on swarm intelligence.*

Keywords: *WSN (Wireless Sensor Network), PSO (Partial Swarm Optimization), Sensor, Protocol, Packet Delivery Ratio.*

1. INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

A Wireless Sensor Network (WSN) can be defined as a network of small embedded devices called sensors which transmit wirelessly following an ad hoc configuration. They are placed strategically inside a physical medium and are able to interact with it in order to measure physical parameters from the environment and provide the sensed information. The nodes mostly use a broadcast communication and the network topology can change constantly due for e.g., to the fact that nodes are prone to fail. Because of this we should feed in mind that nodes should be autonomous and often they will be disregarded. This kind of device has low power, low computational capabilities and low memory. One of the main issues that should be studied in WSNs is their scalability feature and their connection strategy for communication and the limited energy to supply the device. The desire to advance in research and development of WSN was initially motivated by military applications such as surveillance of threats on the battlefield, mainly because WSN can replace single high-cost sensor assets with large arrays of distributed sensors. There are other noticing fields like home control, building automation & medical applications. A number of hospitals and medical centre's are exploring the use of WSN technology in a wide range of applications, including pre-hospital and in-hospital patient monitoring and rehabilitation and disaster response. WSNs can also be found in environmental monitoring applications such as marine fish farms and fire detection in forest and rural areas [5].

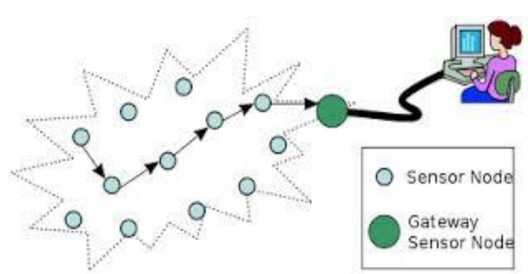

Fig 1.1 Wireless Sensor Network

In many WSN applications, the deployment of sensor nodes is performed in an ad-hoc manner without proper planning or studies. Once installed, the sensor nodes must be able to autonomously organize themselves into a wireless communication networks. As sensor nodes are battery powered and expected to operate and execute their duties without attendance for a long duration of time during the application, it is hard and even impossible to change or recharge batteries for the sensor nodes. Despite the different objectives of sensor networks applications, the main task of wireless sensor nodes is to sense and collect information (data) from a target area, organise, and transmit the information via a radio transmitter back to a command centre where the underlying application resides (sink). In order to achieve this task efficiently, an efficient routing protocol is needed to set up paths of communication between the sensor nodes (sources), and the command centre (sink). The path selection must be such that the lifetime of the network is maximized. Due to the characteristics of the environment in which the sensor node is to work, coupled with severe resource constraints in on-board energy, transmission power, processing capability, storage problem, this prompts for careful resource management and new routing protocols so as to counteract the differences and challenges. The process by which data and queries are forwarded efficiently between the source and the sink is an important aspect and basic feature of wireless sensor networks. The decrease in size and cost of sensor nodes due to technological advancement has encouraged researchers in the past years to engage in an intensive research on addressing the potential of collaboration among sensors in data gathering, processing, coordination, and management of the sensed data flow to the sink. A simple approach to accomplish this task is for each sensor node to exchange data directly with the sink (a single-hop-based approach), or allowing intermediate nodes to participate in forwarding data packets between the source and the destination (multi-hop). Determining which set of intermediate node is to be selected to form a data forwarding path between the source and the destination is the principal task of the routing algorithm. The differences in the way data are forwarded from the nodes to the sink and leads to classifying the routing protocols [2].

As we already mentioned, sensor nodes in WSNs are usually battery powered but nodes are typically unattended because of their deployment in hazardous, hostile or remote environments. A number of power saving techniques must be used both in the design of electronic transceiver circuits and in network protocols. The first step towards reduced power consumption is a sound electronic design, selecting the right components and applying appropriate design techniques to each case.

One of the major causes of energy loss in the WSN node is the idle mode consumption, when the node is not transmitting /receiving any information but listening and waiting for information from other nodes. There is also an energy loss due to packet collision, as all packets involved in the collision are discarded and must be retransmitted. A third cause of energy loss is the reception of packets not addressed to the node. The fourth major source of wasted energy is the transmission –and possible retransmission- of control packets, as these can be seen as protocol overhead [5].

WSN has many advantages, such as broad coverage, self-organization, high precision monitoring, and fault tolerance so on. At present, it shows a great charm in target tracking, security monitoring, disaster salvage, industrial control and monitoring, home automation and defence and other areas. The sensor nodes are generally placed in a hostile environment, its cost is too high or is impossible for people to replace or charge the battery. However, the number of such nodes is considerably high and monitoring these nodes is slightly difficult, especially in the cases when the nodes are distributed in the regions far away from a city or town.

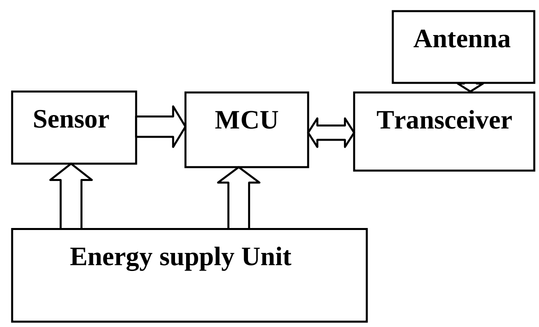

Fig 1.2 Architecture of WSN

The sensor nodes act as both data generator and data router. The architecture of sensor node is displayed in figure 1.2. Typically, data collected from same cluster members are highly correlated. Data aggregation process is done at CHs thus reducing the consumption of energy. The sink node analyses the data which is then used to initiate some specific event or action. The network continuously sensing the data and the energy of the nodes keep on dissipating. Whenever they receive some data and they send it further to other nodes or BS [9].

1.2 TAXONOMY OF ROUTING PROTOCOLS IN WSNs

Determining which set of intermediate nodes are to be selected to form a data forwarding path between the source and the destination is the principal task of the routing algorithm. The computational complexity and their differences in the way data are forwarded from the nodes to the sink. Routing protocols could also be classified based on path establishment. By using the path establishment classification, routing path can be established in one of the three ways: reactive, proactive, and hybrid.

1. **Swarm intelligence based routing protocols**: these are protocols that depend on the collective behavior of biological species (e.g., ants) to provide a natural model for distributive problem solving without

any extra central control or coordination. The most basic concepts of the protocols are self organization, which involves positive feedback, negative feedback, fluctuation amplification and multiple interactions. Let's consider the ant colony as an example to illustrate these concepts. The action of disposing pheromone is a positive feedback mechanism to recruit more ants such that more pheromones are disposed on the shorter path. Nevertheless the evaporation of pheromone is a negative feedback to reduce the pheromone level. In that way, the shortest paths to the food source can be found accordingly. Besides this, stigmergy is defined as the indirect communication used by ants in nature to coordinate their joint problem solving activities. Ants attain stigmergic communication by laying a chemical substance called pheromone that induces changes in the environment which can be sensed by other ants.

2. **Proactive routing protocols**: proactive protocols compute all the routes before they are actually needed and the routes are stored in a table format called a routing table in each node. Each node keeps information on routes to every other node in the network. The settling time for a n/w using this kind of algorithm is extremely high and the no. of messages exchanged in order to maintain route information does grow at an alarming rate, and hence limiting the scalability of the algorithm.

3. **Reactive routing protocols**: reactive protocols compute routes only when they are needed. In this class, each nodes to re-routes only to its immediate neighbor nodes and determine multi-hop routes are required. In reactive protocols, the routing table maintenance over head is drastically reduced in lieu of the time required to send a message, as the path has to be searched each time a packet has to be transmitted across multiple hops to the sink.

4. **Hybrid routing protocols**: hybrid protocols use the combination of reactive and proactive strength, and use a proactive system within a given radius and using reactive system in determination of routes to nodes outside the radius. The radius is always a function of some metric like the number of hops.

5. **Energy efficiency**: it is a measure of the ratio of total packet delivered at the sink node (base station) to the total energy consumed by the network's sensor nodes (Kbits/J). In most cases, sensor nodes are equipped with small and non-rechargeable batteries usually of few ampere-hours. Hence, the efficient battery energy utilization of a sensor node is a critical aspect to support the extended operational lifetime of the individual nodes and of the whole network. A WSN routing protocol is supposed to: (i) minimize the total number of transmissions involved in route discovery and data delivery, and (ii) distribute the forwarding of the data packets across multiple paths, so that all nodes can exhaust their batteries at a comparable rate. This will result in the overall maximize of the network lifetime [2].

1.3 PARTICLE SWARM OPTIMIZATION (PSO):

Particle swarm optimization (PSO) is a very simple, effective, and efficient optimization algorithm. PSO is used to explore the search place. It is very easy to implement & it can be applied for both scientific research and engineering use. In PSO, a global fitness function is used by all the particles in the swarm. In this, No overlapping and mutation calculation speed is very fast. It evaluates the fitness of each and every particle. It occupies the larger optimization ability and it complete very easily. Particles in traditional PSO show the candidate solutions to a single optimization problem. PSO based algorithm is used to locate the optimal sink position to the nodes to make the network is more energy efficient. Some of the techniques are used to improve the network lifetime of wireless sensor network:

- Data fusion algorithm
- Energy-efficient routing
- locating optimal sink position.

PSO is more robust and easy to achieve the solution for real world environmental monitoring and data aggregation problems [6].

Particle swarm optimization is a heuristic global optimization method put forward originally by Doctor Kennedy and Eberhart in 1995. It is originated from swarm intelligence and is based on the research of bird and fish flock movement behavior. As far as particle swam optimization algorithm is concerned solution swam is compared to the bird swarm, the birds' moving from one place to another is equal to the development of the solution swarm, useful information is equal to the most optimist solution & the food resource is equal to the most optimist solution during the whole course. The most optimist soln can be worked out in particle swarm optimization algorithm by the cooperation of each individual [11].

2. RELATED WORK

Jalel Ben-Othman et.al (2010), In this paper, author propose an Energy Efficient and QoS aware multipath routing protocol (abbreviated shortly as EQSR) that maximizes the network lifetime through balancing energy consumption across multiple nodes, uses the concept of service differentiation to allow delay sensitive traffic to reach the sink node within an acceptable delay, reduces the end to end delay through spreading out the traffic across multiple paths, and increases the throughput through introducing data redundancy. EQSR uses the residual energy, node available buffer size, and Signal-to-Noise Ratio (SNR) to predict the best next hop through the paths construction phase. Based on the concept of service differentiation, EQSR protocol employs a queuing model to handle both real-time and non-real-time traffic. By means of simulations, we evaluate and compare the performance of our routing protocol with the MCMP (Multi-Constraint Multi-Path) routing protocol. Simulation results have shown that our protocol achieves lower average delay, more energy savings, and higher packet delivery ratio than the MCMP protocol [1].

Adamu Murtala Zungeru et.al, (2012), This paper presents a comprehensive survey and comparison of routing protocols in WSNs. The first part of the paper surveys state-of-the-art routing protocols in WSNs from classical routing protocols to swarm intelligence based protocols. The routing protocols are categorized based on their computational complexity, network structure, energy efficiency and path establishment. The second part of the paper presents a comparison of a representative number of classical and swarm based protocols. Comparing routing protocols in WSNs is currently a very challenging task for protocol designers. Often, much time is required to re-create and re-simulate algorithms from descriptions in published papers to perform the comparison. Compounding the difficulty is that some simulation parameters and performance metrics may not be mentioned. We see a need in the research community to have standard simulation and performance metrics for comparing different protocols. To this end, the final part of the paper re-simulates different protocols using a Mat lab based simulator: routing modelling application simulation environment (RMASE), and gives simulation results for standard simulation and performance metrics which we hope will serve as a benchmark for future comparisons for the research community [2].

Jeong-Hun Lee et.al (2013), in this study, authors propose mathematical models for a routing protocol (network design) under particular resource restrictions within a wireless sensor network. We consider two types of constraints: the distance between the linking sensors and the energy used by the sensors. The proposed models aim to identify energy-efficient paths that minimize the energy consumption of the network from the source sensor to the base station. The computational results show that the presented models can be used efficiently and applied to other network design contexts with resource restrictions (e.g., to multi-level supply chain networks) [3].

Pratyay Kuila et. al (2014) This paper presents Linear/ Nonlinear Programming(LP/NLP) formulations of the problems followed by two proposed algorithms for the same based on particles warm optimization(PSO).The routing algorithm is developed with an efficient particle encoding scheme and multi-objective fitness function. The clustering algorithm is presented by considering energy conservation of the nodes through load balancing. The proposed algorithms are experimented extensively and the results are compared with the existing algorithms to demonstrate their superiority in terms of network life, energy consumption, dead sensor nodes and delivery of total data packets to the base station [4].

Sandra Sendra et.al (2011) In this work, author present a survey of power saving and energy optimization techniques for wireless sensor networks, which enhances the ones in existence and introduces the reader to the most well known available methods that can be used to save energy. They are analyzed from several points of view: Device hardware, transmission, MAC and routing protocols [5].

K.SyedAliFathima et.al (2014) In this paper, author uses the best energy efficient protocol is LEACH to reduce the energy consumption and it can extend the lifetime of wireless sensor network. Clustering techniques can be used to communicate with cluster-head and base station. If the base station is far away from the cluster-head, energy consumption will be increased and it can reduce the lifetime of wireless sensor network. To overcome these, Particle swarm Optimization technique is implemented with this protocol in order to achieve maximum lifetime of wireless sensor network.PSO is used to extend the scalable and energy efficiency. It is easy to implement and the mutation calculation speed is very fast [6].

Satyesh Sharan Singh et.al (2012) In this paper, author is going to survey the application of particle swarm optimization (PSO) in WSN over different type of clustering based algorithm techniques like LEACH,LEACH-C, PEGASIS, etc In WSN sensors are randomly deployed in the sensor field which brings the coverage problem. Hence energy and coverage problem are very scarce resources for such sensor systems and has to be managed wisely in order to extend the life of the sensors and maximizing coverage for the duration of a particular mission. In past a lot of cluster based algorithm and techniques were used. In this paper author also find out all type of PSO based algorithm, their application and limitation over present techniques to overcome the problems of low energy and coverage of sensor range [7].

Valeria Loscrí et.al (2012) in this paper, author considers sensors that move according to the well-known Particle Swarm Optimization (PSO) scheme in order to improve network coverage. Unlike the original PSO, particle speed is updated by considering

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a consensus algorithm based on local optimum position. Two different versions of the algorithm have been simulated: a global version that allows nodes to use information of the whole sensor field and a local version based only on neighborhood information. The algorithm based on global information is used as comparison term for the local version. Also, a variant of these algorithms has been implemented by adding the concept of pioneers, which are powerful sensors that explore the field to detect interesting areas before the other sensors become active. In order to evaluate the performance of our schemes, different scenarios have been introduced by varying the probability areas for events to occur in. The performance of the network has been evaluated in terms of coverage and energy consumption for movement and has shown that the proposed techniques obtain remarkable results for both parameters considered [8].

Alisha Gupta et.al (2013) in this paper,author proposed LEACH_HE in which confidentiality scheme i.e. homomorphic encryption is added to LEACH protocol. In homomorphism encryption data can be aggregated algebraically without decryption and hence less energy consumption. Simulation results are obtained in terms of three metrics- total energy consumed, amount of data transmitted and number of nodes alive. It is observed that the performance of LEACH_HE is somewhat similar to LEACH [9].

Qinghai Bai (2010) this paper presents some kinds of improved versions of PSO and research situation, and the future research issues are also given [10].

3. PROPOSED WORK/ METHEDOLOGY

In our work, we defined two models i.e. Energy Model and Network Model.

1. **Energy Model**- In this model, both the free space and multi-way blurring channels are utilized relying upon the separation between the transmitter and beneficiary. At the point when the separation is not as much as a limit esteem d0, then the free space (fs) model is utilized, something else, the multipath model is utilized.

2. **Network Model**- We expects a WSN model where all the sensor hubs are sent haphazardly alongside a couple of passages and once they are projected, they get to be stationary. A sensor hub can be allocated to any door on the off chance that it is inside of the correspondence scope of the sensor hub. In this way, there are some pre-specified entryways on to which a specific sensor hub can be allotted.

4. RESULTS AND DISCUSSION

Here we compare the network with PSO with the network without PSO using some performance metrics: Consumed Energy, Packet Delivery Ratio (PDR), and Average Throughput.

4.1 Consumed Energy:

Energy consumption is the consumption of energy or power.

Table 1: Consumed Energy (C.E.)

Simulation Time	C.E. Without PSO	C.E. With PSO
10	32.80	26.80
15	40.66	34.60
20	45.11	39.15

As shown in the graph, consumed energy in the network using PSO is minimum than the network without PSO.

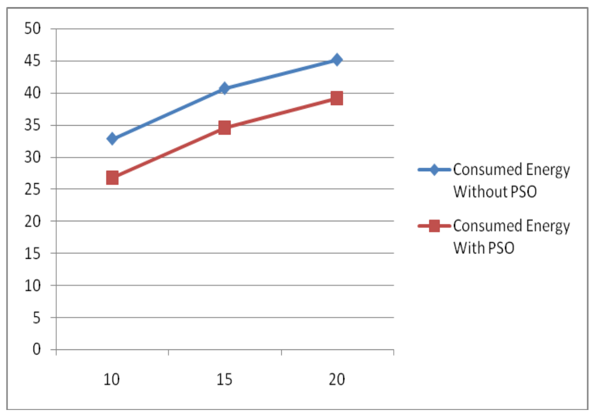

Fig. 4.1 Simulation Time (x-axis) Vs CE (yaxis)

4.2 Packet Delivery Ratio (PDR).

Packet delivery ratio: the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

∑ Number of packet receive / ∑ Number of packet send.

Table 2: PDR

Simulation Time	PDR Without PSO	PDR With PSO
10	82.45	82.45
15	90.15	90.15
20	93.04	93.04

As shown in the graph, PDR in the network without PSO gives the same result as in the network using PSO.

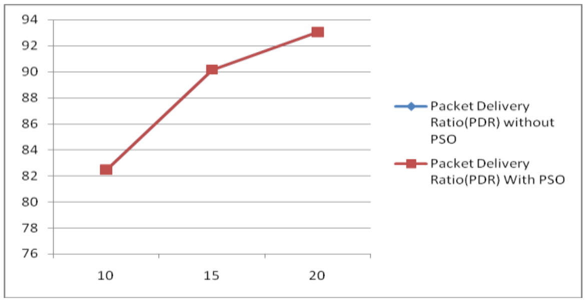

Fig. 4.2 Simulation Time (x-axis) Vs PDR (yaxis)

4.3 Average Throughput:

It is the rate of successful message delivery over a communication channel. It is measured in bits per second(bits/s or bps) and sometimes in data packets per second (p/s pps).

Table 3: Average Throughput

Simulation Time	Average Throughput Without PSO	Average Throughput With PSO
10	318137	318236
15	312729	303275
20	319491	310717

As shown in the graph, the average throughput decreases with the simulation time and increase at the simulation time 20.The average throughput in the network using PSO is less than the average throughput in the network without PSO.

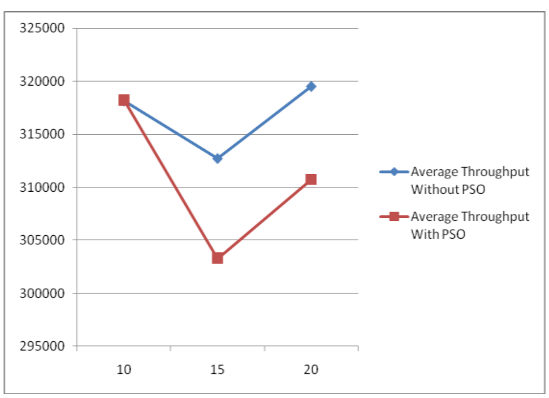

Fig. 4.3 Simulation Time (x-axis) Vs Average Throughput (y-axis)

5. CONCLUSIONS

In this paper, enhancement of DSDV protocol with particle swarm optimization (PSO) is done, and the results of existing PSO are compared with the results of proposed PSO. Packet delivery ratio (PDR) in proposed PSO and existing PSO remains same, consumed energy and average throughput is less in Proposed PSO than the existing PSO. Average Throughput in Proposed PSO is not better than the existing PSO. PSO helps to reduce the consumed energy which results in increase the lifetime of network.

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