Data Gathering Optimization Using ACO and Genetic Algorithm in WSN

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Abstract: ***The Wireless Sensor Network (WSN) is a series of sensor nodes that detect, process and transmit information about any sensing area. In order to increase network lifetimes during data processing, various energy-efficient protocols are of great importance. The parameter that is important in a sensor network for protocols is its knowledge of energy. The distance of nodes from the base station and inter-nodal differences in the network are the reasons that influence unequal energy dissipation between the nodes. The planned protocol should therefore be energy efficient and stable to deal with. Elegant solutions to the problem are given by PEGASIS, which creates a chain using a greedy algorithm. In this article, we first use the greedy chain to introduce PEGASIS and then use the Genetic Algorithm to create the data routing chain, which uses its crossover and mutation operators and finds an optimised data collection routing route. For the same amount of nodes, the Genetic Algorithm increases the network lifespan. Extensive simulations are performed and on the basis of energy consumption and number of rounds, the effects of PEGASIS and GA are compared with each other.***

Keywords: data gathering, PEGASIS, Genetic Algorithm, Ant colony optimization

1. Introduction

Wireless Sensor Networks (WSN) are thin, lightweight node networks organised over wide areas. These nodes will capture, process and transmit the conditions surrounding them, such as temperature, humidity, vibration, etc. Data is sensed and analysed by the sensor node. It routes the data to the base station via a transmission device after processing. Sensor nodes do not need to connect directly with their local peers, but only with the nearest Base Station. In other words, each sensor node becomes an active part of the overall infrastructure. There is no pre-deployed infrastructure. These sensor nodes collect different data types and work together in the network to perform a high-level mission.

The sensor nodes collect the data from the sensing field and route it to the sink or the Base Station, as shown in Fig. 1. As the locations of the individual nodes are not pre-determined, the network must possess self-organizing capabilities. Cooperation between the nodes is the dominant thing in WSN, as these nodes cooperate to circulate the information gathered in the user region.

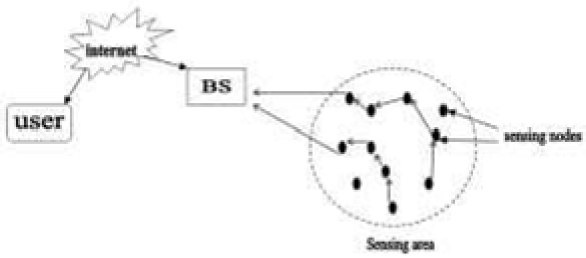


Figure 1: Structure of WSN

An significant parameter for WSN is network lifetime. It is determined by the nodes' power consumption. In different cases, if large numbers of nodes are dead, a network will become non-functional. Thus, balancing the dissipation of energy by the network nodes is a crucial factor in extending the existence of the network. Efficient protocols must be used effectively to maximise the lifespan of network energy. In WSN, multiple routing protocols were implemented on the basis of a number of different mechanisms and optimization criteria. The protocols used should be fault tolerant and scalable to minimise energy dissipation. Various protocols have been introduced. The most elegant approach to the problem of energy dissipation is PEGASIS. Using Ant Colony Optimization (ACO) and Genetic Algorithm, this protocol further enhances the results by increasing the number of rounds for a particular number of nodes.

PEGASIS

In Sensor Information Systems, PEGASIS is Power Efficient Gathering. It is a chain-based protocol that enables the energy consumption at each sensor node to be minimised. As opposed to other protocols such as LEACH, PEGASIS is found to be more robust for node failures. The nodes form a chain in PEGASIS and each node transmits the data to its closest neighbour. The construction of the chain begins from the node closest to the Base Station (BS) and is done using the Greedy Algorithm. Nodes transmit to the BS in turn, so that the average energy spent per node per round is decreased. Each node fuses the data packet with its own data in each data collection round and transfers it to the other neighbouring node, as shown in Fig. 2. The token passing method initiated by the leader to initiate the transfer of data from the ends of the chain is used. Each and every node is presumed to have global knowledge about all the nodes. It is not necessary to revisit the already visited node.If a node dies by bypassing the dead node, the chain is reconstructed. This protocol achieves the solution to the problem of energy usage, but this aim has not been completely accomplished as the inter-nodal distances appear to be high when reaching the end of the chain. In the course of data collection and transmission to their neighbours, these nodes begin to dissipate more energy and as a consequence, those nodes die soon.

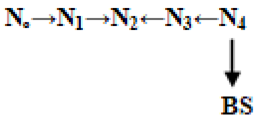


Figure 2: Basic Structure of PEGASIS

PEGASIS is applied in this paper using the Greedy Chain and then using the Genetic Algorithm. The findings are equated with each other and with ACO.

The work performed requires applying the PEGASIS protocol. The protocol is implemented using the traditional PEGASIS implementation form, Greedy Chain. The Genetic Algorithm is then used to execute it. From the farthest node from the base station, the greedy chain initiates the creation of the chain. The next node, at a smaller distance from the others, is picked. So the inter-nodal distances are determined and the nodes are chosen. During this process, the distances start to increase towards the end of the chain, resulting in further dissipation of energy.

2. Implementation

1) Genetic Algorithm

A heuristic search algorithm based on the principles of natural selection and evolution is the genetic algorithm[6]. Genetic algorithms are evolutionary algorithms (EA) that use genetic operators, such as mutation, selection and crossover, to solve optimization problems. A population of chromosomes is created in the genetic algorithm, and the candidate solution (fitness value) is generated[4]. The chromosome population is generated randomly. As follows, various terms related to GA are defined—

a) ***Population***- It is a collection of chromosomes. Itconsists of *r* chromosomes.
b) ***Genes and chromosomes***- By means of a chromosome which contains information for the Genetic Algorithm, we represent our data routing chain. A chromosome is a gene group, and for a given network, each chromosome represents a specific arrangement of the nodes in the routing chain.
c) ***Parent Selection***-The Genetic Algorithm parent selection mechanism decides which two parents will take part in mating to produce an offspring from the total population of r chromosomes.
d) ***Generation***-Using crossover and mutation operations, a new generation is created. For both generations, the population size remains identical.
e) ***Crossover*** –The combination of two parent chromosomes to produce an offspring is indicated by Crossover. For instance, if there are two parent chromosomes selected for crossover, C1 = {2,1,4,5,3,6} and C2 = {1,2,3,4,5,6}. The {3,4,5} slot is randomly selected from C2 and inserted into C1 at the same place. Thus, the generated offspring is O1 ={2,1,3,4,5,6}.
f) ***Evaluation and Fitness*** –A role is required in any evolutionary computation framework to compare and determine the fittest of a candidate from a generation of candidates. A candidate's fitness is determined by the function of the optimization problem. On the basis of the fitness function generated by the chromosomes with the best fitness values, they are selected.

$$f(c) = \sum_{i=1}^{N} d_i^2$$

It calculates the energy of a N gene-containing chromosome C and di denotes the distance in the data collection chain between the (i+1)th (or, gene) node and the ith node. The higher chromosome energy value implies a longer chain and leads to an inferior solution.

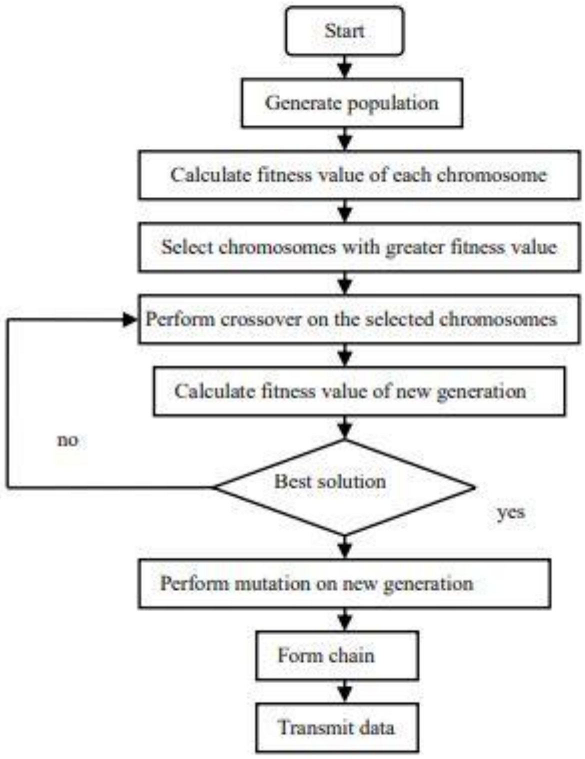


Figure 3: Implementation flow chart

3. Result and Simulation

All simulations were performed on an area of 100m*100m and nodes were distributed randomly in this field. Using 100 nodes, the implemented protocol PEGASIS is simulated. PEGASIS uses a greedy approach and a Genetic Algorithm to construct the chain. The simulations are performed when 10 percent, 30 percent, 60 percent, 90 percent of nodes die, to decide the number of nodes. Each node has an initial energy level that is the same.

The energy analysis of the above schemes is shown in Table 1. Compared with each other the number of rounds completed by the different schemes corresponds to the percentage of nodes alive at the same initial energy level.

Table 1: Energy Analysis

Energy	Protocol	Percentage of alive nodes						
		90	70	60	50	40	30	20
.25	Pegasis	700	730	750	780	790	799	800
	PegasisAco	1410	1570	1590	1600	1790	1960	2100
	PegasisGa	2900	3190	3320	3390	3590	3780	3920
.5	Pegasis	1400	1480	1490	1500	1520	1600	1630
	PeasisAco	2080	2090	2160	2180	2250	2490	2590
	PegasisGa	2580	2700	3000	3350	3480	3690	4100

Chain creation using the Greedy Algorithm results in a lower quality of the chain. The next closest node to transfer data is chosen by the greedy chain in which the inter-nodal distances begin to increase at the end of the chain, resulting in further energy dissipation and earlier node deaths. ACO bypasses the issue and inside the threshold, builds the chain. However in contrast to ACO, the Genetic Algorithm shows better energy efficiency. Using .25 and 0.5 as initial node capacity, the simulations are carried out.

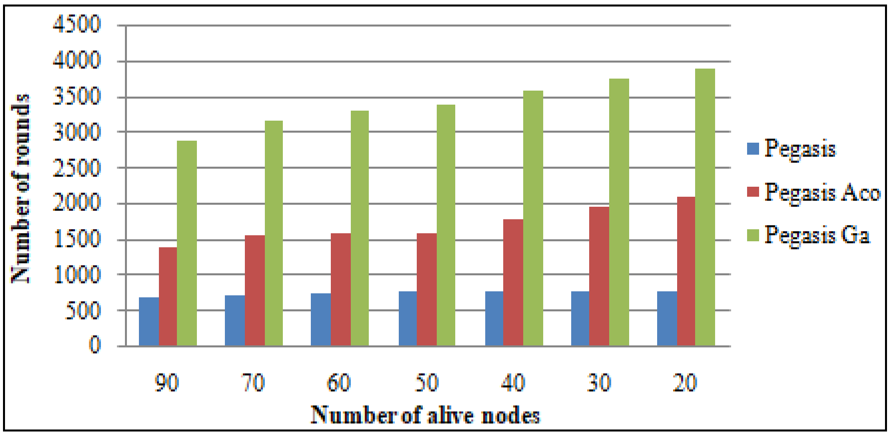
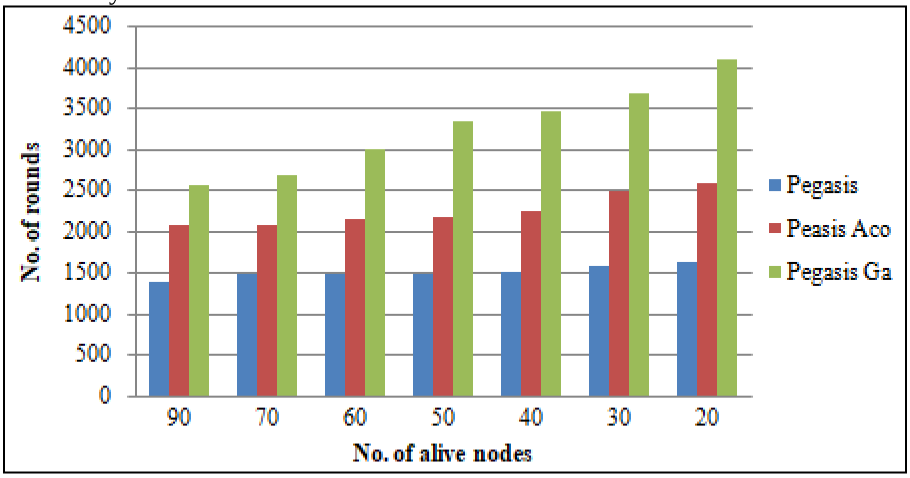


Figure 4: Protocols comparison on the basis of energy

In the case of PEGASIS being implemented using GA, the results indicate better efficiency.

Energy analysis when initial energy is taken as 0.5.



The above results show that the output of GA is better for a 100m*100m region when implemented with GA in the sensor network, PEGASIS can provide us with data for a considerably long period of time. With fewer nodes dead, compared to traditional Greedy chain and ACO, the quality of data will also be fine.

4. Conclusion and Future work

The PEGASIS protocol considered ensures that there is a close utilisation of resources, thus increasing the existence of the network. Using Greedy Chain, PEGASIS reveals certain disadvantages, such as the incremental rise in inter-nodal distances when reaching the end of the chain that is resolved by using Ant Colony Optimization (ACO) and Genetic Algorithm (GA) to implement PEGASIS. In MATLAB, simulations are conducted that are correlated with each other on the basis of the energy consumption carried out in the form of the distance travelled. Compared to ACO, GA's results are higher. By optimising routing routes, the lifespan of the sensor network has been increased. Other frameworks, such as Particle Swarm Optimization (PSO) on PEGASIS, could be introduced and compared to ACO and GA. Packet losses could also be considered and the current model could be adjusted in order to achieve the desired results under the specified conditions.

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