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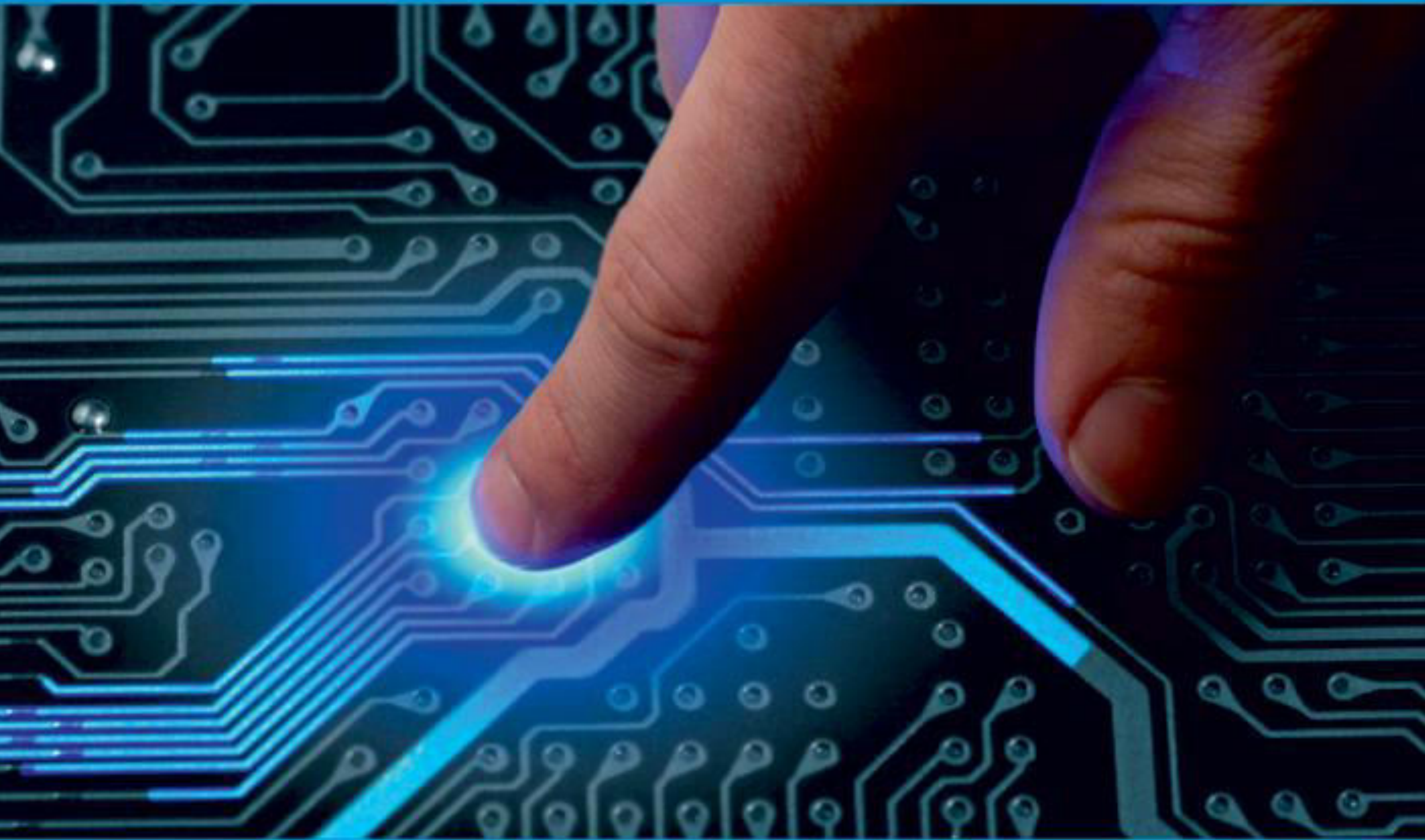

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Genetic Algorithm with PEGASIS Protocol: Energy Efficient Solution

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ABSTRACT*:* Due to its boundless potential applications, Wireless Sensor Networks have been subject to much research in the last two decades. WSNs are often deployed in remote environments making replacement of batteries not feasible. Low energy consumption being of prime requisite led to the development of energy-efficient routing protocols. The proposed routing algorithms seek to prolong the lifetime of sensor nodes in the relatively unexplored area of 3D WSNs. The schemes use chain-based routing technique PEGASIS as basis and employ genetic algorithm to build the chain instead of the greedy algorithm. Proposed schemes will incorporate an energy and distance aware CH selection technique to improve load balancing. Clustering of the network is also implemented to reduce number of nodes in a chain and hence reduce delay. Simulation of our proposed protocols is carried out for homogeneous networks considering separately cases for a static base-station inside and outside the network. Results indicate considerable improvement in lifetime over PEGASIS of 817% and 420% for base station inside and outside the network respectively. Residual energy and delay performance are also considered.

KEYWORDS*:* Pegasis, LEACH, Wireless Sensor Networks, Genetic Algorithms, Energy constrained

I. INTRODUCTION

The Wireless Sensor Network (WSN), a specialized network, consists of two main components: 1. Sensor Nodes and 2. Base Station. The nodes monitor various environmental conditions (temperature, pressure, sound) and share (wirelessly) the information obtained with either the base station or amongst various nodes. WSN is foreseen to be appropriate solutions to many applications in fields of defence, industry monitoring, health monitoring, etc.

A. Structure of Wireless Sensor Networks

Sensor Nodes: Sensor is a device which senses the information and passes it on to mote. A mote consists of processor, memory, battery and A/D converter to connect with a sensor and radio transceiver for the formation of an ad hoc network. A mote and sensor together form a Sensor Node. Fig. 1 shows the block diagram of sensor node.

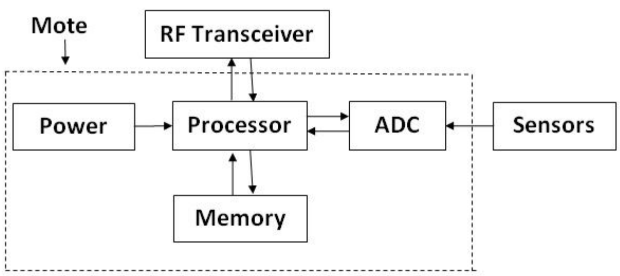

Fig. 1: Block diagram of sensor node

Base Station: A base station (consisting of processor, radio board, antenna and USB interface board) links the sensor network to another network. It is pre-programmed with low-power mesh networking software for communication with wireless sensor nodes. Fig. 2 shows the base station architecture.

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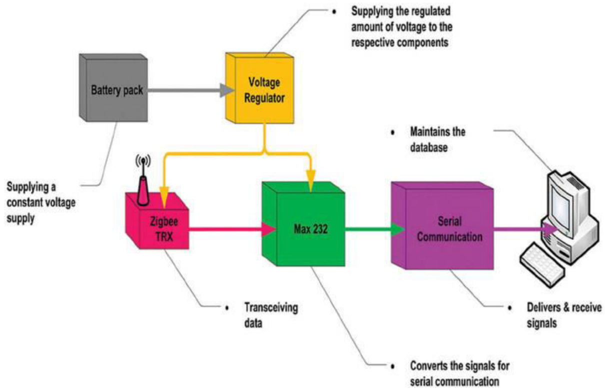

Fig. 2. Base station architecture

Router: Router is a microprocessor-controlled device connected between two or more data lines from different networks which makes connection possible between two or more different network present at same or different geographical locations. It also forwards data packets between computer networks. A Router is used to connect different networks; it extracts the packet destination, selects the best destination path and forwards the packet to the next device on selective path. The router determines the destination of the packet by reading the address information in the packet, when a data packet comes in one of the lines. Using the information in the routing table, the packet is directed to the next network.

In this paper, we have proposed Energy Efficient PEGASIS Based (EEPB) protocol. The proposed protocol is an enhanced PEGASIS algorithm in WSN. In PEGASIS distance algorithm is used to form the data chain and it can result in communication distance between two sensors being too long. Thus, the sensors die early as they consume a lot of energy for the transmission of data. In the chaining process, the average distance of the chain (known as "threshold distance") is considered by a node. If the distance from the closest node and the upstream node is greater than thresh distance, the closest node is the "far node". If the closest node joins the chain, it becomes "long chain". EB-PEGASIS avoids this phenomena using distance threshold. It not only does the energy saving on threshold but also balances energy consumption of all sensor nodes.

II. MATTERIAL AND METHODS

Radio and energy model: The first-order radio model is used to calculate energy consumption of communicating nodes. It is simple to implement the number of bits and transmission distance (d) [18].

$$E_{\frac{Tx}{Rx}-elec} = E_{elec} \times k$$

where E_{elec} is the energy expended per bit to run the transmitter or receiver. The transmission energy used by the amplifiers is a function of both the number of bits and transmission distance (d) [18].

$E_{Tx-amp} = \begin{cases} \epsilon_{fs} \times k \times d^2 & if\ d < d_0 \\ \epsilon_{mp} \times k \times d^4 & if\ d > d_0 \end{cases}$ ETx−amp ¼ where d_0 is a threshold used to determine which fading model is used (free space or multipath) .

To solve the TSP in PEGASIS, a genetic algorithm will be used such that a near optimal chain length is obtained. Genetic algorithm is easy to implement and also less computationally expensive compared to techniques such as ACO [15]. It is inspired from nature and it attempts to imitate the processes which take place in Darwinian evolution. A chromosome is used to represent the solution and a population which contains multiple chromosomes is used. A chromosome contains genes and in the context of TSP, a gene is an index representing a specific node.

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The GA is an iterative process. To find new solutions which may yield a better solution, GA operators are applied on chromosomes at each iteration. The simplest GA operators are [20]:

I. Selection This involves favouring the selection of solutions having better fitness.

II. Crossover This is similar to the reproduction process which takes place in evolution. It involves taking more than one solution and combining them to produce a new solution.

III. Mutation This entails modifying a portion of the solution and it helps to ensure diversity in a population [21]. It consist of the following:

i) Swap operation Two nodes are selected at random in the solution and their positions are swapped. For instance, considering positions 2 and 5

a → b → c → d → e → f becomes a → e → c → d → b → f and widely used in WSN literature [16]. Hence, comparisons to previous protocols are made easier and fairer. Transmitter and receiver circuits need energy to be run. The latter is a function of the number of bits (k) only [18]. ETx=Rx−elec ¼ Eelec3 k (1) where Eelec is the energy expended per bit to run the transmitter or receiver. The transmission energy used by the amplifiers is a function of both

ii) Flip operation Part of the solution is flipped randomly as illustrated below:

a → b → c → d → e → f becomes a → e → d → c → b → f after flipping at positions 2 and 5

iii) Slide operation Part of the solution is selected randomly and it is 'slid' across to modify the solution. For illustration, the part of the solution from position 2 to 5 is considered.

a → b → c → d → e → f becomes a → c → d → e → b → f

An open source code was used to implement the GA for chain building Kirk [22]. It makes use of selection and mutation. The steps in the GA algorithm are outlined below.

Algorithm- I:

I. Initialise the initial population. The initial population contains multiple solutions which are generated in a random manner. Variable globalMin indicates the shortest chain length that has been achieved so far and it is assigned to infinity.

II. Calculate the fitness of each member of the population. populationMin is assigned to infinity. populationMin is a variable which indicates the best fitness value (smallest overall chain length) in the current population.

III. Record solution having best fitness in bestPopSolution. bestPopSolution is a variable which records the best solution in the current population. populationMin is assigned the value of best fitness.

IV. If populationMin < globalMin, a new value globalMin is recorded as populationMin and the globalBestSolution is recorded as bestPopSolution. Variable globalBestSolution indicates the best solution which has been achieved so far.

V. The order of solutions in the population are randomised. For instance, solution 1 can become solution 30 and so on.

VI. For every four members of the population(solutions 1–4, 5–8 and so on), the best solution is taken and the following steps are taken to create 4 new routes (a) Create random route insertion points. These consist of 2 points which indicate where a solution will be modified. (b) The best solution of the initial 4 is taken as new route 1. (c) Flip operation is applied to the best solution to create new route 2. (d) Swap operation is applied to the best solution to create new route 3. (e) Slide operation is applied to the best solution to create new route 4.

VII. Hence, a new population is formed consisting of new solutions.

VIII. Steps 2 to 7 are repeated until the total number of iterations are completed.

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III. PROPOSED METHODOLOGY

The flow chart of the proposed algorithm is given below.

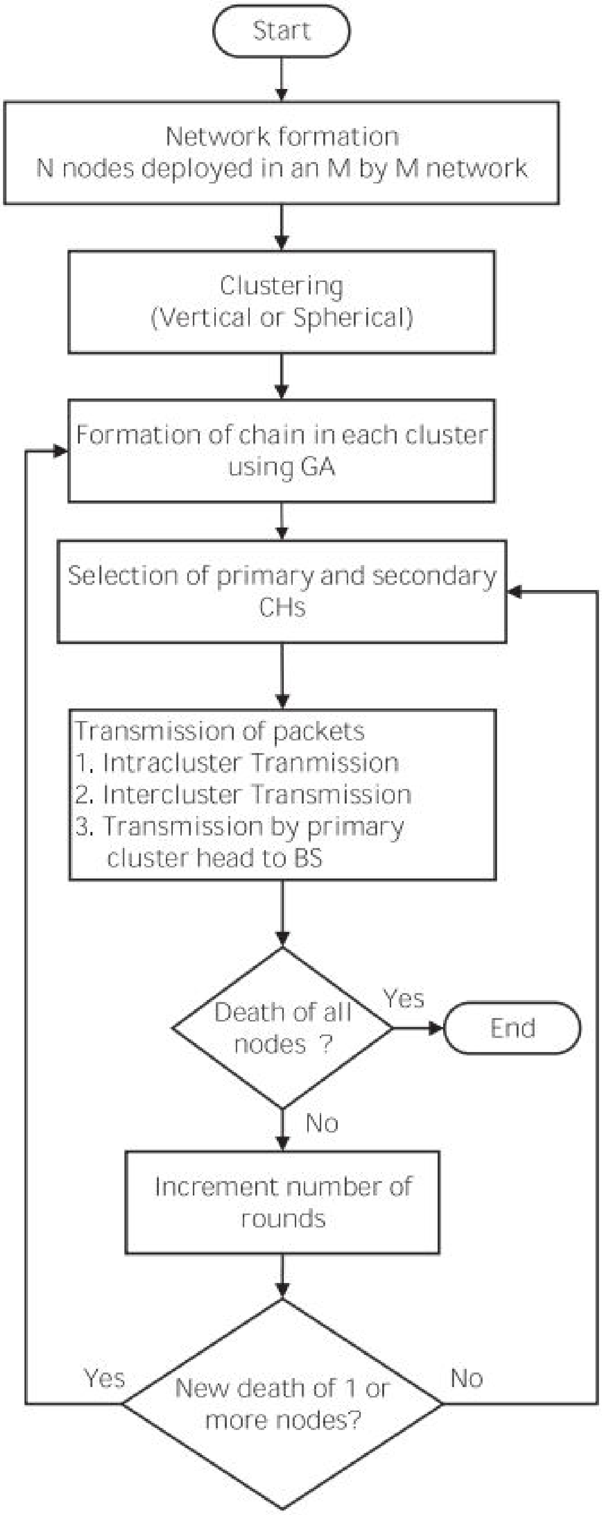

Fig. 3: Block diagram of proposed methodology

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IV. RESULTS

Matlab 2014a has been used for the simulation of PEGASIS code. The performance of pegasis is evaluated by simulating pegasis code using random 100 nodes in a network. Fig. 4 shows a random 100 nodes network. The base station (BS) is located at (50,200) in a 200m x 100m field.

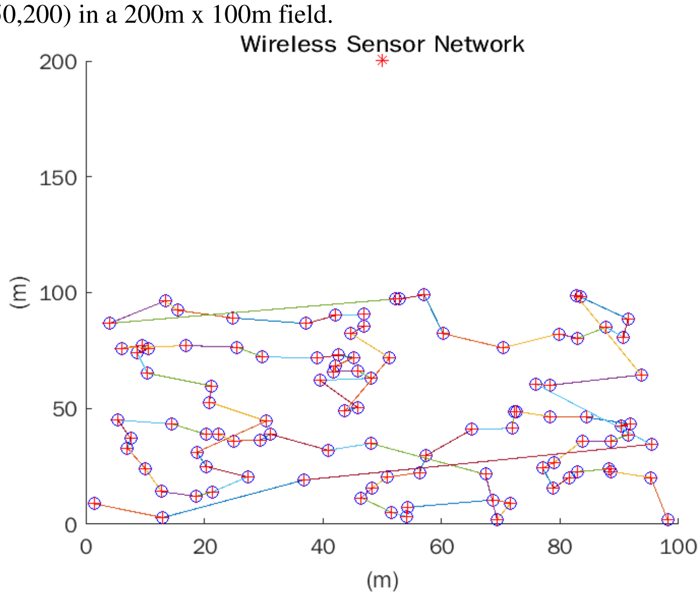

Fig. 4: Proposed scenario of Sensor Network

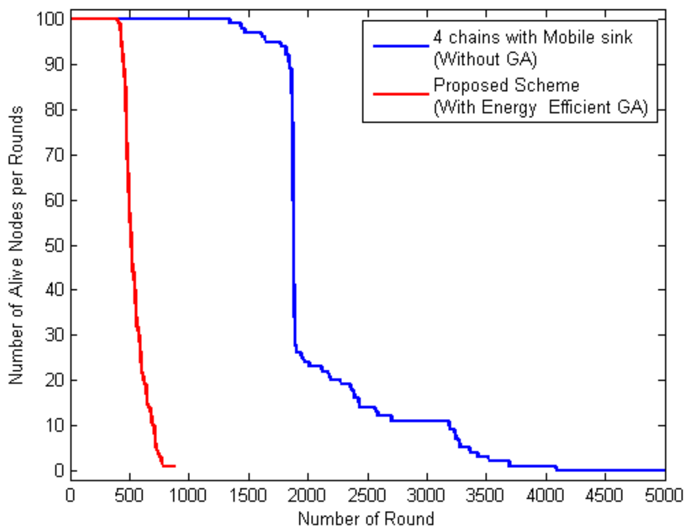

Fig. 5: Number of alive nodes per rounds vs number of rounds.

Figure 5 represents Number of alive nodes per rounds vs number of rounds for 4 chains with mobile sink without Genetic Algorithm and the proposed scheme with Genetic Algorithm. From this figure, we infer that the proposed scheme performs much better than without Genetic Algorithm based approach.

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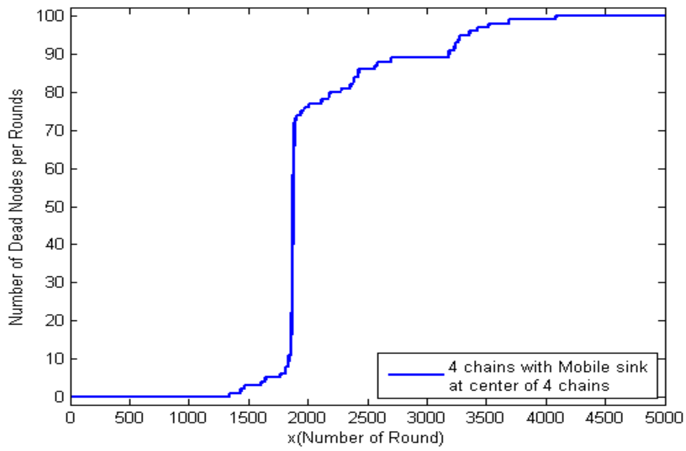

Fig. 6: Number of Dead nodes per round vs x(Number of rounds.)

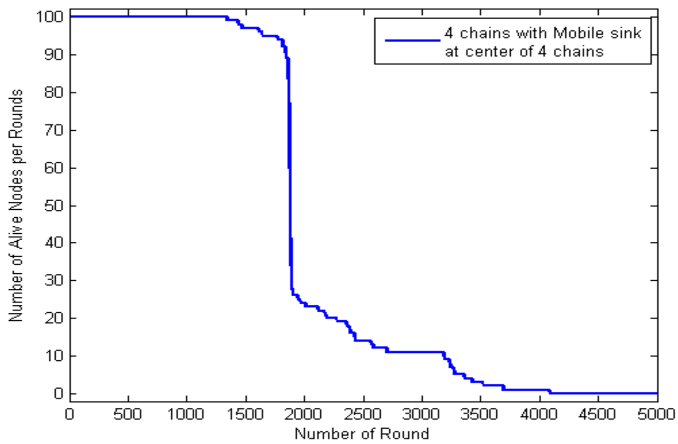

Fig. 7: Number of Alive nodes per round vs Number of rounds.

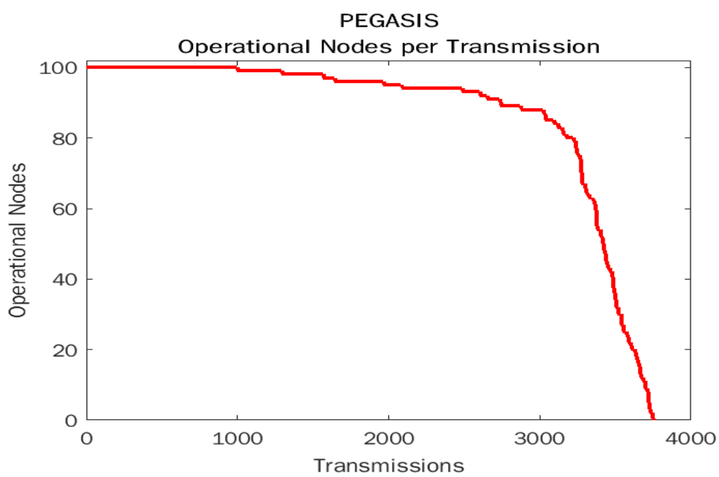

Fig. 8: Operational nodes per transmission vs number of transmission for PEGASIS protocol

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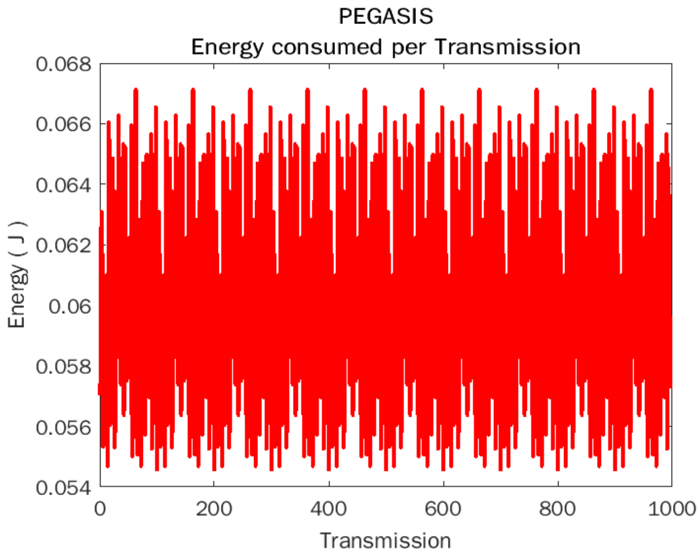

Fig. 9: Energy consumed per transmission vs Number of transmissions.

V. CONCLUSION

In this paper, a novel method of combining PEGASIS, clustering and genetic algorithm to minimise transmission distance was proposed. A variable weight CH selection based on distance and energy for better load balancing was adopted. A new version of PEGASIS is adapted for 3D networks and variants of it were also proposed. Simulations in MATLAB have shown the superiority and adequacy of our proposed protocols in terms of FND. This is illustrated by PEG-GA Vertical Clustering(3) having improvements of 817% and 420% in FND over PEGASIS for base station inside and outside the network respectively. These very high percentages of improvement result from the very poor performance in 3D networks of the greedy algorithm used by PEGASIS and these percentages show the need for our proposed protocols. Residual energy, load balancing and delay performance were also shown to be superior.

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[3] S. Lindsey, C.S. Raghavendra, PEGASIS: power-efficient gathering in sensor information systems, IEEE Aerospace Conference Proceedings 3 (2002) 1125–1130. Routing Protocol Residual Energy(%) PEGASIS 73.5 PEG-GA 26.9 PEG-GA Spherical Clustering(3) 1.6 PEG-GA Spherical Clustering(8) 2.7 PEG-GA Vertical Clustering(3) 1.5 PEG-GA Vertical Clustering(9) 1.6 Table 7. Percentage residual energy at FND (3D BS Outside Case). Energyefficient genetic algorithm variants.

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