Energy Aware Swarm Intelligence Approach for Route Selection with Multi hopping in Wireless Sensor Network

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Abstract— *Wireless sensor networks are formed by small devices communicating over wireless links without using a fixed network infrastructure. Because of limited transmission range, communication between any two devices requires collaborating intermediate forwarding network nodes, i.e. devices act as routers and end systems at the same time. Communication between any two nodes may be trivially based on simply flooding the entire network. However, more elaborate routing algorithms are essential for the applicability of such wireless networks, since energy has to be conserved in low powered devices and wireless communication always leads to increased energy consumption.*

Wireless Sensor Networks consisting of nodes with limited power are deployed to collect and distribute useful information from the field to the other sensor nodes. Energy consumption is a key issue in the sensor's communications since many use battery power, which is limited. In this paper, we describe a novel energy efficient routing approach which combines swarm intelligence, especially the genetic algorithm. The main goal of our study was to maintain network lifetime at a maximum, while discovering the shortest paths from the source nodes to the sink node using improved swarm intelligence. The research also includes maximizing the number of 'alive' particulars overtime, thus prolonging the systems lifetime. Simulation results shows that compared with the traditional Q-Leach algorithm can obviously improve adaptability and reduce the average energy consumption effectively.

Keywords — *Wireless sensor networks, Routing protocols, Energy Efficiency, Swarm Intelligence, Genetic Algorithm.*

I. INTRODUCTION

A wireless sensor network (WSN) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. In WSNs energy consumption is one of major issues which needs to be carefully consume by sensor node to “maximize the network lifetime”. Typically the sensor nodes are powered by small batteries which are incapable to power a long period. Generally, the sensors nodes are deployed in a left unattended area. In such situation feeding energy to the battery or replacing batteries is difficult or even not possible too. Therefore, prolonging the network lifetime is an important optimization goal in this aspect. Hence the energy consumption by whole network in every aspect needs to be minimized. Energy in the sensor nodes fulfills a very important need for real-time data recording from the sensors. So the current research directed towards; how to design an efficient and energy-awareness protocols in order to extend the lifetime of networks.

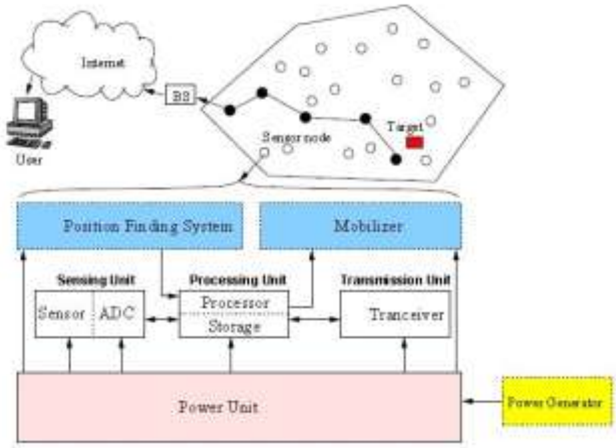


Fig 1. The components of a sensor node

The main elements of Wireless Sensor Network

• **Sensor Node**: A sensor node is the main component of a WSN. Sensor nodes play various roles in a network, such as sensing, data storage, data processing and routing.

• **Clusters**: Clusters are the main organizational unit for WSNs. The dense nature of wireless sensor networks requires the need for network to be broken down into clusters to simplify tasks such as communication.

• **Cluster heads**: Cluster heads are the organizational leader of a cluster. They often are required to organize activities in the cluster. All the communication is done through the Cluster Heads. The choice of Cluster-head is a prime issue.

• **Base Station**: The base station is at the Application layer of the hierarchical WSN. It provides the communication between the sensor network and the end-user.

• **End User**: The data in a wireless sensor network can be used for many applications. Therefore, a particular application may make use of the network data over the internet, using a PDA, or even a desktop computer by the end user.

II. DESIGN FACTORS & CHALLENGES IN WSNs

The efficient and robust realizations of WSNs are challenging and algorithmic task, because of the unique characteristics and several limitations of these devices. Sensor network requires the efficient and robust distributed protocols and algorithms with properties such as:
(a) Scalability: - Able to operate in extremely large networks composed of huge numbers nodes.
(b) Efficiency:- Efficient with respect to both energy and time.
(c) Fault Tolerance:- Network should be able to operate despite of any failure of any nodes.
One of the most crucial goals in designing efficient protocols for WSNs is minimizing the energy consumption. This goal has various aspects:
(a) Minimizing the total energy spent in the network
(b) Minimizing the number of data transmission
(c) Combining energy efficiency and fault-tolerance by allowing redundant data transmission which, however, should be optimized to not spend too much energy.
(d) Maximizing the number of 'alive' particulars overtime, thus prolonging the systems lifetime.
(e) Balancing the energy dissipation among the sensors in the network.

III. SWARM INTELLIGENCE

Swarm intelligence algorithm is a collective behaviour from a group of social insects, namely birds, ants, etc., where the agents (ants) communicate either directly or indirectly in the system using a distributed problem solving approach. This approach supports an optimized routing design, prevents centralization and avoids stagnation of the network nodes. Routing in wireless network is not static; hence this intelligent sensor approach provides a solution to distributed and dynamic optimization problems. Thus making the network robust, decentralized, coherent, flexible and self organized.

A. Genetic Algorithm

In a genetic algorithm, a population of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem is evolved toward better solutions. Each candidate solution has a set of properties (its chromosomes or genotype) which can be mutated and altered; traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible.

The evolution usually starts from a population of randomly generated individuals, and is an iterative process, with the population in each iteration called a generation. In each generation, the fitness of every individual in the population is evaluated; the fitness is usually the value of the objective function in the optimization problem being solved. The more fit individuals are stochastically selected from the current population, and each individual's genome is modified (recombined and possibly randomly mutated) to form a new generation. The new generation of candidate solutions is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population.

A typical genetic algorithm requires:

1. A genetic representation of the solution domain.
2. A fitness function to evaluate the solution domain.

A standard representation of each candidate solution is as an array of bits. Arrays of other types and structures can be used in essentially the same way. The main property that makes these genetic representations convenient is that their parts are easily aligned due to their fixed size, which facilitates simple crossover operations. Variable length representations may also be used, but crossover implementation is more complex in this case. Tree-like representations are explored in genetic programming and graph-form representations are explored in evolutionary programming; a mix of both linear chromosomes and trees are explored in gene expression programming.

Once the genetic representation and the fitness function are defined, a GA proceeds to initialize a population of solutions and then to improve it through repetitive application of the mutation, crossover, inversion and selection operators.

The GA is a random search algorithm based on the concept of natural selection inherent in natural genetics, presents a robust method for search for the optimum solution to the complex problems. The algorithms are mathematically simple yet powerful in their search for improvement after each generation (Goldberg, 1989). The artificial survival of better solution in GA search technique is achieved with genetic operators: selection, crossover and mutation, borrowed from natural genetics. The major difference between GA and the other classical optimization search techniques is that the GA works with a population of possible solutions; whereas the classical optimization techniques work with a single solution. Another difference is that the GA uses probabilistic transition rules instead of deterministic rules. The GA that employs binary strings to represent the variables (chromosomes) is called binary-coded GA. The binary-coded GA consists of three basic operators, selection, crossover or mating, and mutation, which are discussed as follow. In the selection procedure, the chromosomes compete for survival in a tournament selection, where the chromosomes with high fitness values enter the mating population and the remaining ones die off. The selection probability (Ps) determines the number of chromosomes to take part in tournament selection process. The selected chromosomes form an intermediate population known as the mating population, on which crossover and mutation operator is applied. The selected chromosomes are randomly assigned a mating partner from within the mating population. Then, a random crossover location is selected in any two parent chromosomes and the genetic information is exchanged between the two mating parent chromosomes with a certain mating probability (Pc), giving birth to a child (new variable) or the next generation. In binary-coded GA, mutation is achieved by replacing 0 with 1 or vice versa in the binary strings, with a probability of Pm. This process of selection, crossover, and mutation is repeated for many generations (iterations) with the objective of reaching the global optimal solution. The flow chart of the general solution procedure of GA is depicted in Figure 2.

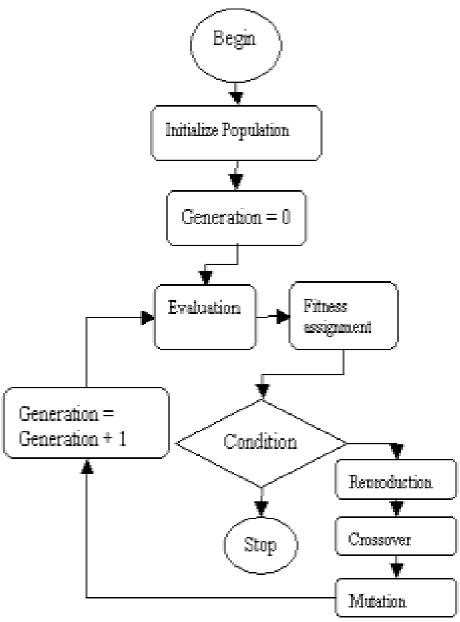


Figure 2. Working Principle of genetic Algorithm

IV. SIMULATION PARAMETERS

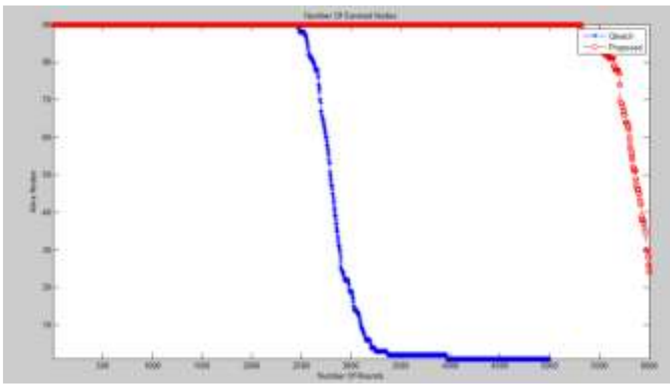
The various parameters considered in this research work are depicted below.

Table 1 Simulation parameters

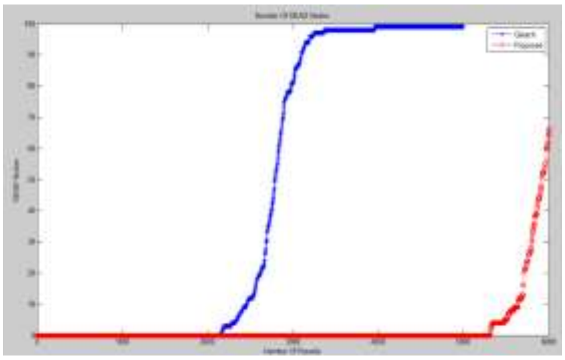
S.No	Parameters	Value
1.	Terrain	100m x 100m
2.	Number of sensor nodes,N	100
3.	Node Distribution	Uniform Square Grid
4.	Initial Energy	0.5 J
5.	Energy Consumed by radio Electronics, Eelec	50nJ/bit
6.	Energy Consumed by power Amplifier, EFs	$10pJ.bit^{-1}.m^{-2}$
7.	Energy Consumed by power Amplifier, ETr	$0.0013pJ.bit^{-1}m^{-4}$
8.	Data Rate	512kbps
9.	Data Generated by each Node	1500bit
10.	Order of System, p	2
11.	Particular Number, n	10
12.	Maximum iteration, m	100
13.	Upper Bound	100m(x and y axis both)
14.	Lower Bound	0(x and y axis both)

V. SIMULATION RESULTS

In this section, we will discuss and compare simulation results of Genetic Algorithm with Q-LEACH in WSNs. Here MATLAB is used as a Simulation tool.



(a)



(b)

Figure3. Performance Evalution of Q-Leach and GA

We deploy a random network of 100 nodes with initial energy=0.5j in field with dimensions of 100mX100m. In this Scenario BS is placed far away from the field network. The evolution of our proposed strategy is on basis of certain parameters such as network stability period (S.P), network life time (N.L.T) and throughput (T.P)

In Fig 3(a) it is shown that network lifetime is enhanced quiet significantly when compared with Q-LEACH. In our case the network remains alive almost up to 6000 rounds assuring network life-time to be more optimized. Moreover, it is also obvious that stability period is also improved i.e., first node dies around 5300 rounds.

Figure 3(b) shows unstable period of network when compared to Q-LEACH it is clear that it also improved. Thus it is clear that overall efficiency and stability is increased in our research work.

VI Conclusions

Energy consumption is one of major issues in WSNs which needs to be carefully utilized by sensor node to "maximize the network lifetime". One of the most important and crucial goals in designing this efficient protocol for WSNs is minimizing the energy consumption, minimizing the total energy spent in the network and maximizing the number of 'alive' particulars overtime, thus prolonging the systems lifetime. The paper also covers the comparison between the Q-Leach and Genetic Algorithm which clearly reflects that the Genetic Algorithm can enhance the life time of nodes more efficiently and effectively and thus maximize the network. The ultimate objective behind the protocol design is to keep the sensors operating for as long as possible, thus extending the network lifetime.

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