Energy Efficient Routing In Wireless Sensor Networks Using Modified Bacterial Foraging Algorithm

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Abstract

A wireless sensor network (WSN) has several number of sensor nodes and are typically battery-operated devices, and therefore energy efficiency is a major issue. In this paper we propose Modified Bacterial Foraging Algorithm (MBFA) algorithm, an enhanced version of BFA. This algorithm is used to minimize the energy of the nodes in wireless sensor networks and it is done by the cluster formation, cluster head selection, and the data aggregation at the cluster-head nodes to minimize the redundancy and thus we can save the energy. The BFA algorithm is a bio-inspired algorithm which is inspired by the social foraging behaviour of the E.Coli bacteria. It is used for selecting the best cluster head for WSN. The Modified Bacterial Foraging Algorithm (MBFA), which could be used for large scale optimization problems. The simulation results increases the performance of the MBFA, based on data transmission, energy consumption and number of alive nodes in the network in comparison with LEACH.

Index Terms— Wireless Sensor Networks, Bacterial Foraging Algorithm (BFA), Modified BFA (MBFA), LEACH, Energy Efficiency.

I-Introduction

A Wireless Sensor Network consists of huge variety of little, battery-operated, presumably mobile, self-adjusting nodes with restricted on-board process, environmental sensing, and wireless communication capabilities. WSN consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as vibration, temperature, pressure, sound, motion or pollutants.

In addition to the sensors, every node within the network is usually equipped with a radio transceiver or alternative wireless communication device, an energy source (usually a battery), and a micro-controller. The sensor node's cost is similarly variable, starting from a few to thousands of dollars, depending on the quality of the individual sensor nodes. Size and value constraints on the nodes can results in corresponding constraints on resources like energy, memory, speed and bandwidth.

WSNs offer some benefits and flexibility to low-power and inexpensive fast deployment for various applications that may be automated without human control. Several of the applications include disaster recovery, target tracking, health administration and military surveillance. WSNs can have the ability to self organize and self-configure by inter-node communications through multi-hop wireless paths. The sensor node encompasses sensing unit, process unit, power basis unit and a transceiver unit. Each of these units included with the assistance of ICs with integrated signal processing and micro-sensing elements. These nodes that forms the network is sited off from the particular incidence, and might still be used for data aggregation and assortment from a foreign location far from the purpose of event-occurrence.

Routing Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is a hierarchical protocol and provides significantly higher lifetime when compared with other flat-based routing protocols. In addition to dipping energy dissipation, leach with success distributes energy-usage among every node within the network such that the nodes die arbitrarily and at essentially an equivalent rate.

In LEACH, most nodes transmit their data to their cluster heads. The cluster heads collects and compresses the data and forwards it to the base station. In this protocol, all the nodes organize themselves into local clusters according to some procedure, with a number of nodes acting as the cluster-heads and other nodes acting as the members of the clusters. This cluster-head node consumes more energy than the member node. It runs many rounds in the lifetime of the network, and each round contains a cluster formation phase and a cluster steady phase. In the cluster formation phase, a number of nodes are selected to act as the local cluster-heads with a certain probability [12]. The following equation gives the definition of probability with which a cluster-head is selected:

$$Tn = \begin{cases} \frac{P}{1-P\left(r \bmod \frac{1}{P}\right)} & if\ n \in G \\ 0 & otherwise \end{cases}$$

where n is the current node, P is the desired percentage of cluster-heads among all nodes, r is the current round, and G is the set of nodes that have not been cluster-heads in the last 1/ P rounds. In the cluster formation phase, each node in the network decides by itself whether or not to become a cluster-head for the current round with a certain probability. This decision is made by the node choosing a random number between 0 and 1. If that number is less than the threshold Tn, the node becomes a cluster-head for the current round.

It has some shortcomings when it faces such problems as the cluster construction and energy management. It does not really support movement of nodes. If a node moves away from its cluster-head, it will have to spend more power in communicating with the current cluster-head. Some cluster-heads which will communicate with the base station directly, and are distributed in the network unevenly. They drain their energy if they are far from the base station. During the cluster-head election procedure, residual energy and positions of nodes are not fully taken into consideration.

BFA

This scheme uses bacterial foraging algorithm in WSN to increase the energy efficiency of every sensor nodes, whereas it is employed in control system [1]. These days bacterial Foraging technique is gaining control optimization issues.

Because

• Philosophy says, Biology provides extremely automatic, strong and effective organism

• Search strategy of bacterium is good (like common fish) in nature

• Bacterium will sense, create a choice and act therefore adopts social hunting (foraging in groups).

To perform social foraging, the animal desires communication capabilities and it gains benefits that may exploit basically the sensing capabilities of the cluster, in order that the cluster will gang-up on prey, persons can get safety from predators whereas in group, and in certain sense, the cluster will forage a form of intelligence. BFA relies on the hunting performance of Escherichia coli (E. coli) bacterium gift within the person intestine.

II-Related Works

M.Tripathy et al has proposed a brand new algorithmic rule bacterial foraging Algorithm(BFA) in conjunction with the transformer faucets are tuned with a view to simultaneously optimize the actual power losses and voltage stability limit. Kelvin M.Passino et al [1] has proposed to enhance the energy potency of the control system using bacterial Foraging algorithm (BFA). Therefore extending the lifespan of the system. Indrajit Banerjee et al [3] has proposed to maximize the life of sensor nodes and conjointly to seek out the shortest path between cluster head and base station for effective data transmission to base station. Weijiang et al, Lejiang Guo has proposed to improve node energy potency, balances energy consumption of all device nodes, enhances the reliability of data transmission and will increase the network system in comparison to LEACH.

Mario A. Munoz et al has proposed some modifications to the original algorithm that simplifies the algorithm structure, and also the addition of best member message into the search strategy, that improves t he performance. Ben Niu et al has planned bacterial foraging optimization (BFA) could be a fairly new bio- heuristic algorithmic program that is based on a figure of communal interaction of the bacterium.

Petre-Cosmin HuruiaHi et al's Wireless Sensor Networks comprise of terribly tiny sensors that area unit characterized by restricted process power and energy resources. WSNs area unit employed in varied domains like military applications, industrial job automation and medical engineering. It's vital to own an best network so as to use its dispensation power at most. This paper proposes and analyzes the effectiveness of a graded routing protocol designed to enlarge the lifetime of the network by minimizing energy use and latency by selecting the simplest nodes to become cluster-heads. Reduction is realized with a multi-objective genetic algorithmic program performed on a central base station and also the fallout sends to the network nodes. Simulation is completed in NS-2.

Cheng JianSheng et al, has planned that Wireless sensor networks have attracted a lot of analysis awareness in recent years. The energy competency's effect in Wireless sensor networks is analyzed, as a result's clustering technique has been confirmed to be an effective approach for reducing energy consumption. T. Datta et al [9], has planned that improved adaptive approach involving bacterial foraging algorithm (BFA) to enhance the amplitude and section of the weights of a linear collection of antennas for optimum array factor at any desired direction and nulls in actual directions. The bacterium hunting algorithmic program is complete adaptive using perspective of adaptive delta modulation.

III-Proposed Scheme

3.1. The Proposed MBFA

A. Bacterial Foraging Algorithm

In this scheme [1], BFA (Bacterial Foraging Algorithm) is employed to enhance the energy efficiency in wireless sensor networks. $cells_{num}$, $problem_{size}$, n_{re}, n_{ed}, nc, $step_{size}$, ns, $w_{repellent}$, $w_{attract}$, $d_{attract}$, $h_{repellent}$, ped are given as a input. Algorithmic rule output made the most effective cell value wherever it is a cluster head. At initial step cell number, problem size is given to seek out the initial population. Based on this, the high energy node is calculated. There are four basic steps, like chemotaxis, swarming, reproduction, elimination and dispersal.

$$P(j,k,l) = \{\theta i(j,k,l) | i = 1.2.K,S\}$$

Let j be the index for chemotactic step, k be the index for reproduction step, l be the index for elimination and dispersal event, and s be the bacteria. Chemotactic is a method of finding nearby nodes. Let Nc be the distance of the lifetime of the bacteria which is measured by the number of chemotactic steps they take throughout their life.

Let $C(i)\, \lambda(0), i, \lambda 1,2, K, S$ denote a basic chemotactic step size is to define the lengths of steps during runs. Tumbling is a method of moving to nearby nodes supported the specific set of directions. To indicate a tumble, a unit length in a random direction, say λ(j) is generated; unit length will be used to define the path of movement after a tumble. In general,

$$\theta i(j+1,k,l) = \theta i(j,k,l) + C(i)\theta(j)$$

Hence $C(i)$ is that the size of the step taken in random direction specified by the tumble. At $\theta i(j+1,k,l)$ the cost $J(i,j+1,k,l)$ is better (lower) than at $\theta i(j,k,l)$then another step of size $C(i)$during this same direction will be taken, and again, if that step resulted in a position with a better cost value than at the previous step, another step is taken.

B. Methods

Chemotaxis: It is a process in the control system which is achieved through swimming and tumbling via Flagella. Every flagellum could be a left-handed coil designed so because the support of the flagellum (i.e., wherever it's connected to the cell) rotates counterclockwise, as viewed from the free finish of the flagellum looking within the direction of the cell, it produces a force against the bacteria, so that it can push the cell. In particular

$$\theta i(j+1,k,l) = \theta i(j,k,l) + C(i)\theta(j)$$

Where $j+1,k,l$ represents the ith bacterium at the jth chemotactic step, Kth reproductive step and the lth elimination and dispersal step. $C(i)$ is that the size of the step taken in the random direction given by the tumble (run length unit).

Swarming: When a collection of E. coli cells is found in the center of a semisolid agar with a single nutrient chemo-effecter (sensor), they shift out from the middle in a traveling ring of cells by shifting up the nutrient gradient fashioned by consumption of the nutrient by the cluster. This order results from outward movement of the ring and also the native releases of the attractant; the cells provide a magnetism signal to every other so they swarm together.

Reproduction: The minimum healthy bacteria die and the other healthier bacteria each split into two, and are placed in the same location. This makes the inhabitants of microorganism constant.

Elimination and dispersal: It is probable that within the native surroundings, the lives of a population of bacteria changes either step by step (e.g., via consumption of nutrients) or unexpectedly as a result of another influence. Actions will occur such that all the bacteria during a space are killed or a group is isolated into a new a part of the environment.

B. Modified Bacterial Foraging Algorithm

The MBFA is a self organizing one and each node works independently and it provides efficient and scalable energy reduction [11].

The unit step length of the fundamental BFA is constant which can guarantee smart searching results for small optimization problems. However, when applied to complicated problems with high dimensionality it shows poor performance. The unit length parameter is that the key issue for controlling the native and global search ability of the BFA. From this angle, balancing the exploration and the search may be achieved by adjusting the run-length unit. in this paper we tend to propose a nonlinear decreasing dynamic function to perform the swim walk rather than the constant step. The function is expressed as:

$$C(i,j+1) = \left(\frac{\left(C(i,j) - C(Nc)\right)}{\left(Nc + C(Nc)\right)} * (Nc - j)\right)$$

Where j is that the chemotactic step and NC is that the most number of chemotactic steps whereas $C(Nc)$ could be a predefined parameter.

This method is proposed for economic dispatch problem and achieved optimum result in control optimization. In this paper this technique is incorporated in routing in wireless sensor networks for selecting the best cluster heads in the same fashion. The results are compared with LEACH and BFA.

IV-Performance Analysis

The performance analysis is based on three parameters; the number of alive nodes, data transmission rate, and energy consumption. These parameters are compared for LEACH, BFA and MBFA.

4.1. No. of Alive Nodes

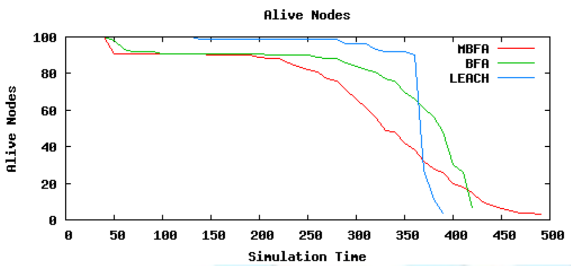

Fig 4.1. No of Alive Nodes

The number of alive nodes in LEACH and BFA is maximum than MBFA but both has less lifetime in the network than MBFA.

4.2. Data Transmission

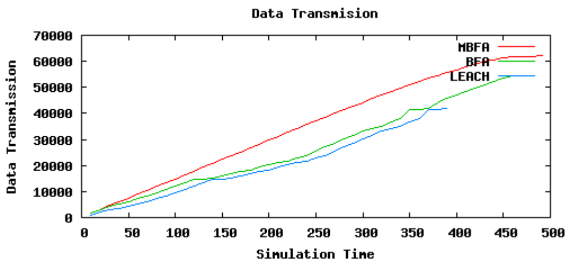

Fig 4.2. Data Transmission

The data transmission rate in LEACH and BFA is minimum than MBFA.

4.3. Energy Consumption

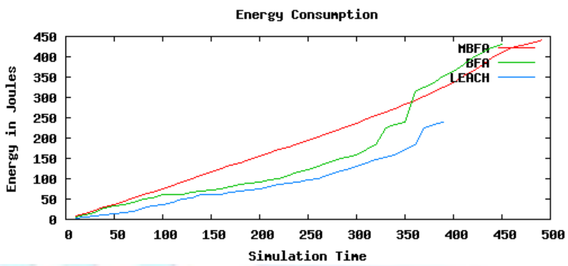

Fig 4.3. Energy Consumption

The Energy Consumption is high for MBFA but it has maximum lifetime in the network than LEACH and BFA.

V-Conclusion

The Bacterial Foraging Algorithm is used in routing to enhance the lifetime of the nodes in the wireless sensor networks. The Modified BFA is used for large scale optimization problems. To validate this algorithm, simulations had been applied using NS2. Simulation results showed higher performance of MBFA as compared to other clustering protocols like leach, in terms of performance metrics like number of alive nodes, data transmission rate and total energy dissipation within the system. MBFA provides better lifetime for the nodes in the network when compared to LEACH. It is also seen that MBFA is able to supply the alive nodes for optimum duration and can minimize the energy while comparing with BFA and LEACH.

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