

Anycast Routing Algorithm Based on Krill Herd Optimization for Wireless Sensor Networks

Yun-li Gu, Xin Xu, Ya-ping Cheng, and Yan-juan Zhang
College of Computer and Software.,

Nanjing University of Information Science and Technology, Nanjing 210044, China
(Received April 26, 2017, accepted June 19, 2017)

Abstract. Krill herd optimization is a novel bionic swarm intelligence optimization method, but currently it is mostly used only in the field of engineering optimization. Since node's energy is limited and establishing effective routing is difficult in wireless sensor networks, in this paper, we try to apply krill herd optimization in anycast routing algorithm for wireless sensor networks. The krill are moved to the high fitness area (anycast paths with better energy consumption condition) through induced motion, foraging movement and random diffusion behaviors. Moreover, crossover and mutation operators in genetic reproduction mechanisms are adopted for improving the ability of accelerating optimization speed and breaking away from the local optimum. In comparison with ant colony optimization, simulation experiments results show that the performances of the proposed algorithm are better in terms of convergence speed, optimization results and scalability.

Keywords: krill herd optimization, wireless sensor networks, anycast, routing algorithm.

1. Introduction

In wireless sensor networks (WSN), node' energy is limited and hard to supply, moreover, communication and computing ability of sensor nodes is very weak. So, table-driven routing protocols such as OSPF (Open Shortest Path traditional table First), are not suitable for WSN. And, on-demand routing protocols such as unlimited flooding, have the disadvantage of huge cost for routing query. Therefore, the focus for WSN is to design an efficient routing algorithm with less energy consumption.

Recently, a bio-inspired swarm intelligence optimization algorithm called Krill Herd Optimization (KH) was for the first time proposed by Gandomi and Alavi in [1]. This algorithm is based on the simulation of the herding of the krill swarms in response to specific biological and environmental processes. The minimum distances of each krill individual from food and from highest density of the herd are considered as the objective function for the krill movement. The [aggregation](#) process of krill is the process of finding the optimal solution.

After the introduction of KH, it received a great deal of attention from some scholars. Wang and Gandomi[2] added the crossover and mutation factors of genetic mechanism to KH; for further improving KH' performance, Wang and Gandomi[3] introduced a new krill migration (KM) operator when the krill updating to deal with optimization problems more efficiently and applied the improved algorithm for solving complex optimization tasks; Bulatovic[4] improved the fitness function, food position and crossover factor in KH, and applied the improved algorithm to the optimization design of four-bar linkage; for traditional KH has a deficiency which cannot achieve the excellent balance between exploration and exploitation in optimization processing, Li[5] proposed an improved KH with linear decreasing step; Sultana[6] applied KH to optimal capacitor allocation problem in reconfigured distribution network in order to minimize real power loss of radial distribution systems, the author integrated the opposition based learning (OBL) concept with KH for improving the convergence speed and simulation results; Deng[7] proposed a mobile service sharing community composition approach by utilizing the KH; Rostami [8] proposed an improved KH to moderate the charging effect of PHEVs. For practical economic load dispatch problem has non-smooth cost function with nonlinear constraints which make it difficult to be effectively solved, Mandal [9] proposed a new and efficient KH to solve both convex and non-convex economic load dispatch problems.

KH is a novel bio-inspired swarm intelligence optimization algorithm, and the current research results are mainly focus on engineering optimization field. This paper attempts to apply KH to WSN anycast routing field.

2. Problem Description

For saving node's energy and balancing energy consumption, multiple base stations are often deployed in WSN. In this way, sensor nodes can broadcast their monitoring data information to any one or more base station (anycast) according to base stations' circumstances. Therefore, how to find the optimal path between the source node and the base station with the best energy consumption efficiency has become a key problem of WSN anycast routing algorithm.

Some scholars have applied genetic algorithm [10], ant colony algorithm [11], and other intelligent swarm algorithm to solve WSN routing problem. This paper attempts to apply the novel KH to solve the problem.

In this paper, we model a WSN as an undirected connected graph $G(V, E)$ where wireless nodes are represented by V and located in a two-dimensional space. Any directed link between nodes is belongs to set E . And, in this paper, we also let A be the anycast address; $G(A)$ be the set of anycast communication group members (i.e. base station sets) sharing the same anycast address A ; A_i be the i -th member of $G(A)$; N be the number of nodes; M be the number of $G(A)$ members.

Different from traditional wired networks, in WSN, one of the most vital policy for routing algorithm is to find the anycast path with the least energy consumption and save the cost for routing queries as possible.

Suppose there are k paths between the source node s and base station A_i , the energy consumption of the path with the least energy consumption is

$$E_i = \min(E_{i1}, E_{i2}, \dots, E_{ik}) \quad (1)$$

Where, E_{ij} is the total nodes' energy consumption for receiving and transmitting monitoring data packets of all nodes which are belong to path p_{ij} , and the path $p_{ij} = p_j(s, A_i)$, that is the j -th path between the source node s and the base station A_i . Thus, we have

$$E_{ij} = \sum_{t \in p_j(s, A_i)} (E_s(t) + E_r(t)) \quad (2)$$

Where, E_s is the energy consumption of node t for transmitting data packets; E_r is the energy consumption of node t for receiving data packets.

$$E_s = E_{amp} \times d^n \times k + E_{elec} \times k \quad (3)$$

$$E_r = E_{elec} \times k \quad (4)$$

Where, n represents attenuation index; d represents the physical distance between the sender and the receiver. When sending packets, the sender needs to amplify the signal for transmitting, and we represent the amplifier power parameter E_{amp} ; in addition to the amplifier, the transmission must also be guaranteed to supply power to other circuits, and we let E_{elec} represent this power.

Therefore, the minimum energy consumption E of anycast paths (the source node s to any base station) is as follows:

$$E = \min(E_1, E_2, \dots, E_M) \quad (5)$$

Finding anycast routes with QoS constraint in multi-base-station multi-path WSN is a NP-complete problem [12]. That is, we cannot give a finite polynomial solution. So, in this paper, we attempt to use KH to optimize the WSN anycast QoS routing problem.

3. Problem Description

We number each node in WSN with 1 to N (the sending node is marked number 1), then create a two-dimensional adjacency 0-1 matrix W (in W , the element of matrix is either 1 or 0) to represent an anycast path of WSN. While the matrix element (i, j) is 1, that means, in the anycast path there exists the link (i, j) ; otherwise (i, j) is 0, there dose not exists the link (i, j)

For instance, there are sensor nodes n_1, n_2, n_3 , base station A_4, A_5 in WSN connected graph G . With regards to the anycast path $n_1 \rightarrow n_3 \rightarrow n_2 \rightarrow A_5$, we have matrix W as follows