Swarm Intelligence based Energy Efficient Wireless Sensor Network

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Abstract : There are a lot of conventional routing algorithms present for WSN. Swarm Intelligence (SI) is an emerging area that has recently captured much attention in the field of network routing. Swarm Intelligence is basically shows the complex behaviors that arise from very simple individual behaviors and interactions, which is commonly observed in nature, mainly among social insects such as ants, bees, fishes etc. In this paper, bio-inspired routing protocols have been discussed. In this work a study and performance evolution has been done on the behavioral aspect of different swarm based routing protocols like Ant-based and FFA (Firefly Algorithm) based using the NS-3 simulation tool.

IndexTerms **- WSN, E-D ANT, FFA, SI.**

I. INTRODUCTION

Swarm Intelligence provides solution for complex optimization problems which are not easily solved by other techniques. Swarm is defined as a set of mobile agents that collectively solve troubles. Each individual of the swarm has easy rule of action and access to a limited amount of information via its immediate neighbor. On the other hand, even with of limited information and simple actions of members, the swarm, as a whole, is capable to accomplish very hard problems of the computation and optimization. SI based paradigms copy the behavior of real insects for food searching, organized living and self-protective styles for computational problems. The SI based techniques are more appropriate for the routing and energy resources optimization, due to the nature, architecture, topology and functionality of ad hoc and wireless sensor networks.

II. SWARM INTELLIGENCE BASED ROUTING PROTOCOLS AND ALGORITHMS

In this section, we review selected SI routing protocols for WSNs and highlight their properties. In the following subsections, we discuss Ant based and FFA based protocols.

2.1 Ant Based Routing Protocol

ANT Based Routing Protocol has taken the inspiration from real ants which are wandering around their nests to forage for search of food. Upon finding food they will return back to their nests and simultaneously deposit pheromone trails along the paths. The ant selects its next hop based on the amount of pheromone deposited on the path to the next node. The problem of finding shortest paths maps quite well to the problem of routing in networks. The ants are nothing but small control packets, which have the task to find a path towards their destination and collect information about it.

2.1.1 Energy-delay ant-based routing (E-D ANT)

E-D ANTS proposed by Wen et al. [8] focuses on reducing the delay in data packets. In these ants discovers the path and maintains a stack of residual energy level and also of delay experienced by them in discovering the path or hop to hop movement. Simulation results show that they help in increasing the network lifetime. It is reactive type of protocol. E-D ANTS algorithm maximize network lifetime and provide a real-time data delivery service by finding a route with minimum energy-delay product. The E-D ANTS algorithm routes the packets through optimal and energy-efficient paths and also avoids congested paths.

2.2 Firefly Algorithm

In mathematical optimization, the firefly algorithm is a metaheuristic proposed by Xin-She Yang and inspired by the flashing behavior of fireflies. In the book of Yang, there is an explanation of how the algorithm that follows the firefly characteristic [20]. Firefly is an insect that frequently produces small and cadenced flashes that produced by a method of bioluminescence. The purpose of the flashing light is to attract partners or attract potential prey and as a protective warning toward the predator. Thus, this intensity of light is the factor of the other fireflies to move toward the other firefly. The light intensity is varied at the distance from the eyes of the beholder. It is safe to say that the light intensity is decreased as the distance increase. The light intensity also the influence of the air absorbs by the environment, thus the intensity becomes less appealing as the distance increase.

III. CUSTOMIZED FIREFLY ALGORITHM

There is a wide range of variation among the community of live individuals in terms of fitness and quality. In order to improve the performance of the community by making changes in the individual's position a new algorithm based on firefly algorithm is developed. The new algorithm allows making changes in the position of the individuals and increasing the possibility of getting the finest solution in the firefly population.

3.1 Proposed Methodology

This section deals with the customized firefly algorithm (CFFA) with the assumptions made for building this novel protocol. Assumptions are:

1. All the nodes can communicate with each other and with the BS directly.
2. There is a single hop from ordinary node to Cluster Head and from CH to BS.
3. All the nodes are static, where the algorithm run at a particular time instant and update for next round, and all the nodes are location aware. They update their location information to the BS before entering into the set-up phase.
4. 2-D space is considered for sensor node deployment.

IV. Simulation Environment

There are number of quantitative metrics that can be used for evaluating the performance of routing protocols in WSN.

4.1 Performance Matrices

We have used the following metrics for evaluating the performance of routing protocols E-D ANT (Energy-delay ant-based routing) and customized FFA (Firefly Algorithm):

4.1.1 Delay

This includes all possible delay caused by buffering during route discovery latency, queuing at the interface queue, retransmission delay, propagation and transfer time. It is defined as

D = (Tr –Ts)

Where Tr is receive Time and Ts is sent Time.

4.1.2 Energy Consumption

After transmitting or receiving data to /from neighbours, some energy of nodes gets dissipated. So along with the passage of time the remaining energy or residual energy of nodes decreases.

4.2 Simulation Setup

As already outlined we have taken routing protocols, namely E-D ANT and customized FFA. For all the simulations, the same movement models were used and simulation time is varied. The performance analysis is done on Ubuntu Operating System. Ns-3 was installed on the platform. Some specific parameters are as shown in Table 4.1.

Table 4.1: Scenario for Implementation of E-D ANT and CFFA

Platform	Ubuntu
Simulator	NS3
Protocols	E-D ANT, CFFA
Channel type	Wireless channel
Traffic type	Constant bit rate (CBR)
Number of nodes	40
Simulation area size	5000 x 5000
Mobility model	Random way point mobility
Antenna model	Antenna/Omnidirectional
Packet size	712 Bytes
Max. packet in ifq	50

V. Result And Discussion

5.1 Delay

In Fig. 5.1, if simulation time increases, delay of E-D ANT is more while CFFA shows lowest delay with the increase in simulation time. It means packet delivery in between source to destination take the less time as simulation time increases in CFFA.

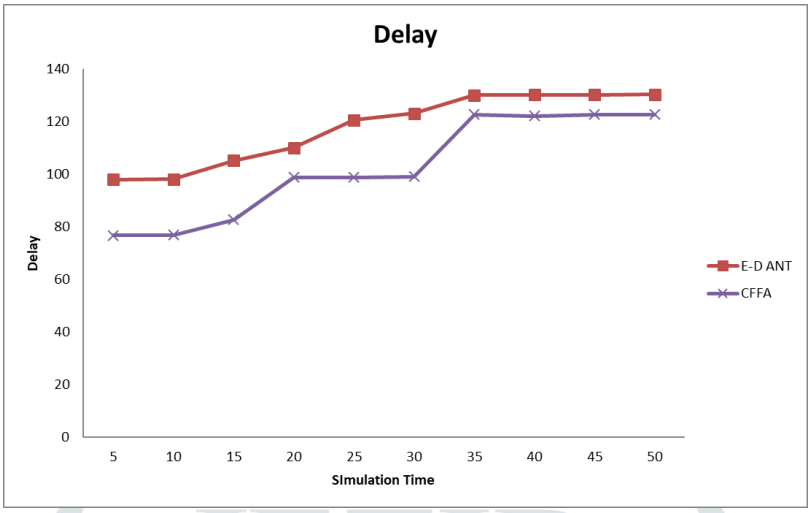

Figure 5.1 Delay versus simulation time for E-D ANT and CFFA

5.2 Energy Consumption

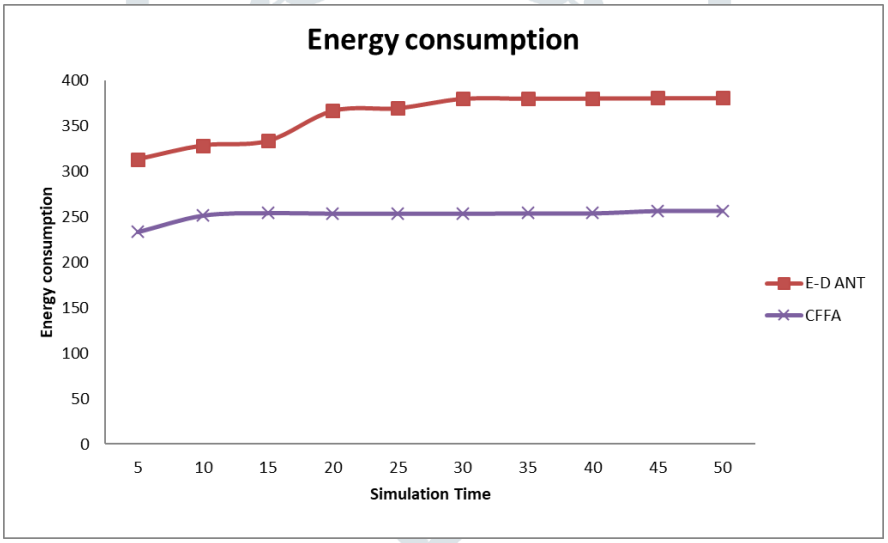

Figure 5.2 Energy Consumption verses simulation time for E-D ANT and CFFA

The Fig. 5.2 shows the relationship between Energy consumption at y-axis and simulation time at x-axis for E-D ANT and CFFA Routing Protocol. E-D ANT's energy consumption is the high and CFFA shows lowest value for this. CFFA is more energy efficient.

VI. Conclusion

Energy efficiency is an important factor in wireless sensor networks. In this paper, we present a evaluation of the different swarm based routing techniques for WSNs from the current work. In this paper, clustering using customized firefly algorithm has been done. The cost function makes use of the distance between the nodes and the cluster head and the energy of the nodes. The simulation results show that the algorithm provides high energy efficiency and long-standing network lifetime than the other protocol. Future scope includes combination of other bio-inspired algorithms and introduces hybrid techniques for efficient clustering in WSNs.

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