Bio-Inspired Routing Protocol to Enhance Performance of Wireless Sensor Network

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Abstract: Tremendous advancements are seen in communication technologies for the past few years. Mechanisms and concepts used for transmission are facing continuous updates. The challenges arise when data pass from wired medium to wireless medium. The advent of WSN provides a new dimension in network research particularly towards controlled devices. In those types of networks, communication between sensor nodes entirely depends on sensing the location and tracking the changes that get happen. These kinds of sensor nodes permit WSN to (i) perform the operation in a broad range, (ii) receive the accurate information. Routing plays a major role in WSN to deliver the sensed information to the destination node. Poor routing ends with network failure. In this paper, bio-inspired optimization based routing is proposed to enhance the performance of the routing by minimizing the delay and energy consumption. Proposed protocol is inspired from characteristics and behavior of saddle goatfish. Results indicate that the proposed routing protocol attains the better performance than other routing protocols.

Keywords: Routing; Energy; Bio-inspired; Delay; Sensor

1. INTRODUCTION

Among the multiple research domains inside wireless sensor network (WSN), there exist significant number of issues in real world where the WSN can be possibly applied. Few popular fields of WSN are agriculture, military related applications, surveillance, tracking, and monitoring. The major problem of all these fields is to have an extended network lifetime to provide better quality of service. The way the network is built is a big factor in this. Nevertheless, topology is specified mainly by the setting and context of the application. Sensor data is normally collected in a certain topology by means of the available gates. That information is then moved to an executive node or a base station called Sink.

The emerging field of the network of wireless sensors brings sensing, measurement and communication into one small unit. Such devices generate a sea of communication, expanding the scope of cyberspace into the realm of physics, via sophisticated mesh networking protocol. The composition of thousands of devices provides revolutionary new technical possibilities, although the capacities of any single device are limited. Wireless network sensor strength have the ability to accommodate a large number of small, self-assembled nodes. The scenarios for such tools vary from real-time tracking, environmental monitoring, to pervasive computing environments, to structural or equipment safety monitoring. They have the ability to control the actuators, which enhance control over the space of cyber from the real world, while often known as the wireless sensor network.
Sensor network routing is distinct from conventional IP-based networking. Researchers recently investigated new sensor network routing schemes that are much different from those used in TCP/IP design in Internet Protocol Fit. Indeed, the collection of data from all network sensors inevitably led to the analysis of obsolete and redundancy node data. This process is not at all successful from the perspective of storing or consumption of energy. Processing of data should be independent of the application with a reliable routing system at different network rates in the field of communications.

This paper focuses on the significant concern present in WSN namely, elevated consumption of energy and utilizing the energy in an efficient way while communicating with other nodes and identifying the better forwarding node in routing which utilizes the bio-inspired concepts.

2. LITERATURE REVIEW

Designing of QoS based Multipath Multimedia Transmission Planning (Q-MMTP) for modeling the transmission of multipath to create paths for routing. The flow control for routing multipath was also designed to redirect subflow of the heavy load to its underlying load by using its input and consumption of its energy for every subflow inorder to make sure about the input of the method. The result shows the effectiveness of the paths and how the energy was reduced to the deepest extent even when there was delay. Directional Forwarding for routing in geographical area was exploited [2] in which the node for sensor was sent through many data redundant based messages. Aggregation was performed automatically and a group of nodes in the sensor can output the aggregation of data. The simulation analysis was also executed for proving the level of aggregation and energy consumption reduction. Efficient with Secure Trusted Routing Mechanism (ESTRM) was structured [3] to make node to select distinct path when there is failure in the current path delivery. It also afford the solitude from the serious stabbing attack for network defined through repayment of data in routing and the output of the system gives increased accuracy than the traditional systems.

A bi-objective network-solving problem with load balancing of network and the length of flow path was investigated [4]. The algorithm was used to retrieve the lesser amount of solutions for a set of Pareto-optimal sets. Network setting was also made and the analysis with the mathematical results gives an optimal solution for the shortest path problem and its difference was evaluated. A routing protocol for prediction of efficient energy [5] namely, Low Energy Adaptive Clustering Hierarchy (LEACH) was presented. This helps in making higher lifetime for the network also. The energy usage of the complete network was decreased when tested with other clustering-based protocols and there are various differences in the amount of sensor nodes. A secured process for routing to improve the life span of network [6] was proposed with Spatial and Energy-Aware Trusted Dynamic-Distance-Source Routing (SEAT-DSR) algorithm. Grouping of nodes of the wireless sensor was integrated and quality of services was provided. Multiple attributes for the model was also recommended for the model. The model was evaluated with the simulation process and the experiment proves that the implemented algorithm was the one works good for packet transfer rate improving than the other methods.

Evaluation of the proposed algorithm with micro grid [7] was performed for localization of the grid edges. Fault tolerance and adaptive edge based algorithm was developed by optimization technique called Particle Swarm technique. The energy, traffic and the distance for head node of each cluster are considered. The output of the algorithm shows the increased accuracy of the proposed method. A heuristic algorithm was implemented for route selection optimization [8] in Wireless Sensor Network. Dolphin Echolocation Algorithm (DEA) was developed which uses the energy of residuals to make selection for efficient energy routes. The algorithm was also compared with other heuristic based methods to show its performance in the throughput of the network and the consumption of the energy. A novel Neuro-Fuzzy Rule Based Cluster Formation and Routing Protocol [9] was developed to portray its routing strategy efficiently in wireless network based on sensors. The proposed technique was also able to enhance its quality in the network. Experimental results reveal that the model implemented gives a good network for packet delivery ratio, to handle its delay and for the utilization
of energy. A well designed solution for resolving the issues in data gathering through sensor [10] was performed with the proposed algorithm namely, Spatial correlation based Hierarchical Routing Protocols (SCHRP). The performance of each modeling algorithm was evaluated by taking different parameters like packet delivery ratio, packet drop, efficiency of energy, throughputs and end-to-end delay. The working of the novel algorithm was evaluated with k-d tree algorithm and simulation tool result was also portrayed to know its level of performance.

3. SADDLE GOATFISH BASED ROUTING PROTOCOL

The concerted behavior of saddle goatfish modeled as a principle for developing a new bioinspired optimization based routing protocol, namely Saddle Goatfish Routing Protocol (SGRP). This proposed protocol believes the field of hunting as the search area. Individuals imitate a set of fish in the approach. Initially, the theoretical model designates the spatial distribution of individuals for a variety of groups or sub-communities. There are two types of search agents (fish) in the algorithm: chasers and blockers. Every fish plays an essential role in each sub-population, while the rest are seen as blockers. Every item is subjected to a series of different evolutionary activities, depending on the category, that emulates the various cooperative behaviors in natural hunting behaviour. Fitness is treated as an important metric of success towards an item in the hunting cycle.

3.1 Beginning Stage

Population \( Q \) of \( n \) Goatfishes \( \{q_1, q_2, \ldots, q_n\} \) is generated randomly within \( b^{high} \) and \( b^{low} \) search area boundaries in m-dimension, in which \( m \) is the size of the population and \( q_j \in Q \) is defined as a vector of decision variables \( q_j = \{q^j_1, q^j_2, \ldots, q^j_m\} \). The initialization is as follows:

\[
q^j_i = \text{rand.} \left( b^{high}_i - b^{low}_i \right) + b^{low}_j \quad j = 1, 2, \ldots, n; \ i = 1, 2, \ldots, m
\]

where \( \text{rand} \) is a number chosen randomly among [0,1].

3.2 Chaser-fish

Each set of goatfish have only one Chaser-fish \( \Phi_r \in Q \) the same as the one that leads the search. The fitness value is determined as per the particle representing the Chaser-fish. Particles with the best fitness value have to be the nearest to the solutions for each cluster. The function of Chaser-fish is therefore chosen. The Chaser-fish would help locate falls where the bead will hide by randomly swimming. Chaser-fish's new position is estimated as:

\[
\Phi_r^{s+1} = \Phi_r^s + \alpha \odot \text{Levy} (\beta)
\]

\[
0 < \beta \leq 2
\]

3.3 Blocker-fish

The residual Chaser-fish become blockers after each cluster has been selected. The method of hunting the blocker \( \Psi_f \in Q \) is to encircle the specific corals and avoid their escaping routes as the hunters seek to kill their beasts. A stochastic spiral for the action of blocking fish is used to model this behaviour. The action of blocker-fishes makes pursue the spiral path through chaser-goatfish because of chaser-fish nearer to the prey.

With new blocker-fish location \( \alpha \Psi_f^{s+1} \) the logarithmic spiral defined as follows is calculated:

\[
\Psi_f^{s+1} = Z_f \cdot e^{b \rho} \cdot \cos 2\pi \rho + \Phi_r
\]

3.4 Exchange of roles

A blocker is mainly aimed at stopping a prey’s scape. Prey changes its location to the hunting area even during hunting cycle. However, blocker-fish nearest to prey will turn the hunt into the new-fangled chaser-fish and the previous chaser-fish becomes a blocker-fish. This method is referred to as roles exchange. This is, based on the assumption participant having best fitness in a group transforms into chaser-fish

3.5 Change of zone
Having completely exploited an region, the community will shift its role to another sector in order to find new beasts. The proposed model takes an over-explosion parameter $\beta$ into account under these circumstances. Thus, if a preset number of iterations $\mu$ is reached for each cluster without finding a better solution, then a good hunt is taken into account, in order to adjust the area on all Goatfish in the cluster as follows:

$$q_{f}^{s+1} = \frac{\Phi_{\text{best}} + q_{f}^{s}}{2}$$

(4)

4. SIMULATOR AND SETTINGS

The research is carried out for the evaluation of the proposed process in a simulation environment that is capable of replicating wireless network data transmission near real-time conditions. Various simulators like contiki, OMNET, qualnet, MATLAB, NS3 etc are available, but this research work has selected NS2 for testing the proposed protocol performance. As an open source, NS2 offers programmable operations via Tool Command Language (TCL) at various stages of use. TCL reduces network description flexibility up to analysis through communications protocols such as TCP and UDP. NS2 has the ability to model real-time scenarios closely. NS2 supports static and dynamic topology variations, queue parameters, and networks during execution [13]. The NS-2.34 simulator model is then used to simulate the WSN energy cycle. Simulation Settings used for this research work is shown in Table 1.

Table 1. Simulation Settings

| Parameter Name          | Value                      |
|-------------------------|----------------------------|
| Simulator name          | Network Simulator          |
| Simulator version       | 2.34                       |
| Base protocol routing   | ORP                        |
| Type of Network         | Wireless                   |
| Type of Antenna         | Omni Antenna               |
| Model of Simulation     | Energy model               |
| Type of Interface       | Wireless Physical          |
| Type of MAC             | IEEE − 802:11              |
| Queue type              | Droptail − priority Queue  |
| Simulation Duration     | 100 seconds                |
| Initial energy of nodes | 100 Joules                 |
| Node Count              | 25; 50; 75; 100; 125; 150; 175 |
| Data rate               | 4500 bits per seconds      |
| Length of Queue         | 50 bits                    |
| Receiving data packet   | 0.8 Joules per bit         |
| Transmitting data packet| 0.9 Joules per bit         |
| Idle power of the node  | 0.05 Joules per bit        |
| Sense power of the node | 0.01750 Joules per bit     |

5. PERFORMANCE METRICS

Performance metrics used to measure the efficiency of protocol. This research makes utilization of below mentioned metrics to measure proposed protocol performance against AREOR. Parameter used is Time (in seconds).

- **End-to-End Delay (EED):** It indicates the time taken by a packet to get transmit between source and destination in a network.
- **Energy Consumption (EC):** Amount of energy utilized by the packet to reach destination from source.
- **Packet Delivery Ratio (PDR):** Success rate of packet reach destination from source.
• **Message Success Rate (MSR):** It is the successful transmission of complete message to destination from source.

6. RESULTS AND DISCUSSION

This section compares the proposed protocol SGRP against PARP [11] and AREOR [12].

6.1 EED Analysis:
Fig 1 compares the EED of SGRP against PARP and AREOR. It is clear that SGRP is also facing the EED but not like PARP and AREOR, because SGRP performs route optimization before sending the data. PARP and AREOR do not perform any route optimization and send simply sends data in available route.

![End-to-End Delay](image1.png)

**Fig 1. Analysis of End-to-End Delay**

6.2 EC Analysis:
Fig 2 compares the EC of SGRP against PARP and AREOR. Energy consumed by PARP and AREOR is very higher than SGRP. Due to sending the data in optimized route EC is minimized with SGRP, where PARP and AREOR gets struck with looping paths and much energy is wasted.

![Energy Consumption](image2.png)

**Fig 2. Analysis of Energy Consumption**

6.3 PDR Analysis:
Fig 3 compares PDR of SGRP against PARP and AREOR. It is very clear to understand that PDR of
SGRP is higher PARP and AREOR. When the count of nodes gets increased, PDR of SARP is getting increased, where AREOR also having somewhat better PDR but not like SGRP. PDR of PARP is getting worst when the number of nodes gets increased.

![Packet Delivery Ratio](image)

**Fig 3. Analysis of Packet Delivery Ratio**

**6.4 MSR Analysis:**
Fig 4 compares the MSR of 3 routing protocols namely SGRP, PARP and AREOR. It is evident that SGRP have the highest MSR than PARP and AREOR. MSR of PARP and AREOR are getting increased when nodes getting increased, but it didn’t have the remarkable MSR like SGRP.

![Message Success Rate](image)

**Fig 4. Analysis of Message Success Rate**

**7. CONCLUSION**

This paper has proposed a bio-inspired based routing protocol namely saddle goatfish based routing protocol. The protocol inspired by characteristics and behavior of saddle goatfish. It involves five main stages, which are initialization, chasing, blocking, role exchange, and change of zone. For evaluating the performance of proposed protocol, this research work chooses benchmark performance metrics with node count as parameter. Better results of proposed routing protocol indicate that it is highly suitable for implementing in WSN for better result.
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