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Moth-Dolphin Based Routing in Wireless Sensor Network

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Abstract: The energy consumption in Wireless Sensor Network (WSN) is a crucial issue as WSN is a battery-operated network. The energy consumption in WSN can be reduced by using an efficient routing algorithm to route the information to the Base Station (BS). This study designs a routing algorithm that inherits the behavior of Moth and Dolphin to route the information towards BS. The routing algorithm depicts the routing and communication behavior of Moth and Dolphin, respectively to route the data from source to the BS. The performance of Moth-Dolphin routing algorithm has been compared with other three existing state of art algorithms including CCPAR, ACO-MNCC, sleep control based on frog satellite behavior and MFRA by using energy consumption, throughput, network life-time and the delay. The performance evaluation proves the significance of the algorithm as the Moth-Dolphin algorithm enhances the network lifetime with higher throughput as compared to other existing state of art techniques.

Key words: Wireless sensor network, Dolphin, Moth, routing, energy consumption, nature-inspired

INTRODUCTION

Wireless Sensor Systems (WSN) have ventured into a compelling calendar to gather information of the environment. Distinctive little, tried and true and detestable detecting components are utilized to get acknowledged data (Lee *et al*., 2011). In addition because of the advancement of remote system, a huge number of sensors are begun in a specially appointed way to carefully notice and depiction the state of an area. In this manner, remote sensor systems are accepting further applications in various practices for example, water observing, war zone reconnaissance and fire alert. Meanwhile, many sorts of sensor convention are considered to make simple the capacity of sensor systems (Heo *et al*., 2009). Alongside every one of the conventions, the power able information get together convention is amazingly noteworthy to remain the system job proposed for the broad timeframe. As a rule, data can be amassed by three courses are as, tree-based, group based and chain-based (Xie *et al*., 2013).

Routing in sensor systems is exceptionally testing because of a few qualities that recognize them from contemporary correspondence and remote specially appointed systems. Remote sensor systems are framework less, remote connections are inconsistent (Sharma, 2013). The sensor hubs are firmly compelled as far as transmission power and in this way require cautious asset administration. The sensor hubs are thickly sent either inside the sink or near it and have restricted power, computational limit and memory. Sensor hubs are extremely inclined to disappointments. Sensor hubs might not have worldwide recognizable proof (ID) as a result of the substantial measure of overhead. Sensor hubs are thickly conveyed in expansive numbers. Along these lines, the major objective of a WSN is to create data from detected information by individual sensor mode by delaying the life time of WSN the constrained force of sensor hubs orders the plan of vitality proficient correspondence convention. The activity in remote sensor systems causes excess and influences the vitality and transmission capacity usage. Analysts have contrived numerous conventions for correspondence and security in remote systems life framework based systems, specially appointed systems, versatile systems and so on (Sharma, 2013).

Power and routing awareness is consolidated in convention stack and join the data with systems administration conventions and transmit the vitality capably amid the remote medium. Many layers are incorporated into convention stack for example, information connect, physical layer, transport, control administration sheet and errand administration plane. Different sort of utilization programming can be made that

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relies on upon the detecting errand and can be utilized by application layer. Transport layer deal with the stream of the data in the event that it can be required by the sensor systems application layer. Organize layer can be irritated of steering the data gave by the vehicle layer. Macintosh conventions ought to be power mindful and fit to lessen crash with neighbors transmit if the surroundings is uproarious. Physical layer check the necessities of simple, yet, energetic affectation, correspondence and getting strategies. Besides, the control, quality and errand administration planes watch the power, movement and assignment distribution between the sensor hubs. These planes help the sensor hubs interrelate the discovery movement and lesser the broad power use (Singh *et al*., 2012).

Natural computing is a field of research that declarations against the specialization of orders in science. It appears with its three principle regions of examination that information from different fields of research are important for a superior comprehension of life, for the review and reproduction of characteristic frameworks and forms and for the proposition of novel registering ideal models. Physicists, scientific experts, engineers, researcher, PC researchers among others, all need to act together or possibly share thoughts and information with a specific end goal to make normal registering practical. The greater part of the computational methodologies common processing manages depend on exceedingly streamlined variants of the instruments and procedures introduce in the comparing normal wonders. The purposes behind such improvements and deliberations are complex. As a matter of first importance, most disentanglements are important to make the calculation with an extensive number of elements tractable. Likewise, it can be profitable to high light the insignificant components important to empower some specific parts of a framework to be recreated and to watch some emanant properties. In this study, natural computing is used to route the data from source to the BS in a WSN. As the proposed procedure is propelled by the nature, so, it plays out the undertaking in a streamlined and effective way (Castro, 2007).

Literature review: This study covers the various algorithms designed for the wireless sensor network. Different scheduling algorithm for the WSN have been covered by the researcher of Musilek *et al*. (2015) while the routing behavior has been described here. Majumder *et al*. (2010) proposes another power-aware, versatile, various leveled and chain based convention-CCPAR (Clustered Chain based Power Aware Routing) that uses the occasional assignments of the bunch make a beeline for various hubs in light of the most noteworthy remaining battery limit with regards to guaranteeing the even dispersal of force by every one of the hubs. Transmission from a solitary group make a bee line for the base station in each round and the conveyance of the information total reserach load among every one of the hubs, spare the bunch heads from early fatigue. The utilization of information accumulation additionally diminishes the measure of data to be transmitted to the base station. By tying the hubs in each group and utilizing a different chain for the bunch heads, CCPAR offers the upside of little transmit separations for a large portion of the hubs and subsequently helps them to be operational for a more drawn out timeframe by monitoring their restricted vitality. This convention has been demonstrated superior to anything the other customary conventions LEACH (Xiangning and Yulin, 2007), PEGASIS (Lindsey and Raghavendra, 2002), TEEN (Manjeshwar and Agrawal, 2001), APTEEN (Manjeshwar and Agrawal, 2002). Lai *et al*. (2007) proposes a genetic calculation to tackle the DSC issue. The Disjoint Set Covers (DSC) finds the most extreme number of sensor spreads can be settled by means of change as more sensor spreads can be found to draw out system lifetime. Lin *et al*. (2012) proposes an ANT Colony optimization-based approach for Maximizing the Number of Connected Covers (ACO-MNCC) to boost the lifetime of heterogeneous WSNs. The technique depends on finding the most extreme number of disjoint associated covers that fulfill both detecting scope and system network. A development chart is composed with every vertex meaning the task of a gadget in a subset. In view of pheromone and heuristic data, the ANTS look for an ideal way on the development chart to boost the quantity of associated spreads. The pheromone fills in as a similitude for the pursuit encounters in building associated covers. The heuristic data is utilized to mirror the allure of gadget assignments. A neighborhood look strategy is intended to additionally enhance the hunt proficiency. Mutazono *et al*. (2012) proposed approach has been connected to an assortment of heterogeneous WSNs to its importance. Propose a self-sorting out scheduling plan enlivened by Japanese tree frog calling conduct for vitality proficient information transmission in remote sensor systems. The frogs are known to make calls on the other hand with their neighbors keeping in mind the end goal to raise the likelihood of mating. This conduct can be connected to stage control that acknowledges crash free transmission planning for remote correspondence. These frogs likewise show a kind of conduct known as satellite conduct wheree a frog quits calling once it identifies the calls of other neighboring frogs. This conduct can be connected in the outline of a vitality proficient rest control system that gives versatile operation periods. This study designs a Moth-Dolphin based routing algorithm for WSN discussed in futher study.

MATERIALS AND METHODS

Moth Flame based Routing Algorithm in wireless sensor network (MFRA): The Moth-Flame Optimization Algorithm (MFOA) (Mirjalili, 2015) depicts the nature of butterfly to fly towards moon. This algorithm has been proved better than various existing state of art techniques (Mirjalili, 2015). The MFOA can be applied for the routing in the Wireless Sensor Network (WSN). The WSN consists of N sensor nodes with sensing as well as communication features to send the sensed data. These nodes also forwards the data received from previous node towards the base station. Here, each data packet is considered as the moth which moves towards the base station, taken as moon. The data packet follows the straight motion when the packet is far away from the base station, otherwise the spiral motion is followed as in the case of MFOA. The process of Moth-Flame based routing in WSN can be elaborated as follow.

In the MFRA, n nodes (Moth) to transfer data from source towards the base station BS (moon) in 2 dimensions (x, y coordinates) then corresponding position matrix can be given shown as Eq. 1:

$$P_d = \begin{bmatrix} P_{1,1} & P_{1,2} \\ \vdots & \vdots \\ P_{n,1} & P_{n,2} \end{bmatrix} \quad (1)$$

The distance of the node from the BS is used to calculate the fitness value so:

$$F_{d_m} = \begin{bmatrix} F_{d_{m1}} \\ \vdots \\ F_{d_{m2}} \end{bmatrix} \quad (2)$$

Where:

$$F_{d_{mi}} = \sqrt{\left(P_{i,1}\text{-}BS_1\right)^2 + \left(P_{i,2}\text{-}BS_2\right)^2} \quad (3)$$

Here, BS1 and BS2 is the x and y coordinates of base station, respectively. The best position in the matrix of Eq. 1 is the entry with minimum fitness value in Eq. 2. The best position vector is marked as flame which is given by Eq. 4:

$$P_f = \begin{bmatrix} P_{f_{1,1}} & P_{f_{1,2}} \\ \vdots & \vdots \\ P_{f_{n,1}} & P_{f_{n,2}} \end{bmatrix} \quad (4)$$

The corresponding values of the objective function in shown in Eq. 5:

$$F_{d_f} = \begin{bmatrix} F_{d_{f1}} \\ \vdots \\ F_{d_{fn}} \end{bmatrix} \quad (5)$$

Now, compare the values of Eq. 5 with the corresponding entry of the Eq. 2 and perform the Eq. 6:

$$\text{if}\left(F_{(d_{fi})} > F_{(d_{mi})}\right) \begin{Bmatrix} \text{Replace } P_{fi} \text{ vector in } P_f \text{ by } P_i \text{ and} \\ F_{(d_{fi})} = F_{(d_{mi})} \end{Bmatrix} \quad (6)$$

If the position is updated only if corresponding fitness value is better than the existing one. When the packet reaches nearer to the BS then it starts to follow the spiral motion which can be specified by using Eq. 7 as shown:

$$P_{m_i,\, f_j} = F_{df_j} + \left|F_{d_{fj}}\text{-}F_{d_{mi}}\right| * \cos(2\pi r) * e^{br} \quad (7)$$

The $P_{mi,\, fi}$ denotes the updated position using the spiral motion while the b is a constant to define shape of the motion. The r is used to define the Moth and flame relationship if the value of r is 1 then the moth follows the flame, resulting the best possible position near the flame is selected otherwise the moth selects the best far position from the flame. This updated position is used to move towards the optimization. The number of flames is decreasing with the increase in iteration which can be represented by Eq. 8:

$$\text{Counting (flames)} = \text{ceil}\left(n\text{-iteration}_{no} * \frac{n\text{-}1}{\text{Tatal}_{iteration}}\right) \quad (8)$$

Where the total number of iterations and the current iteration number is given by the $\text{Total}_{iteration}$ and iteration_{no}, respectively. In the MFOA the Moth are moving and changing their positions while in the MFRA the position of nodes is fix and the data packet selects a node with the location nearest to the updated position. It means MFRA gives the updated position of the data packet on the basis of the position of the node. The step by step description of the Moth Flame based Routing Algorithm in wireless sensor network (MFRA) is defined as.

MFRA (n, P [][], data, S, BS): The MFRA is implemented on a network with n sensor nodes with corresponding position vector is given by P_d [][]. The node S wants to route the "data" to the Base Station (BS).

Algorithm 1; MERA:

1. Initiate network with n nodes
   For i = 1: n
   Calculate fitness value:
   $$F_{d_{mi}} = \sqrt{(P_{i,1}\text{-}BS_1)^2 + (P_{i,2}\text{-}BS_2)^2}$$
   End
2. F_{dN} = Quick sort (F_{dm})
3. $Current_{node} = S$
4. While $Currentn_{node} \neq BS$
   i. $P_{current_{node}} f_j = F_{dfj} + \left|F_{dfj} - F_{d_{current_{node}}}\right| * \cos(2\pi r) * e^{br}$
   ii. $F_{dfi} = \sqrt{(P_{current_{node}} f_j\text{-}BS_1)^2 + (P_{current_{node}} f_j\text{-}BS_2)^2}$
   iii. if ($F_{(d_{fi})} > F_{(d_{mi})}$) {Replace P_{fi} vector in P_f by $P_{(i)}$ and $F_{(df_i)} = F_{(d_{mi})}$}
   iv. Select next node in the route
   v. F_{dN} = Quick Sort (F_{dfi}, $F_{d\,current\,node}$)
   vi. End if
   vii. Update b and t
   viii. Update $Current_{node}$
   End while
5. Exit

The above algorithm is used route the data from Source (S) to the Base Station (BS). The algorithm is implemented and corresponding analysis is discussed in the performance evaluation study.

Moth Dolphin based Routing Algorithm in wireless sensor network (MDRA): Dolphins, similar to people, have expansive brains, live in obviously complex social gatherings and speak with a broad collection of acoustic signs (Marino, 2004; Connor *et al*., 2001). Without a doubt, Dolphins have a famous status in mainstream culture as a higher type of insight, yet how advanced and dialect like dolphin correspondence truly is and how keen they are all in all, remain fervently. Lilly (1961) recommended that dolphins trade keen data, utilize human-like conversational tenets to do as such and even endeavor to set up between species correspondence with people. This study embeds the communication behaviour of the dolphin to the Moth, resulting Moth can communicate with each other and the best path as well as the worst path can be communicated among all Moth. The communication behavior among the Moth results in the positionupdation which can be denoted by Eq. 9:

$$P_{current_{node} f_j} = P_{current_{node} f_j} + r_1 \left(p_{best_{node}} f_j - \left|p_{current_{node} f_j}\right|\right) - r_2 \left(p_{worst_{node}} f_j \left|p_{current_{node}} f_j\right|\right) \quad (9)$$

Here, the current position of the node is updated which moves towards the best route position and avoids the worst route. This updated position is selected only if the correspoding fitness value is better than the existing fitness value. The detial procedure is shown in the form of algorithm given in next subsection.

MDRA (n, P [] [], data, S, BS): The MDRA is implemented on a network with n sensor nodes with corresponding position vector is given by P_d [] []. The node S wants to route the "data" to the Base Station (BS).

Algorithm 2; MDRA:

1. Initiate network with n nodes
   For i = 1: n
   Calculate fitness value:
   $$F_{d_{mi}} = \sqrt{(P_{i,1}\text{-}BS_1)^2 + (P_{i,2}\text{-}BS_2)^2}$$
   End
2. F_{dN} = QuickSort (F_{d_m})
3. $Current_{nodes} = S$
4. While $Current_{nodes} \neq S$
   i. $P_{current_{node} f_j} + \left|F_{d_{fj}} - F_{d_{current_{node}}}\right| * \cos * (2\pi r) * e^{br}$
   ii. $F_{d_{fi}} = \sqrt{(P_{current_{node} f_j}\text{-}BS_1)^2 + (P_{current_{node} f_j}\text{-}BS_2)^2}$
   iii. $P_{current_{node} f_j} + r_1 \left(p_{best_{node}} f_j - \left|P_{current_{node}} f_j\right|\right) - r_2 \left(P_{worst_{node}} f_j - \left|P_{current_{node}} f_j\right|\right)$
   iv. $F_{d_{fi}} = \sqrt{(P_{current_{node} f_j}\text{-}BS_1)^2 + (p_{current_{node}}\text{-}BS_2)^2}$
   v. if $(F_{(d_{fi})})\uparrow < F_{(d_{fi})}$ {Replace P_{fi} vector in Pf by $P_{(f)}\uparrow$ and $F_{(d_{fi})}$}
   vi. if $(F_{(d_{fi})} > F_{(d_{mi})})$ {Replace P_{f_i} vector in P_f by $P_{(i)}$ and $F_{(d_{fi})}$}
   vii. Select next node in the route
   viii. F_{dN} = QuickSort ($F_{d_{fi}}$, $F_{d_{current_{node}}}$)
   ix. End if
   x. Update b and t
   xi. Update $current_{nodes}$
   End while
5. Exit

Exit: The above algorithm describes the process of data routing from a source station to the BS using the Moth-Dolphin behavior. The implementation and corresponding results has been discussed in next study.

RESULTS AND DISCUSSION

The algorithm described in previous sections, i.e., MFRA and MDRA has been implemented using the MATLAB. The performance of the MDRA had been compared with the CCPAR (Majumder *et al*., 2010), ANT-MNCC (Lin *et al*., 2012; Frog (Mutazono *et al*., 2012), MFRA on different network scenario using the following parameters.

Performance evaluation parameters: The following parameters have used for the performance analysis.

Energy consumption: It is the amount of energy consumed during the routing of the data from source station to the BS. The network has analyzed for n data transfer from different source station to the BS. The energy consumption can be calculated by Eq. 10:

$$\text{Energy consumed} = \sum \text{Initial enrgy} - \sum \text{Remaining energy} \tag{10}$$

Throughput: It is the amount of data (in bytes) delivered to the BS in unit amount of time. It is given by Eq. 11:

$$\text{Throughput} = \frac{\text{Data transfererd}}{\text{Time}} \tag{11}$$

Average end 2 end delay: It is the average of the total delay taken in routing of data from source station to the BS. It is given by Eq. 12:

$$\text{E2E delay} = \frac{\sum_{i=1}^{n} \text{arrival time}_i \text{-sending time}_i}{n} \tag{12}$$

The performance evaluation on these parameters is discussed in next study.

Performance evaluation: The performance evaluation is done on different scenarios having 20 nodes and a BS. The different 7 scenarios differs in position of nodes and BS. Moreover, in each scenario the data is transferred from different source stations to the BS. The comparison of parameters stated in previous subsections is shown in Fig. 1-3.

Figure 1 clearly shows that, the amount of energy consumed in each scenario is lower than all the other state of art techniques. The MFRA consumes less energy than the other algorithms due to spiral and straing motion combination of the data towrds the BS. The furthermore reduction of energy consumtion in MDRA as compared to MFRA is due to the avoidance of worst path and selection of best path.

The throughput of the MDRA shows a significant improvement over the other algorithms is due to the proper path selection of the data towards the BS. Moreover, MDRA selects the dynamic path which lead to better results.

The comparison of average end to end delay is shown in Fig. 3 over different secnario. In each scenario the amount of time taken to transfer the ata from source to BS is less in MDRA as compared to the otheralgorithms.

Figure 4 compared the end to end delay on networks having different number of nodes. In each scenario the delay of MDRA is lower than the other algorithms proves the significance of the algorithm.

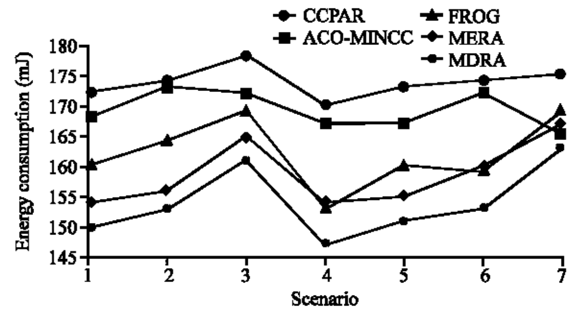

Fig. 1: Comparison of energy consumption over different network scenario

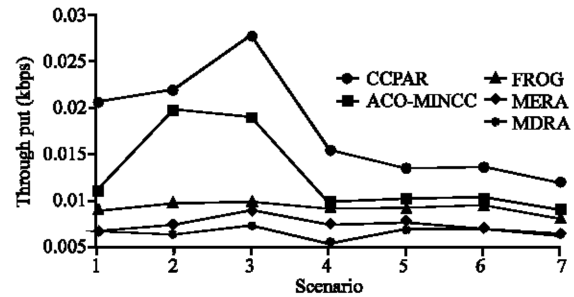

Fig. 2: Comparison of throughput over different network scenario

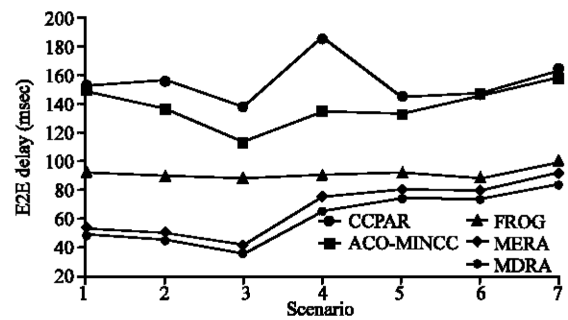

Fig. 3: Comparison of E2E delay over different network scenario

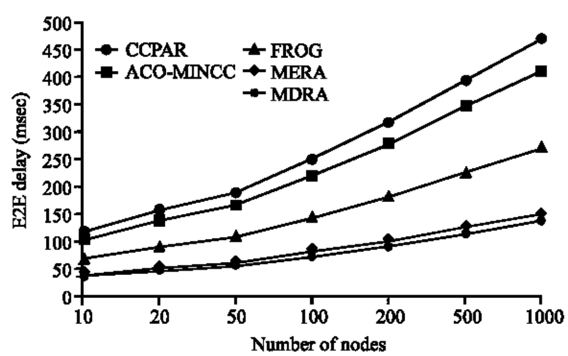

Fig. 4: Comparison of E2E delay over different scaled networks

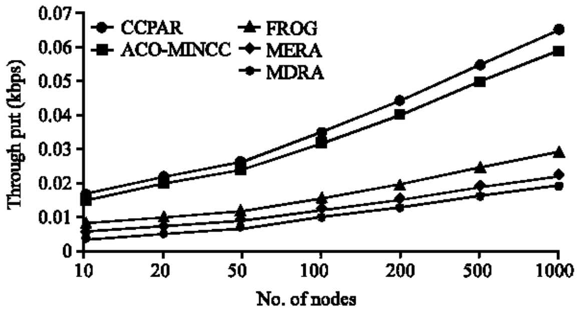

Fig. 5: Comparison of thoughput over different scaled networks

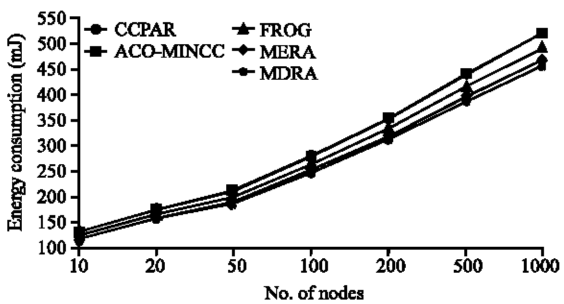

Fig. 6: Comparison of energy consumption over different scaled networks

Figure 5 and 6 compares the throughput and energy consumptionon networks with different nodes. The comparison shows the improvement of MDRA over the other algorithm. The performance analyses clearly signifies the improvement of performance of MDRA over the other existing state of art techniques.

CONCLUSION

This study has firstly extended the Moth Flame Optimization Algorithm (MFRA) for the WSN. This algorithm takes data as Moth and BS as moon, uses the spiral and straight motion of Moth to transfer the data to the BS. Furthermore, the MFRA is extended to MDRA by introducing the communication among the moths. This communication selects the best possible route for the data routing towards BS. Moreover, the MDRA algorithm avoids the worst path of routing the data to the BS. The performance of the MDRA is shown better than the CCPAR, ANT-MNCC, frog optimization and the MFRA in terms of energy consumption, throughout and delay. Overall, the algorithm performs significantly well as compared to other existing state of art techniques.

RECOMMENDATIONS

In future, the algorithm can be extended towards security. This algorithm can be extended to research on the wireless body area network.

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