

TRI OBJECTIVE BASED ROUTING PROTOCOL USING RDA OPTIMIZATION FOR AGRI-WIRELESS SENSOR NETWORKS

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Abstract

Agriculture is one of the main areas where a country's economy hugely depends on. But, the agricultural lands yielding the crops and the crops themselves face huge threats from environmental impacts and aggressions. To overcome these issues, several steps have been taken from the past to the present. Though the problems keep on evolving, the countermeasures are also being developed alongside. In this way, the introduction of Wireless Sensor Network into agriculture made a huge revolution. With Wireless Sensor Network, the crops could be grown with precaution. The sensor nodes of the network update the user with interest data through a sink node. This process is automatic and much faster than the existing methods. The Wireless Sensor Network can even be upgraded by optimizing it with relevant optimizers. This enhancement is necessary for constant improvements in crop yield. And hence, a genetic algorithm-based optimization method is implemented in Wireless Sensor Network in this paper. A genetic algorithm is nothing but an algorithm like other algorithms with a background of any behaviour or activity of certain living species that perfectly matches the concerned system approach. The genetic algorithm being used here is the newly emerged Red Deer Algorithm. The red deer algorithm is derived from an unusual behaviour of the Scottish red deer species during their mating saga. The simulation results show that introducing the red deer protocol in wireless sensor network gives massive output and is more efficient than the former existing methods.

Keywords: Wireless sensor network, sensor node, sink node, genetic algorithm, red deer algorithm

Introduction

The development of our rural economy is one of the most significant factors in agriculture. Traditional agriculture production lacked the most widely used information technology in industries, environmental monitoring and other parts of life. Evaporation, spilling and absorption into a deep layer of soil are just a few ways of wasting water. Wireless sensor networks and information technologies applications

are able to monitor soil information and support the traditional irrigation system in the field of soil interest (Al-Karaki and Kamal, 2004). By changing the irrigation methods and by collecting data in agriculture production, agriculture is made smarter.

To avoid water waste, low soil fertility, fertilizer misuse, and diseases, the Wireless Sensor Network makes significant efforts to comprehend

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accurate irrigation, fertilizer, and pesticides (Keshtgary and Deljoo, 2012). Sensor nodes in the farmland can sporadically transmit composed soil information to the sink node via wireless communication (Chen and Yu, 2010). Sensor nodes are nothing but simple sensing elements that sense the interest data which are to be examined. Similarly, the sink node is the central node basically a base station that acts as a data hub collecting information from every other sensor node. The lifetime of wireless sensor networks in agricultural applications is determined by the energy consumption of sensor nodes. Since the sensor nodes are buried into the soil at least 20 cm below the surface, the sensor nodes are not able to be recharged or change batteries, unlike the sensor nodes that are used in friendly environmental conditions such as industrial environments (Nurellari and Srivastava, 2018). As a result, in a wireless sensor network, energy consumption is a big concern.

Apart from energy consumption, there are other important factors too. The other basic metrics are path length and lifetime of the network. To optimize on the basis of these parameters, several optimization techniques are being implemented on the system. A few of the most commonly used techniques are Orthogonal Multiple Access (OMA) (Benjebbour *et al.*, 2013) and Non-Orthogonal Multiple Access (NOMA) (Zhang *et al.*, 2017). The latter is the widely used of both. The non-orthogonal multiple access technique works with a relay.

For the initial model, a 1,000×1,000 m square field is chosen. The sensor nodes and sink nodes are spread out across the field. The distribution of nodes are in such a way that the sink node is placed at the middle while the sensor nodes are placed at 200 m away from each other throughout the field. During uplink transmission, a high data rate is essential for communication which is provided by the NOMA. The sensor nodes located close to the sink node serve as a relay for the sensor nodes located at the agricultural field's margins. The sensor nodes present at the edges of the field are called edge sensors. The sensor nodes at the middle do the work of both themselves and the edge sensors. It is responsible for transmitting its data to the sink node during uplink transmission and the data from the edge sensor nodes and the same during downlink transmission, too (Gürses and Akan, 2005). As a result, central sensor node energy consumption is significantly increased. The central sensor nodes' lifetime is thus reduced. The drawbacks of non-orthogonal multiple access algorithms are overcome by the present high-flying genetic algorithms.

In this proposal, an effective genetic optimization named Red Deer Protocol (RDP) has been implemented (Fard and Hajiaghaei-Keshteli, 2016). The red deer protocol is inspired by the unusual mating behaviour of Scottish red deer. The male red deer is called Stags, while the female red deer are called Hinds. The unique process prior to mating forms the basis of this protocol. The protocol's important features are roaring and fighting between the stags to become the commander of the harem. A harem is a group of females with a male commander that has the mating right. The hinds are impressed by the stags that roar louder. However, competition arises between stags during the roaring period, which results in a fight. The winning stag in the fight forms the commander of the harem. This is the optimization flow used here.

The implementation of this protocol is possible in wireless sensor networks by relating them to certain parameters. These parameters are the path length of the nodal network (Xu *et al.*, 2010), energy consumed by the nodes during communication (Shinghal *et al.*, 2011) and the lifetime of the nodal network (Nguyen *et al.*, 2011). The magnitude of the parameters is determined using appropriate techniques. After the collection of required data, the protocol is applied to the proposal, which gives the expected output

Literature Review

Jawad *et al.* (2019) have proposed an accurate empirical path-loss model based on particle swarm optimization for wireless sensor networks in smart agriculture. It used two path-loss models. They resulted in decreased path-loss during the period of communication. However, the model was not applicable on certain agricultural farms like apples, oranges etc.

Abouzar *et al.* (2016) have presented an RSSI-based Bayesian localization algorithm for Wireless Sensor Network in precision agriculture. It was designed for pest management and pH sensing. The coupled variables phenomenon accounted for a significant amount of communication overhead. However, the system overcame computational complexity and scalable communication only at the expense of accuracy.

Lu *et al.* (2020) have put forward an energy efficiency optimization in Wireless Sensor Network for smart agriculture. It focused on the optimization of information resources of agriculture. It improved the quality and product of agricultural products. The proposal used a two-phase communication

process. The drawback of the system was the inability to get rid of interference, and route optimization was not explained.

Gulec *et al.* (2020) have introduced a new distributed connected dominating set algorithm on WSNs with solar energy harvester nodes for precision agriculture applications was proposed. It contained an algorithm that replaced traditional methods. The output was in such a way that it increased the lifetime of the nodes by six times more than the traditional methods. Though the proposal had a high impact, the impact area is much narrower.

Wang *et al.* (2020) have produced an efficient routing algorithm based on the elite hybrid metaheuristic optimization algorithm. The algorithm concentrated on the maximization of the survival time of wireless sensor networks. The proposed algorithm inventively brought together the particle swarm optimization algorithm, pheromones of ant-colony optimization algorithm and difference operator of the differential algorithm. However, this method gave infeasible solutions when the work environment is infeasible.

Hu *et al.* (2019) have compared the use of Non-Orthogonal Multiple Access in wireless sensor networks for smart agriculture. By separating symbols in the power domain, non-orthogonal multiple access can send many symbols at the same time on the same resource element. The results showed that this method outperformed the traditional Orthogonal Multiple Access scheme. However, the working complexity of the project was accountable and simpler methods were required.

Upadhyay *et al.* (2018) presented a non-linear Gaussian regression-based adaptive clock synchronization technique for wireless sensor networks in agriculture. It exchanged fewer synchronization messages to improve accuracy and efficiency. The proposed model used 20% lesser energy than the existing methods.

Chan and Rudolph (2015) have propounded a new energy-efficient routing algorithm for wireless sensor networks. The proposal establishes a routing algorithm to optimize the energy efficiency in which the number and the total transmission distance is reduced. The proposed method is more energy-efficient than its predecessors, according to simulations. However, the proposed method was not always cent per cent efficient in complex networking.

Elsayed *et al.* (2018) have projected a self-maintenance model for wireless sensor networks. It used a self-healing mechanism for fault detection, diagnosis and healing. The system successfully

diagnosed a higher percentage of different hardware faults in comparison with the state of the art method. However, there could be an improvement in the betterment of diagnosis.

Sinha *et al.* (2010) have proffered a redundant radix-based approach for wireless sensor networks. It used simple modulation techniques to code and decoded the transmission signals. Because of this approach, simple, low-cost devices were able to be implemented, thus reducing energy consumption. Though battery life could be saved, the accuracy level of the received signals was not up to the level.

In ref. Jawad *et al.* (2019), the authors proposed an empirical path-loss model for WSN in agriculture. Though it resulted in decreased path-loss, it wasn't much suitable at certain agricultural fields. The authors of ref. Abouzar *et al.* (2016) present RSSI based Bayesian localization algorithm for pest management and sensing. It costed accuracy to reduce computational complexity and communication overhead. An energy-efficient optimization in the same regard was put forward by the authors of ref. Lu *et al.* (2020). Although the quality and product of agriculture improved, the inability to get rid of interference was unacceptable. The authors of ref. Gulec *et al.* (2020) introduced a distributed connecting algorithm with solar energy harvester nodes. The impact area was much narrower, although the lifetime of the nodes was increased. Ref. Wang *et al.* (2020) produced an elite hybrid metaheuristic optimization algorithm by manipulating three other algorithms. However, it was unsatisfying for the results of infeasible environment.

The comperes of ref. Hu *et al.* (2019) proposed the application of NOMA in WSN, which outperformed the traditional OMA scheme. But it was complex to work with. The authors of ref. Upadhyay *et al.* (2018) suggested a non-Gaussian regression-based adaptive clock synchronization solution for WSN. The 20% less energy consumption than the existing methods came up with the drawback of increased system complexity. In ref. Chan and Rudolph (2015), the propounded energy-efficient routing algorithm was more energy-efficient, although it was not fit for more complex networking. The ref. Elsayed *et al.* (2018) authors projected a self-maintenance model that successfully diagnosed many hardware faults, but it could not provide the output to the required level. In ref. Sinha *et al.* (2010), a redundant radix-based approach was proffered. It saved the battery life by letting the network use simple, low-cost devices. On the other hand, the accuracy of the received signal kept on fading.

Projected Approach

Wireless Sensor Network for smart agriculture is basically a collection of data of interest from the particular form of implementation. The collected data are useful in perceiving the environmental condition around the field. This helps in improving crop yield both in terms of quality and quantity. Moreover, the price demand can also be reduced.

In this application of Wireless Sensor Network in agriculture, a 1,000×1,000 square agriculture field is chosen to implement the proposed method. The Wireless Sensor Network's Sink Node is located in the centre of the square farming field. The Sensor Nodes, on the other hand, are dispersed throughout the field. Distribution of the Sensor Nodes is in such a way that each Sensor Node is placed 200 m away from each other. The Sink Node and Sensor Nodes arrangement are in such a way that the Sink Node is set at the centre while the Sensor Nodes are distributed throughout the agricultural field. When compared to Wireless Cellular Network, the Sink Node is equivalent to the Base Station, and the Sensor Nodes are equivalent to the cellular phone users. The difference is that the users in the Wireless Cellular Network are mobile, but the Sensor Nodes in the Wireless Sensor Network are static. The relatively stable network topology in Wireless Sensor Network makes it simple during both uplink and downlink processes.

The sink node is so strong that it can be connected to all sensor nodes, but only with neighbours can every sensor node communicate. Through relays using short rang multi hops, the Sensor Nodes are linked to the Sink Node. Only the sinking node can communicate with the sensor nodes nearest to it. In Wireless Sensor Networks, Sensor-Sink uplink or Sink-Sensor downlink communication is utilized to convey data or network signalling. The data's main outgoing traffic conduit from the field to the user platform is the Sink Node. The uplink transmission is comparatively significant than the downlink transmission since data collection is the most important phase of the system. On the other hand, the downlink transmission plays the mere role of routing and scheduling information to the Sensor Nodes.

The Sensor Nodes are shut down after every uplink transmission in order to save energy. This process takes place periodically under a time schedule. During the shutdown period, the Sensor Nodes gather information by consuming low energy. The data collected by the Sensor Nodes on the farm's edges are the data collected and operated by the other Sensor Nodes in upline transmission as a relay to the edge sensors and the Sink Node.

The edge sensors provide data via short-range multi-shop communication to the sensor nodes closest to the sink node first because the sensor nodes near the sink node operate as relays. Sensor nodes close to the sink node decode the encoded information of the edge sensors. The Sensor Nodes need to transmit their own data as well as the data from edge sensors. Thus, the Sensor Nodes are highly sensitive and energy consuming, affecting the lifetime of the Wireless Sensor Network directly. As a result, in uplink transmission, huge connectivity and high data rates are required from the Sensor Nodes to the Sink Node. In order to overcome the disadvantages, certain algorithms are being implemented. The below Figure 1 illustrates the architecture of the proposed methodology.

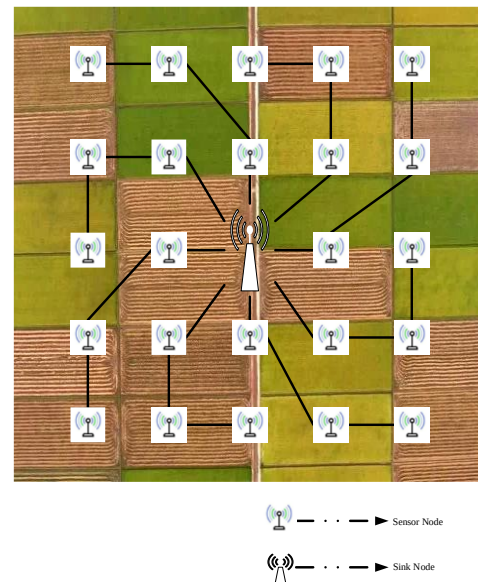


Figure 1. Ideal architecture of the proposal

This project uses the help of a genetic optimization protocol called Red Deer Protocol. Here, the basic input is given in three metrics: path distance, energy consumption, and time taken for data transmission. The sub-nodal network with the efficiency of the three said parameters is considered to be proficient of all. To calculate these metrics, several other processes are done. The work flow of the proposed methodology is shown in Figure 2.

Measuring the Path Distance

The distance between two or three nodes in a sub-nodal network is called the path distance. It can be measured by a few methods. Mostly, the received signal strength is used to measure the path distance. Greater the received signal strength, the shorter the path distance. It is measured by

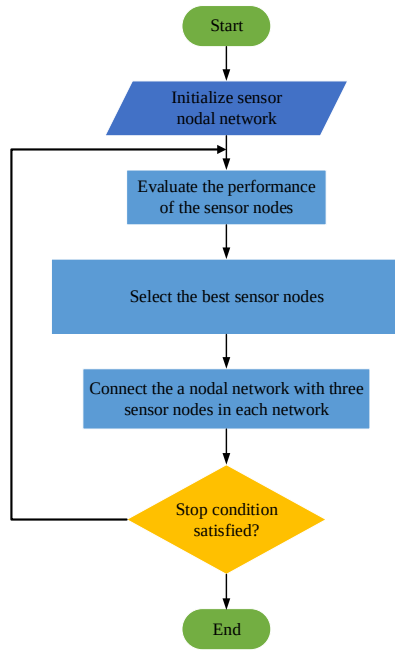


Figure 2. Flow-chart of the working of the proposed red deer protocol

the Receiver Signal Strength Indicator technique. The Received Signal Strength Indicator can be

$$P_R = P_T \frac{G_T G_R \lambda^2}{(4\pi)^2 r^n}, n = 2 \text{ for open space propagation}$$

where,

- P_R = power at the receiver
- P_T = power at the transmitter
- G_T = gain of the transmitter
- G_R = gain of the receiver
- λ = wavelength of the signal
- r = radius of the sphere, which is the distance between transmitter and receiver

Measurement of Energy Consumed

The amount of energy spent by sensor nodes for communication with neighbouring sensor nodes and sink nodes is referred to as consumed energy. Each sensor node's energy consumption can be determined by

$$e = \frac{E}{AT} \quad (i)$$

where,

- e = energy consumed by each node
- E = total energy consumed
- A = total area of the network
- T = total time taken by the network for communication

By expanding (i), we get,

$$e = k_4 \mu r^{\alpha-1} + k_1 r^{-2} + k_0 \rho \quad (ii)$$

where,

- r = transmission range
- μ = traffic load
- ρ = node density
- k = constant

Measuring Network Life-Time

In the wireless sensor network, the lifetime of each sensor node is a significant concern. The lifetime of a sensor node depends on various factors such as network trafficking and other external factors. The lifetime of the network can be calculated by

$$\text{Network lifetime, } L = E - (U + \sigma)$$

where,

$$U = \frac{\sum U_i}{N} \text{ and } \sigma = \sqrt{\frac{(U_i - U)^2}{N}}$$

$U_i \Rightarrow$ average energy used

$N \Rightarrow$ network node number

Red Deer Protocol

The importance of optimization challenges has grown in proportion to the size and complexity of industrial organizations. Due to this rise in demand, several meta-heuristic optimizations emerged. They were inspired by both artificial and natural processes. They gave both easy and cost-efficient methods for researches. However, natural processes based on Genetic Optimizations are more efficient in solving high complexity problems. Hence, a genetic optimization algorithm based on the unusual mating behaviour of Red Deer has been taken into account, and a reliable genetic algorithm has been made and instigated.

The protocol is based on the species of Scottish Red Deer where the males are called as Stags, and the females are named Hinds. When the breeding season arrives, competition arises between the stags for possessing the female groups. The competition begins with antagonism where the Stags roar at each other to attract the Hinds. The Hinds prefer high roaring males rather than low roaring males. The Hinds then form a group with a male as the commander. The commander is the head of the harem, and he has the sole right to mate. The commander also has to defend the harem from enemy aggression and protect the Hinds. To become a commander, the males must encounter a predictable fight. The winner will be crowned as the commander.

Another unusual thing is their rutting behaviour. The intolerant Stags from the bachelor group comes out and might become commanders of

various Harems. They have a limited period of reign over their harem. After which, they might be overthrown by another Stag. These are the phases that are taken into account for shaping the Red Deer Optimization Protocol.

The synchronization of the Red Deer Protocol (RDP) with the proposed method needs a few metrics to be relevant. For this, the basic attributes such as energy consumption, path distance and time taken.

Protocol Sequence

The entire sequence of the Red Deer Protocol is listed below.

Generate an Initial Red Deer

Within the solution space, a Red Deer corresponds to a possible solution X. As a result, Red Deer is a solution's counterpart. This solution X1 has a dimensionality of N_{var} . As a result, a red deer is a 1 N_{var} array. It is characterized by

$$Red\ Deer = [X_1, X_2, \dots, X_{N_{var}}] \quad (2)$$

Assuming that each Red Deer(X) consists of the three metrics path distance(P), energy consumed(E) and time taken(T),

$$X = (P, E, T) \quad (a)$$

$$\therefore Red\ Deer = [(P_1, E_1, T_1), (P_2, E_2, T_2), \dots, (P_{N_{var}}, E_{N_{var}}, T_{N_{var}})] \quad (b)$$

Also the function value for each Red Deer can be evaluated.

$$Value = f(Red\ Deer) \quad (3)$$

$$= f(X_1, X_2, \dots, X_{N_{var}})$$

Roar Male Red Deer

The neighbours of the male Red Deer are taken into account regarding the solution space. If the neighbours are better than the male Red Deer, they are replaced with the prior ones. To modify the position of males, the following equation is provided.

$$male_{new} = \begin{cases} male_{old} + a_1 \times ((UB - LB) * a_2 + LB), & \text{if } a_3 \geq 0.5 \\ male_{old} - a_1 \times ((UB - LB) * a_2 + LB), & \text{if } a_3 < 0.5 \end{cases} \quad (4)$$

where,

UB and LB are Upper Bound and Lower Bound respectively in the search area.

$male_{old}$ is the current location of the Red Deer.

$male_{new}$ is the updated location of the Red Deer. a_1, a_2 and a_3 are generated randomly by a uniform distribution between 0 & 1.

Select γ Per Cent of the Best Male Red Deer as Male Commander

There are two types of Male Red Deer: commanders and stags. The number of commanders can be computed using the formula below.

$$N_{com} = round\{\gamma \cdot N_{male}\} \quad (5)$$

The following equation is used to determine the number of stags.

$$N_{stag} = N_{male} - N_{com} \quad (6)$$

Fight Between Male Commanders and Stags

Letting the commander fight stags randomly, the new commander could be selected by two solutions.

$$New1 = \frac{(Com + Stag)}{2} + b_1 \times ((UB - LB) * b_2) + LB \quad (7)$$

$$New2 = \frac{(Com + Stag)}{2} - b_1 \times ((UB - LB) * b_2) + LB \quad (8)$$

where New1 and New2 are the two solutions obtained from the fighting process.

Form Harems

The amount of females in the harem is determined by the commander's power. The commanders' hinds are proportionally divided among themselves to produce the Harems.

$$V_n = v_n - \max_i\{v_i\} \quad (9)$$

where v_n is the power of the n^{th} commander and V_n is its normalized value.

The commander's normalized power is given by

$$P_n = \left| \frac{V_n}{\sum_{i=1}^{N_{com}} V_i} \right| \quad (10)$$

In other words, a male's normalized power is the portion of hinds that he should have. A harem will have the following number of hinds:

$$N.harem_n = round.\{P_n \cdot N_{hind}\} \quad (11)$$

Mate Commander of a Harem with a Per Cent of Hinds in His Harem

The commander and α percentage of the hinds in his harem are responsible for mating.

$$N.harem_n^{mate} = round\{\alpha.N.harem_n\} \quad (12)$$

where, $N.harem_n^{mate}$ is the n^{th} harem hinds that matches the commander. Generally, the mating process is formulated by

$$offs = \frac{(com+hind)}{2} + (UB - LB) \times c \quad (13)$$

where offs are a new solution and the distribution function between 0 & 1, generates c randomly.

Mate Commander of a Harem with β Per Cent of Hinds in Another Harem

The amount of hinds in another harem who mate with the victorious side's leader is determined by

$$N.harem_k^{mate} = round\{\beta.N.harem_k\} \quad (14)$$

where, $N.harem_k^{mate}$ denotes the number of hinds in the k^{th} harem.

Mate Stag with the Nearest Hind

Each stag mates with the nearest hind during the breeding season. The J-dimensional distance to the nearest hind should be found for the stag to determine the nearest hind, which is done by

$$d_i = \left(\sum_{j \in J} (stag_j - hind_j^i)^2 \right)^{1/2} \quad (15)$$

The distance between the i^{th} hind and a stag is d_i .

Thus, the effective routing protocol found the better path for effective data transmission. This process is automatic and much faster than the existing methods. The Wireless Sensor Network can even be upgraded by optimizing it with relevant optimizers. This enhancement is necessary for constant improvements in crop yield.

Results and Discussion

Evaluation of proposed Red Deer Algorithm routing protocol was done in NS-2 (Version 2.35) network simulator with several system configurations such as, Intel (R) Core Processor with i5-3330s CPU @ 2.70 GHz, 8.00 GB Memory (RAM) and 64-bit operating system with x64 based processor. The experimental analysis is taken with the help of the

sensor nodes that are deployed within a 1,000×1,000 square agriculture field. There are 25 sensor nodes are deployed in the cultivation area and each sensor nodes are placed 200 away from other sensor node and each sensor node have the energy range is 10 joules. Several stimulation parameters considered for the analysis is given in the Table 1.

In the experimental analysis, the initial process are deployment of sensors in the specific region of the agriculture for gathering or sensing various information related to plants, soils, moisture and so on. In this analysis, entirely twenty five sensor nodes are deployed in a sequential manner and each nodes are positioned 200 m away from each other. Figure 3 illustrates the distribution of sensor nodes in wireless sensor network and source node are represented in the pink color dots and blue dots denotes the Base station. The located nodes are static and not in motion. The data transmission from one sensor node to neighboring sensor nodes is demonstrated in Figure 4, in addition the data

Table 1. Stimulation parameters considered for the experimental analysis

Simulation parameter	Values
Type of Channel	Wireless
Simulator	NS 2.25
Propagation model	Two Ray Ground
Network interference Type	Phy/WirelessPhy
MAC type	802.11
Number of sensor nodes	25
Simulation time	30 sec
X&Y dimension	1000m&1000m
Packet size	500 bytes
Packet rate	100 packets/sec
Energy	10 joule

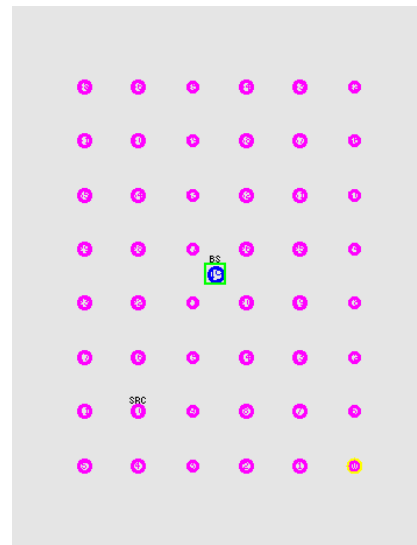


Figure 3. Distribution of sensor nodes in wireless sensor network

transmission path represented in the rounded circle in the figure. Moreover, the base station is located at the center of the field land. In addition, several parameters are taken for efficient data transmission and Received signal strength indicator is utilized to estimate the path distance among the sensor nodes and each sensor nodes energy consumption and lifetime of the network also calculated. These parameters are given in the RDO to find the best communication path of the sensor network.

Figure 4 represents the sensor nodes being routed with the possible optimal path.

The performance analysis of the proposed energy efficient Tri Objective based Routing Protocol was carried out utilizing several metrics. Considered several metrics for this analysis such as, Packet delay, Packet delivery ratio, Packet drop, Energy consumption, Network lifetime, Overhead and Throughput. These parameters are estimated for the proposed RDO and the existing optimization techniques in order to prove the effective routing protocols in the WSN. The existing approaches taken for the comparison analysis such as, Grey Wolf Optimization (GWO), Particle Swarm

Optimization (PSO). Table 2 shows the parameter values estimated for the proposed and existing techniques.

Packet Delay

Packet delay is the time delay caused by the network in transmitting the packets from the source to the destination. But the proposed method provides a high data rate, so that packet delay is reduced.

Figure 5 expresses the difference in packet delay between Grey Wolf Optimization, Particle Swarm Optimization and the proposed optimization in which the proposal gives lower delay than the rest.

Packet Delivery Ratio

The packet delivery ratio is the proportion of packets received at the receiver to those sent out by the transmitter. This is improved in the proposal by making the nodes choose a suitable network.

In Figure 6, the packet delivery ratio of the network with the proposal and other existing methods are plotted, and the differences are

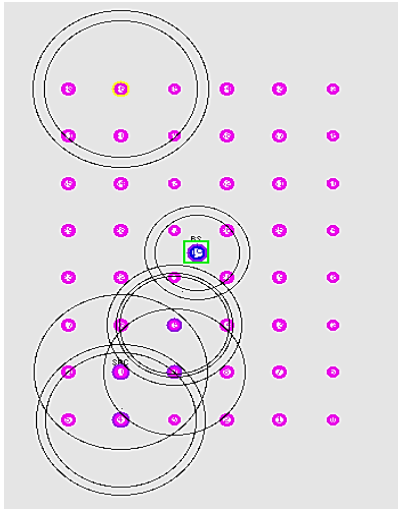


Figure 4. Sensor nodes searching for best possible path using RDA

Table 2. Parameters estimated for the proposed and conventional approaches

Performance Metrics	GWO	PSO	Proposed (RDO)
Packet delay (sec)	50	60	37
Packet delivery ratio (%)	0.81	0.79	0.9
Packet drop	8	17	4
Energy consumption (J)	2	5	0.5
Network lifetime	300	250	350
Overhead	40	70	20
Throughput (Kbps)	1000	900	1025

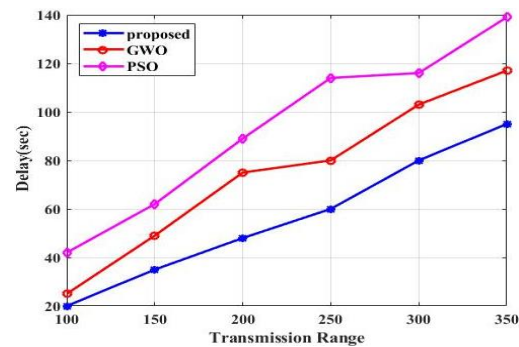


Figure 5. Packet delay – Transmission range graphical comparison

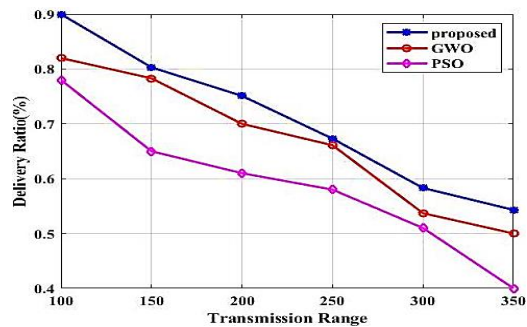


Figure 6. Packet delivery ratio – Transmission range graphical comparison

observed. The graph showed that the proposed method is way better than the previous methods.

Packet Drop

In the realm of wireless sensor networks, packet loss is an inherent worry. It arises due to network congestions. This is overcome by letting the sensor nodes choose their own optimal paths towards the sensor nodes.

When compared to other current approaches, the suggested method has a substantially lower packet drop, as illustrated in Figure 7. The PSO model has a very high packet drop percentage which is overcome by the proposed red deer protocol.

Energy Consumption

Energy consumption is a major area of concern that determines the lifetime of the network. Once the energy of the sensor nodes is totally consumed, they cannot be replenished, so letting them die is the only way. This unavoidable condition is permanent; however, the proposed method can reduce energy consumption by letting the sensor nodes select their own optimal path.

In Figure 8, the energy consumed by the sensor nodes from the three methods is shown. Again the

proposed system is being the better of the three. The proposed system consumes energy much lesser than the previously existing methods.

Network Lifetime

Several factors affect the network lifetime. The important factors like energy consumption and external attacks on the WSN system must be considered. The proposed system makes use of the proposed algorithm and performs the most needed requirement of life improvement.

Figure 9 shows the graphical representation of the network lifetime in three methods. However, the proposed method proves to be the better of the three.

Overhead

Overhead is another factor that is not much welcomed in a networking system. Overhead is the process of consuming an excess of resources from the network, which is not a good thing for a wireless system. However, the proposal tends to minimize the overhead character of the network.

Figure 10 shows the overhead–transmission range graph for the three methods. It is obvious here that in low power consumption, the method proposed is much better.

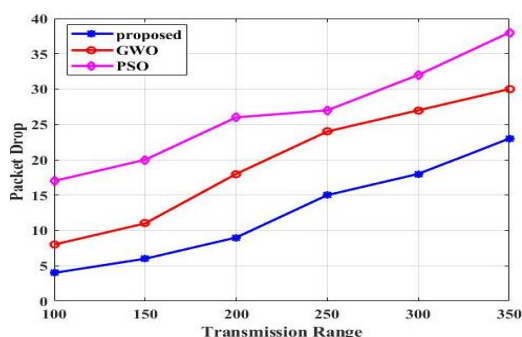


Figure 7. Packet drop – Transmission range graphical comparison

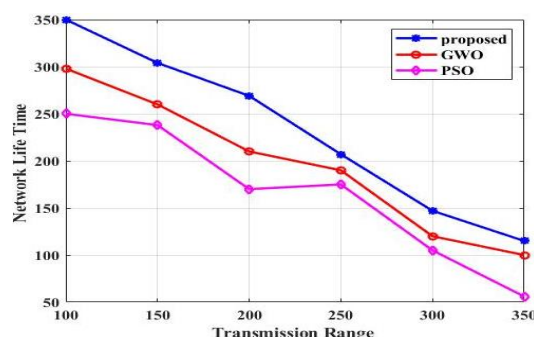


Figure 9. Network lifetime – Transmission range graphical comparison

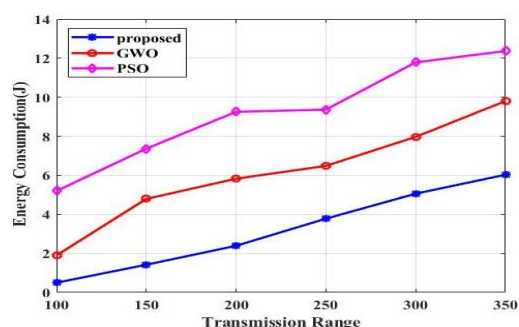


Figure 8. Energy consumption –Transmission range graphical comparison

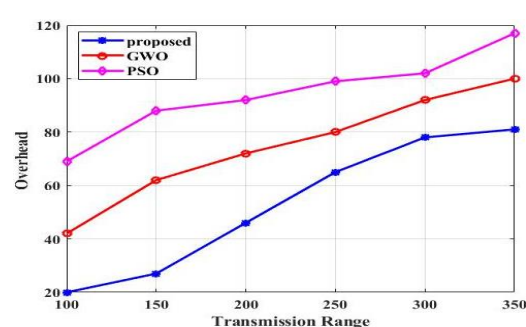


Figure 10. Overhead – Transmission range graphical comparison

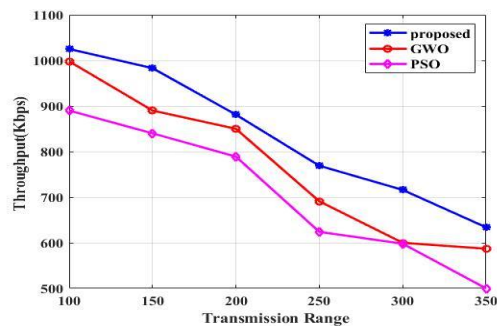


Figure 11. Throughput – Transmission range graphical comparison

Table 3. Comparison of path loss among proposed and existing techniques

Techniques	Path loss (db)					
Proposed	70	90	95	105	110	115
GWO	100	105	115	120	129	135
PSO	110	115	120	125	130	140

Table 4. Comparison of BER among proposed and existing techniques

Techniques	Bit Error Rate (BER)				
Proposed	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-7}
GWO	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-6}
PSO	10^{-1}	10^{-1}	10^{-2}	10^{-3}	10^{-4}

Table 5. Comparison of relation among WSNs and WUSN

Features	WSNs	LPWAN
Deployment	Placed over ground	Buried under-ground
Depth	Anywhere over ground	Topsoil (0-30 cm) and subsoil (> 30 cm)
Communication range	100 m	0.1-10m
Frequency	MHz 2.4 GHz	(433 MHz, 8-300 kHz)
Energy consumption	lower	higher
Cost	lower	higher

4Throughput

Throughput is the scale for measuring the efficiency of the network. The Higher the

throughput, the greater the efficiency of the network. The proposed system showed a higher range of throughput when compared to the previously existing methods.

Throughput - range graph is shown in Figure 11, which elucidate that the proposal is way much better than the other methods. The throughput of the

proposed red deer protocol is found to be better than the previously proven grey wolf protocols.

Table 3 illustrates the comparison of path loss among the proposed and the existing techniques. The proposed model attained less path loss than other techniques. The path loss obtained at different transmission range is shown in the above table. Table 4 illustrates the comparison of BER among the proposed and the existing techniques. The proposed model attained less path loss than other techniques. The flat fading is the type of Multipath fading effect. The flat fading effect is estimated utilizing the BER. The BER obtained at different transmission range is shown in the above table.

The relation of WSN and LPWAN is illustrated in Table 5 (Tamoghna *et al.*, 2015). Compared to the LPWAN the proposed technique have better performance than LPWAN.

Conclusions

The process of finding the suitable path was not easy with the existing methods and algorithms. Hence, the proposed method used Red Deer Protocol in the wireless sensor network system in the agriculture field. The proposal faced several real-time issues like reducing energy consumption, increasing network lifetime, improving packet delivery ratio etc. These parameters were a concern in the previous methods, which could not provide highly optimized output. However, wireless sensor networks using the red deer protocol provided with highly optimized output ratio. The sensor nodes that were spread throughout the agriculture field were given rights to search their own path that was better suitable for all the parameters mentioned above. Thus, the introduction of red deer optimization into the scenario put a major step front in the field of smart agriculture. The fast-growing red deer algorithm was derived from the real life mating process of the Scottish red deer, where the females choose the best male for mating. The same ideology here on sensor nodes gave a massive revolution in sensor node routing. Hence the proposed genetic algorithm on agricultural wireless sensor networks has historically improved production.

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