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Development of an Energy Efficient Routing Protocol Based on the Diversity of Site Temperature and Recent Technologies for IoT Applications

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Abstract: With the rapid development of Internet of Things (IoT) technology, researches in IoT and Wireless Sensor Networks (WSNs) has led to a very heavy reliance on Software Defined Networking (SDN). WSNs have some resource scarcities that affect their performance, such as power supply, processing units, memory, and communication capacity. This paper suggests an optimized routing protocol, named Future Search Algorithm-Temperature Routing protocol (FSA-TR) that is based on the temperature and recent technologies to find the optimal set of clusters. The SDN and Cloud technologies have been used in the architecture of the proposed protocol. A Multi-objective FSA that considers resource restrictions of the sensors, such as energy and communication capability, has been presented to identify the best solution. The temperature of the IoT sensors according to their distribution in the geographical has been considered. Accordingly, a Cluster Head (CH) is selected depending on the remaining energy, the distance between nodes, and environmental temperature. Finally, the experimental results showed an enhanced system performance of many features, such as energy dissipation, network lifetime and the number of packets sent to the sink. For instance, the network lifetime of the proposed protocol has been increased by approximately 36%, 27% and 20% compared to LEACH, SEP and optimized protocol PSO-C, consecutively.

Index Terms: Internet of Things, Wireless sensor networks, Software defined networking, Future search algorithm, Routing protocol, Cluster head, and Cluster members.

1. Introduction

IoT is a new concept that is quickly gaining traction in today's wireless telecommunications environment. The basic idea behind this definition is the presence of a variety of things or items everywhere, such as Radio-Frequency Identification (RFID) tags, sensors, actuators, cell phones [1]. WSNs play a critical role in surveillance systems for battlefields, smart transportation systems, health care systems, environmental monitoring, industrial management, [2] etc. WSNs are considered as an efficient monitoring infrastructure for IoT networking [3]. WSN is very important in IoT, due to its behaviour of gathering data from a large-scale network.

WSNs are made up of small sensing devices, typically working on battery power, and the main issue with batteries is the limitation of their energy. The sensors of the WSNs are dense and random in the field and scattered. Each sensor has a sensing capability, position detecting, and wireless characteristics of communication that enable it to perceive the setting while collecting and transmitting all the collected information from and to the base station [4]. However, sensors must be periodically recharged or replaced because of the weakness in battery life, limited capacity, computing capabilities, and memory in WSN devices. Therefore, the minimization of energy consumption is considered a significant criterion for ensuring the full existence of the network. Cluster-based routing protocols are developed to enhance energy savings in a network.

A significant role of WSN is energy-saving during transmission due to the energy expended to send and process data. The battery serves as the primary power source for sensors in IoT. Usually, there are large numbers of nodes scattered over wide geographical environments. Typically, the sensor nodes are installed in areas where it is difficult to reach. The batteries of these large numbers of sensor nodes are installed remote and inaccessible easily by users, so weather conditions trigger high fluctuation in sensor nodes in thein the external climate. Variations in environmental conditions, transmission channel fluctuations, and efficient data transmission are significant factors that must be considered. Therefore, to avoid rapidly draining the battery, the energy savings of the sensor nodes must be taken into account. It is, therefore, necessary to set up an efficient system of energy conservation.

It is possible to minimize energy efficiency consumption by organizing sensor nodes in the form of clusters. One efficient method for minimizing power consumption in WSN is a clustering technique. It is used to generate FSA clustering method that utilizes cloud resources such as data centres and storage units via a centralized SDN controller located over the cloud. Moreover, the FSA is implemented by the SDN controller, which is in the middle and controls the parts of the network. The areas are divided into clusters, the first determine CHs in each cluster, and members of the clusters are identified (non-CHs) or Cluster Members (CMs). The CHs and CMs are responsible for looking after the sensing field. The CHs acquire the data from all of the cluster members in the cluster. Moreover, the information gathered from the environment is forwarded to the sink through single-hop or multi-hop connectivity. Furthermore, the nodes in adverse environmental conditions such as rain, fog, humidity, and high temperatures are vulnerable to attacks, faults, and misbehaviour [5]. Therefore, the temperature has a significant impact on battery life, component quality, and transceiver efficiency [6]. The nodes operate at high temperatures for long periods, causing the microcontroller unit to slow down voltage generation, reducing node speed [7]. However, to improve the battery's discharge characteristics, data on the ambient atmosphere temperature and its effect on the sensor node must be gathered [8]. Additionally, since a CHs node consumes significantly more energy than a CMs node, each node must take a turn as a CH.

In this paper, an optimized routing protocol is, named FSA-TR, based on temperature and recent technologies that have been proposed. The suggested protocol is designed to find the optimal set of CHs suitable for heterogeneous, random, dispersed and condenses IoT networks. Recent techniques, i.e. SDN, cloud with an efficient FSA intelligent method have been incorporated in the suggested network architecture. Furthermore, in order to generate the best group of clusters, an objective function concentrated on three factors, residual energy, distances between nodes and proposed temperature effect on WSN devices. Additionally, the main goal of this work is to study the impact of temperature on the energy conception of commercial IoT devices within diverse applications. In conclusion, the contributions of this paper can be summarized as follows

1. Development of an energy-efficient routing protocol called FSA-TR.
2. Involvement of an efficient FSA technique during the cluster configuration process.
3. Suggested a new fitness function as shown in Eq. (9), which determine the impact of temperature on the IoT network.
4. The proposed algorithm has been simulated and showed better results in comparison to other algorithms.

In the remainder of this paper, Section 2 presents the Literature Review, to be grouped into two subsections. The exploration and functioning of the FSA algorithm and mathematical equations are discussed in Section 3. While the proposed bundling protocol based on the SDN architecture and the FSA is introduced in Section 4. The results of the proposed protocol are reviewed in Section 5. Finally, the present paper concludes with a short conclusion and suture suggestions in Section 6.

2. Related Works

Several energy-aware protocols have been proposed to improve the performance of WSNs. The literature presents several studies of traditional and optimization clusters. There are also some traditional energy-efficient routing protocols proposed in [9] [10], etc. The main objective of most of those research is to enhance the lifetime of the network. This section has been divided into two parts:

2.1 Clustering Protocol: The initial ways

Low Energy Adaptive Clustering Hierarchy (LEACH) [10], a hierarchical clustering protocol that collects data by selecting CHs, is selected randomly between nodes, creating clusters in the field. Additionally, this protocol consists of two phases: the set-up phase and the steady-state phase. CH is selected and the work of formulating clusters is completed during the set-up phase. While in the steady-state phase, the sensor nodes work by transferring the information of location and the data to CHs according to the TDMA scheduled by CH. Thus, this protocol has been used to route data to increase the life of the network. In addition, in [11], has been proposed protocol to boost the current LEACH cluster to enhance the LEACH protocol by choosing a cluster dynamically, according to the residual energy of nodes. In [12], has been suggusted to modified the LEACH protocol by introducing the RBNS encoding scheme in data transmission, that can minmaze the transmission energy in the network and in this process can reduce the energy requirement in the network which in turn bigiest the network life time. In [13], DF-LEACH has been proposed to enhancement the lifetime of the network and save communication energy by measuring the distance between the sink and CH. In addition, the Stable Election Procedure (SEP), which is based on clustering, is suggested in [14]. This protocol has an advantage over LEACH that also increases lifetime and the results show that since it considers two degrees of heterogeneity. According to the initial capacity of the nodes in the network, nodes are divided into two parts. The first is called "advanced nodes," and the second is called "normal nodes." When CHs are randomly selected, they are given high energy nodes and thus have a high probability of becoming CH. In [15], three degrees of heterogeneity have been developed in terms of node initial capacity, regular nodes, intermediate nodes, and advanced nodes are enhanced in the SEP protocol. In order to select the best node in all networks to select a set of CHs. Then, in [16], the initial probability of each sensor node to be the head of the cluster based on the residual energy of the sensors was relied on to choose the CHs. While, in [17], the authors propose an energy-aware multi-hop gateway based on remaining energy. The protocol for routing (M-GEAR) logically increases the lifetime of the network, and the area is separated into four regions. First-area nodes interact directly with the base station, whereas other regions have nodes that communicate to the gateway node directly. In the other two, nodes of the cluster hierarchy and sensor nodes are used by regions to transmit their results, via their CHs, to the gateway node. In [18], has been using the clustering algorithm. An exponential function is used to compute the optimum set of clusters. It's calculated by adding the number of active nodes to the total number of alive nodes in the network at any given time. The energy consumption is lowered significantly and the network's lifetime is increased by using the appropriate number of clusters at each round.

2.2 Clustering Protocol: The second or modern ways

Then, routing algorithms based on improvement were developed, and some of these algorithms are Particle Swarm Optimization based Clustering (PSO-C), by Latiff et al [19], have been built a centralized, energy-aware cluster-based protocol, to extend the lifetime of the sensor network using PSO algorithm. Their proposal employs a high-energy node to select it CH, resulting in clusters that are uniformly distributed throughout all sensing regions of the nodes, reducing the distance between nodes inside the cluster, However, They did not take into account the distance between the CHs and the sink. Moreover, the clustering routing technique developed in [20], selects the best CHs using an improved PSO. The objective function of PSO chooses the optimal CHs with high residual energy and proximity to the base station based on the remaining energy and position of the nodes. The protocol chooses a relay to minimize CH's energy consumption. This protocol successfully extends the life of the network. Furthermore, because of various algorithmic restrictions, there is no guarantee that the chosen clusters and relays are the best passes in the solution. An energy-saving algorithm was proposed in [21], by planning some active nodes and guiding the data between nodes using the ACO algorithm, to reduce energy waste in directing redundant data and improving energy by selecting the optimal path to CHs. Combining scheduling and clusters. To control the network and pass data to the sink, each cluster requires a CH. TDMA selects the CHs based solely on the remaining energy of the nodes. In [22], suggesting an efficient algorithm or scheme for selecting CHs based on a state-of-the-art Spider Monkey Optimization formulation, named SMOCH, and a Monkey-Inspired Optimization (MO) algorithm. The network is divided into clusters to reduce communication costs and also reduce the energy consumption of the nodes for routing the packets and selecting CHs. Furthermore, a greedy selection method is used to choose between current node positions and newly produced node positions. The greedy algorithm is based on common sense since the best option is picked without regard for the impact of this step on the overall solution. Based on ant colony optimization (ACO) [23] proposed a WSN routing algorithm for IoT and analyzed it to improve scalability, accommodate node mobility, and minimize initialization delay for time-critical applications in IoT to route the data and find the best data transmission path. Using an updated artificial bee colony (ABC) method in [24], propose a clustering technique that picks cluster heads. An efficient enhanced ABC algorithm is presented based on the conventional ABC method, and then network cluster head energy, cluster head density, cluster head position, and other comparable factors are added into the better ABC algorithm theory to solve the clustering problem in WSNs. In [25], has been focusing on multiple CHs and Cluster Head Leaders (CHLs) that used in large fields and large networks to transmit data to the BS and also in the data transmission process of the network. Furthermore, these CHs and CHLs were chosen by using fuzzy logic. Moreover, This study attempts to reduce the total energy consumption and maximize the lifetime of the network.

3. Future Search Algorithm

FSA suggested in [26], discovered in 2018 by M. Elsisi1, Every human on the planet strives to live the greatest life they can. When things aren't going well in a person's life, they want to live the life of the happiest person on the globe. This behaviour is used by the FSA to find the best solutions. Furthermore, some simple mathematical equations are used to construct the FSA. As discussed in the Abstract and Introduction sections, it can update the random initial and use the local search between people and the global search between the histories of optimal people. The solution space is defined by a person who wants the best life possible in various countries around the world. Moreover, the individual that achieves the best results in a country is a reference for the best local solution among others, individual this solution can be updated every year. Furthermore, the different person's approach from a different country, the person that achieves the best results in a country over years represents the best global solution between the other persons. This algorithm's methodology is based on the following mathematical equations, and it begins its steps with random solutions provided by this equation,

$$\mathrm{S}(\mathrm{i},:) = \mathrm{Lb} + (\mathrm{Ub} - \mathrm{Lb}) \times \mathrm{rand}\,(1, \mathrm{D}) \tag{1}$$

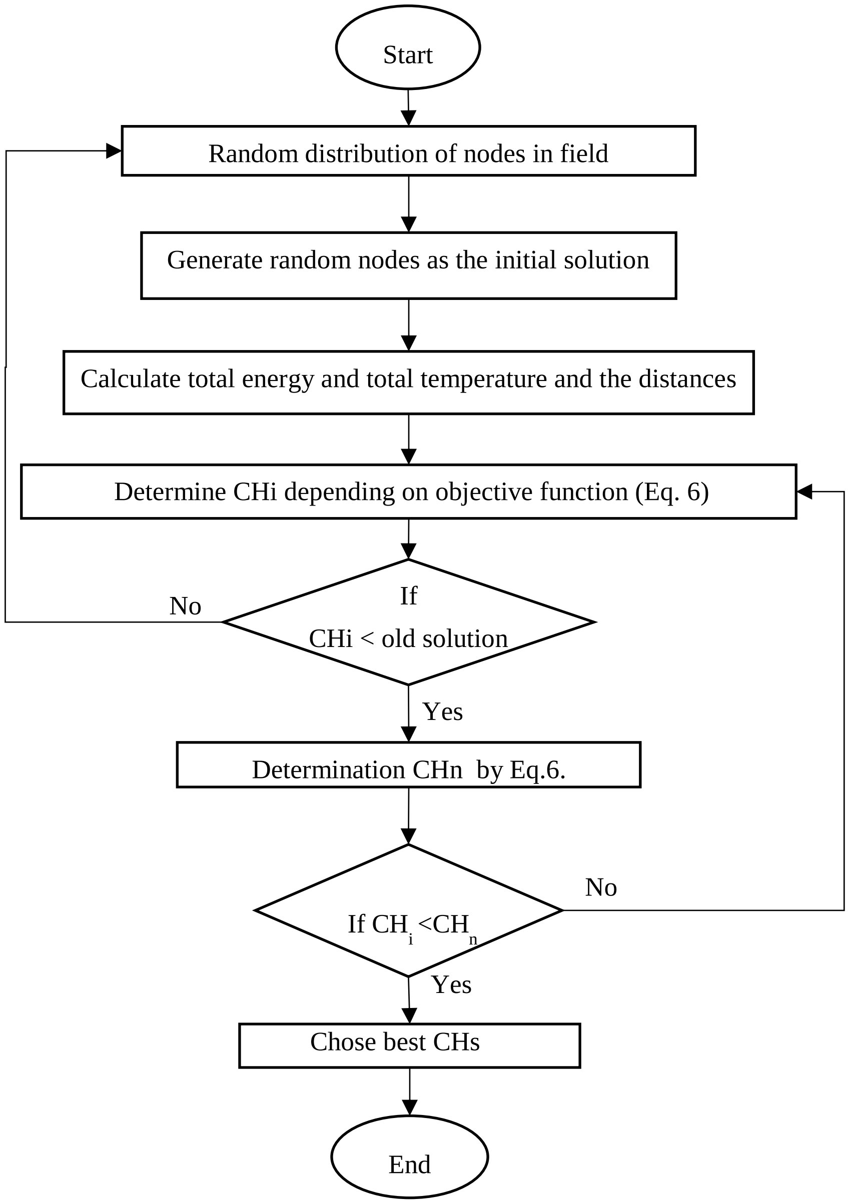

Fig.1. The flowchart of the future search algorithm

Where S denotes the solution, and *i* denotes the actual population size solution, Lb denotes the lower limit bounds, Ub denotes the upper limit bounds, rand denotes uniformly distributed pseudo-random numbers, and *D* denotes the problem of dimensions.

After finding the solutions, each one is labelled as a Local Solution (LS), the best of which is chosen and labelled as a Global Solution (GS), and the algorithm iterates to find the best solution. The following equation, which is based on GS and LS, determines the solution of each individual in the population size solution. Therefore, the following equation, which is based on GS and LS, determines the solution of each individual in the population size.

First, the search in each country is determined by the LS that supports the proposed algorithm's exploitation characteristic and is computed by

$$S(i,:)L = (LS(i,:) - S(i,:)) \times rand \tag{2}$$

Second, the search in all world is determined by the GS, which is defined as follows and supports exploration in the proposed algorithm.

$$S(i,:)G = (GS - S(i,:)) \times rand \tag{3}$$

After computing the local and global convergences, each person's solution is determined by

$$S(i,:) = S(i,:) + S(i,:)\,(4)\,L + S(i,:)G \quad (4)$$

The algorithm then updates the GS and LS, the algorithm updates the random initial of Eq. (1) after finding the solutions in the current iteration and the new GS and LS, and this property is added to help the proposed algorithm's exploration characteristic, and it is defined by

$$S(i,:) = GS + (GS - LS(i,:)) \times rand \quad (5)$$

The algorithm then compares the GS and LS due to initial updating and updates them if they are stronger than the GS and LS of the algorithm's main loop. The FSA measures are summarized in the flowchart in Fig.1.

4. Suggested Routing Model

Clustering-based routing protocols, also known as hierarchical routing protocols, are new methods used to reduce energy consumption, that can improve network scalability and longevity. The recommended strategy for reducing energy use is as follows, the proposed method begins by determining the network topology. While the network architecture is built at random in a geographic region with different temperatures degrees. After that, the sensor nodes are grouped based on their geographic proximity to the sink. Hence, an intelligent algorithm has been implemented that simulates human life called FSA, to choose the best set of CHs in each round. Also, a new cost function has been suggested based on the effect of temperature on sensors, as well as, the distance between sensors and remaining energy for IoT devices. Finally, the best set of CHs is updated in the fourth step.

The FSA algorithm was chosen because it is modern, easy to use, and better than the rest of the methods that have been proved in [26]. Moreover, the effectiveness of FSA results confirms the better performance of this algorithm in obtaining the optimal solution with fewer iterations than other algorithms. For these reasons, it was chosen and entered into the IoT networks and to obtain the best results. In the following sections, an explanation of the proposed protocol process is provided.

4.1 FSA-TR

This section explains the FSA-TR protocol that has been suggested in this work. All nodes are presumed to be static, and the Graphical Position System (GPS) [10] sends their coordinates in the cloud to the sink, to be used by the SDN controller during the CHs selection process.

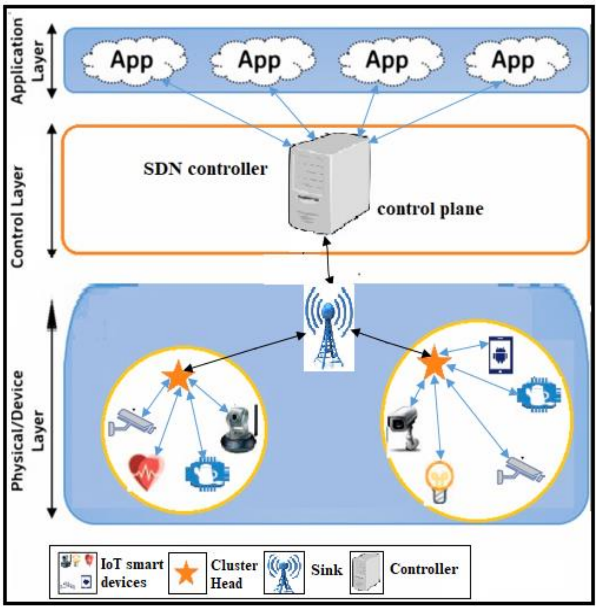

Fig.2. Network architecture for IoT devices based SDN concept

4.2 A Network Model

The proposed protocol balances the number of CHs based on the geographical distribution of node density. The protocol uses the principle of SDN to provide complete separation between the control plane and the data plane [27], as shown in Fig.2. Moreover, the proposed IoT structure is made up of three layers: infrastructure, control, and application. The infrastructure layer is made up of many nodes that are directly responsible for packet forwarding. The SDN controller is located in the control layer and is responsible for network decisions such as protocol. As well, the application layer is placed on top of the cloud and is intended to be used for business purposes. Moreover, the SDN controller makes use of cloud resources, including storage and data centres, to perform complex calculations and store data. The following figure shows the network structure used based on the concept of SDN.

4.3 Clustering Model

The main objective of this study is to use cloud resources to identify a load-balanced group of IoT network clusters using a centralized SDN controller. Furthermore, the controller processes the cluster formulation using a load-balanced FSA algorithm. The controller generates the first round utilizing only the information about the node coordinates. The controller uses the acquired information about distances and remaining energy to determine the best set of CHs for the upcoming rounds. The information is then sent to the sink by the SDN controller. Information about each cluster, such as the number of CHs and CMs, is shown in Fig.2. Then the sink broadcasts the information to all nodes, and each node checks to see if it's a CH or CM.

4.4 FSA-TR based clustering

FSA begins with a random set of solutions. Each solution refers to the Identification Address (ID) of a specific set of CHs. Then, define GS and LS, compute the local and global convergences by Equations (2) and (3), then define new solutions by Eq. (4). After that, update GS and LS based on the objective function. Then update the random initial of Eq. (1) by Eq. (5). Finally, it checks the GS and LS due to the updating of the initial. Moreover, the solutions are then evaluated and the cost function of the following equation is minimized:

$$\text{Cost function} = \alpha f_{1+}\beta f_2 + \tau f_3 \tag{6}$$

$$f_1 = \frac{\sum_i^n E_{n_i}}{\sum_j^V E_{CH_j}} \tag{7}$$

$$f_2 = \frac{\sum_j^V T_{CH_j}}{\sum_i^n T_{n_i}} \tag{8}$$

$$f_3 = \sum_j^V \frac{\sum_i^{N_{CH}\, j} d_{(n_i, CH_j)}}{N_{CH}} + \frac{\sum_j^V d_{(CH_j, BS)}}{V} \tag{9}$$

Where coefficients α, β, and τ are shown in Table 1. V assigned to the number of CHs, as shown in Table 2. The function f_1 chooses the set of CHs with the maximum energy level. Function f_2 the temperature of the environment. The function f_3 includes the communication cost between the CHs to the sink. In the CHs selection process, the SDN controller uses the information contained in the nodes that are saved in the cloud. The SDN controller leverages the information contained in the cloud-stored nodes in the CHs selection process. The SDN controller sends an information table to the sink, containing the best set of CHs and their CMs to send to the nodes. Following that, each CM uses the information specified by their CH to turn on or off their radio. The work of this paper can be summarized as follows:

1. Randomly distribute the nodes in different regions.
2. Determine the initial energy of the nodes.
3. Receipt of primary data, such as the location of the IoT devices, node addresses, type of nodes, etc.
4. Used the intelligence algorithm and the cost function to choose the best set of CHs.

4.5 Model of Radio Energy

The energy wasted in the proposed protocol is calculated using the first-order radio model in [10]. In transmission (ETX), reception (ERX), and data aggregation (EDA), this model looks at the node's energy exhaustion. The temperature has an impact on WSN [28]. When the temperature is higher, the effect on E_{elec} is stronger, and when the temperature is lower, the effect on E_{elec} is weaker. The energy dissipated in the transmitter and receiver nodes is calculated as follows:

$$E_{TOT} = ά(E_{TX} + E_{RX} + E_{DA}) \tag{10}$$

$$E_{TX}(l,d) = l \times E_{elec} + l \times \varepsilon_{FS} d^2 , \quad if\ d < d_0 = l \times E_{elec} + l \times \varepsilon_{am} d^4 , \quad if\ d \geq d_0 \tag{11}$$

While ά is a variable that depends on the temperature. d_0 Is the threshold transmission distance, and E_{elec} is the energy expended per bit to run the transmitter or receiver circuits and l is the data length of the packet. ε_{FS} ,ε_{am} are the power amounts utilized in the free-space and multipath models, and they serve as criteria for determining d_0 as follows.

$$d_0 = \sqrt{\frac{\varepsilon_{FS}}{\varepsilon_{am}}} \tag{12}$$

The radio spends the following to receive an l -bit message:

$$E_{RX}(l) = l \times E_{elec} \tag{13}$$

Where E_{TX} ,E_{RX} Are the energy dissipated in transmission and reception, respectively, and d is the distance between two nodes. Table 2. Also defines $d_0, E_{DA}, E_{FS}\ and\ E_{elec}$.

5. Simulation and Results

In this paper, we added our proposed equations and algorithm, and the final results were obtained as shown in Table 3. To prove that the simulation of the proposed protocol has the highest performance, we took the same parameters published in [19,26]. Hence, they gave the same research results, and the results proved the correctness of the work. The following sections present the proposed network that has been worked on as well as the simulation results for the proposed protocol.

5.1 Network Set-up

In this simulation, the following assumptions are made about WSNs and network sensors, and the show of the virtual zones of the network, as shown in Fig.3. In M*M, a monitoring area has been selected. N denotes that sensor nodes have been deployed randomly and have been selected. N is 100 sensor, the sink is in the middle of the monitoring area, all nodes are static in the field, and no human interaction is required after network deployment. All sensor nodes are heterogeneous, the initial energy is between 1J and 5J, the processing and communication capabilities are not equal, and are allocated at random. Based on the received signal strength, all nodes may detect their leftover energy and calculate the distance between themselves and the signal sending end. Each node can communicate with the CHs directly, and the CHs communicate directly with the sink. In every round, the number of CHs (V) is fixed at 10% of the total number of live nodes. The calculation of power and the energy of the sink is limitless.

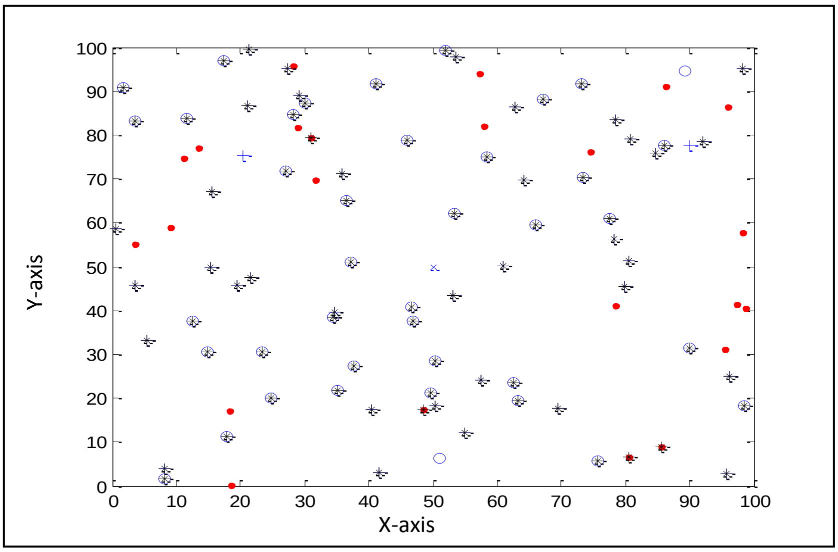

Fig.3. Virtual zones of the network

Communication between the nodes can be done through the connection in the adjacent and near nodes. It is maintained in one active node and has high energy and controls all the nodes in the network and contains all the data for the nodes by receiving the data of the nodes as shown in Fig.3. It is in the middle of the network and it is called the sink it symbol is (x). Moreover, the rest of the regular nodes are denoted by the symbols (*), and nodes that are ready to become the CHs are denoted by the symbol (+), while the nodes that are dead are denoted by the red symbols.

5.2 Results and Performance

MATLAB has been used to simulate the proposed FSA-TR protocol. Its efficacy is demonstrated by contrasting it with other clustering protocols. For instance, traditional routing protocols such as LEACH, SEP and optimized protocols are PSO-C. In terms of remaining energy, network lifetime, and throughput or data sent in all nodes.

Table 1. FSA parameters

Parameters of FSA	Values
population size (S)	30
Maximum number of iterations (Maxitr)	50
Temperature variable (α̇)	1.2&1.4
Spiral constant (τ)	2
Energy parameter (α)	8
Distance parameter (β)	6

Table 2. Radio simulation parameters

Parameters of the radio model	Values
The energy dissipated per bit (Eelec)	50 nJ/b
Amplifier energy for free space (εFS)	10 pJ/b/m2
Energy for data aggregation (EDA)	0.0013 pJ/bit/m4
Packet size	4000 bit
Number of CHs (V)	10% × No.of alive nodes

Fig.4. shows the network lifetime for the suggested method compared to the other algorithms, and it showed the effect of temperature on IoT devices. Furthermore, in the same figure, the proposed protocol has been compared with traditional routing protocols and optimization routing. On the other hand, Table 3. shows the compared lifetime of the network. The biggest problem with the IoT sensors is the battery lifetime of the nodes, which has been improved by the proposed protocol. Where the experimental results show the lifetime battery has been increased by closely 36% for LEACH protocol and about 27% for SEP protocol with the proposed method. In addition, the result indicates an increase in the lifespan by approximately 20% with PSO-C of the optimized routing protocol.

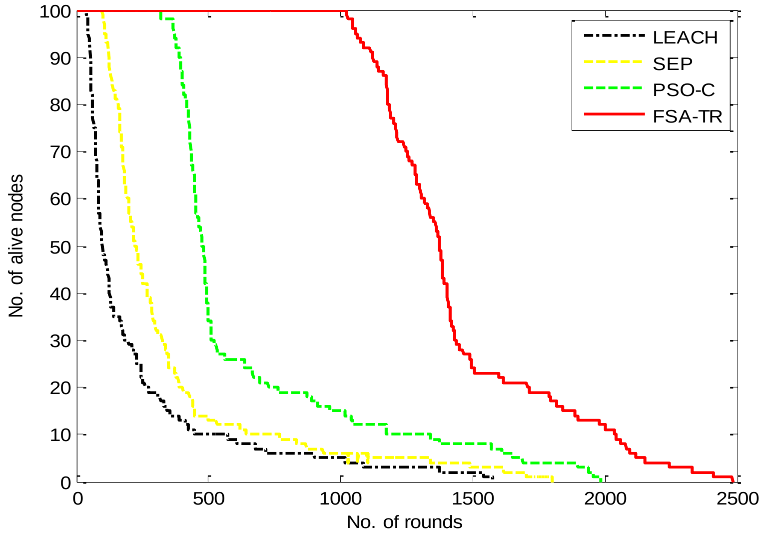

Fig.4. Network lifetime at all rounds

Table 3.Compaction between Protocols for Lifetime of network

No. of round	No. of alive nodes for LEACH	No. of alive nodes for SIP	No. of alive nodes for PSO	No. of alive nodes for FSA-TR
150	35	81	100	100
450	10	14	61	100
600	9	12	26	100
1000	5	6	15	100
1200	3	5	10	76
1500	2	3	8	24
1850	0	0	4	15
2000	0	0	0	12
2400	0	0	0	2
2500	0	0	0	0

The suggested method enhances the number of packets sent to the sink compared with other algorithms, as shown in Fig.5. This increase in the number of packets is due to the rise lifetime of the network. The proposed FSA-TR algorithm presents an enhancement in data sending between nodes over LEACH, SEP, and PSO-C. The reason for this is the return to the consideration of temperature equalization (see Eq.8) and the suggested algorithm FSA during the building of the clusters. Hence, extra data are transferred to the sink. In contrast to other algorithms that compare with the proposed protocol, may result in insufficient energy consumption in some clusters than others in the network.

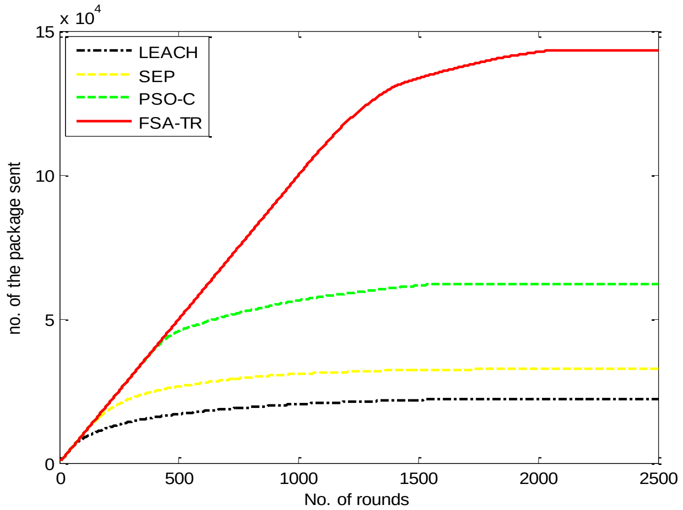

Fig.5. No. of the Packets sent to the sink

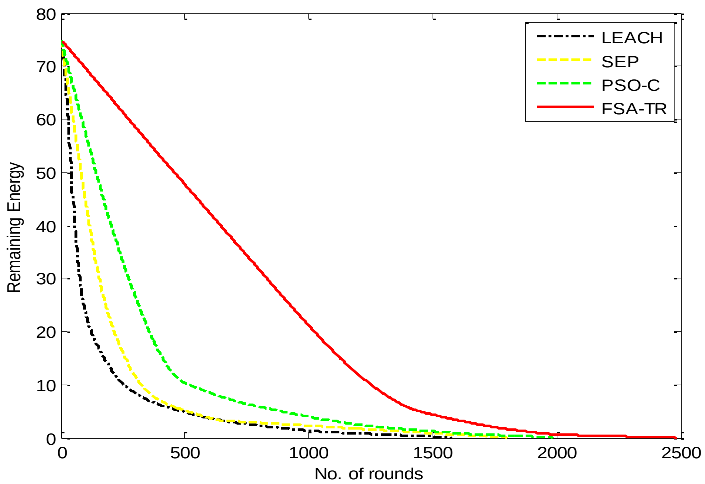

Fig.6. The remaining energy in the network

Fig.6. shows the remaining energy for all protocols with each round. It can be observed that all the methods started with the same initial energy for the nodes. It is also evident that the FSA-TR efficiently distributes energy dissipation among the whole nodes during each round compared to another method as shown in the below figure. Furthermore, the whole network using the suggested algorithm stays alive for a longer time compared to other protocols. This increase in the network lifetime is due to using the objective function that stady effecat tempartuer on the IoT sensors (see Eq.8) and using recent techniques such as SDN architecture and cloud technique.

6. Conclusions and Future Works

This research proposed a new routing protocol to reduce wasted energy for IoT devices. The proposed protocol has been designed based on the concept of SDN by separating the control plane from the data plane. Moreover, a new intelligence algorithm that mimics human behaviour, named FSA, has been used. Additionally, this work proposed a cost function that takes into consideration the remaining energy, the distance between nodes and an indispensable factor called the environmental temperature of the nodes. After that, the suggested protocol has been compared to the traditional routing protocols of LEACH, SEP, and the optimized PSO algorithm. Finally, the simulation results show that the proposed protocol gives longer network life, better performance and provides more data sent to the sink.

From the simulation results, it can be said that the ability of the suggested algorithm to explore the positions of the CHs in an intelligent way stems from the strength of the FSA algorithm in searching for the optimal location among the CHs. In this research, the number of network nodes is assumed to be fixed, not mobile, whereas the proposed protocol is capable of customizing for networks with mobile nodes. For instance, the sink could be assumed to be mobile and not fixed, and the routing algorithm can be optimized accordingly. Another new optimization algorithm can be chosen accordingly.

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