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Optimization on WSN Cluster Formation and Lifetime Expansion through M-Genetic Algorithm

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Abstract: WSNs may be used for different tracking, control and surveillance purposes. Either the sensor nodes form a flat network topology where sensor nodes both serve as routers and move data by multi-hop routing to a sink, or a hierarchical network topology where more efficient fixed or mobile relays are used to capture and transport sensor data to a sink. Wireless Sensor Network (WSN) is a wireless network for node-shaped connecting devices used to collect data. Any linked node has little capacity, as it only uses batteries. Already, there are many routing protocols that function to save resources from network nodes.
Keyword: Genetic algorithm, Wireless sensor network.

I. Introduction

Wireless Sensor Networks are made up of a large number of inexpensive devices that are networked via low power wireless communication. Networking capability enables cooperation, coordination and collaboration among sensor assets. The technological growth in the areas of wireless communication, low-power integrated electronic devices, Micro-Electro Mechanical systems (MEMS), and computational technology has stimulated the growth of Wireless Sensor Networks and made to establish its use across diverse applications.

Wireless sensor networks (WSNs) are envisioned as autonomous and self-organizing systems consisting of a large number of tiny, inexpensive, battery-powered sensor-radio devices called as sensor nodes or motes densely deployed throughout a remote physical space. Wireless Sensor nodes are deployed largely in wide geographical remote areas, to monitor physical and environmental conditions, such as temperature, pressure, light, humidity, chemical level and fire detection. The sensor nodes gather information, process and forward to the base station directly or via the other sensor nodes to the base station for further processing.

1.1 WSN Architecture

Wireless Sensor Network (WSN) consists of large number of small devices with limited resources such as CPU, storage, battery power, and communication bandwidth which are called sensor nodes. These sensor nodes can sense task-specific environmental phenomenon, and communicate wirelessly to other sensor nodes or to a sink also, called data gathering node. WSNs can be used for a variety of applications dealing with monitoring, control and surveillance.

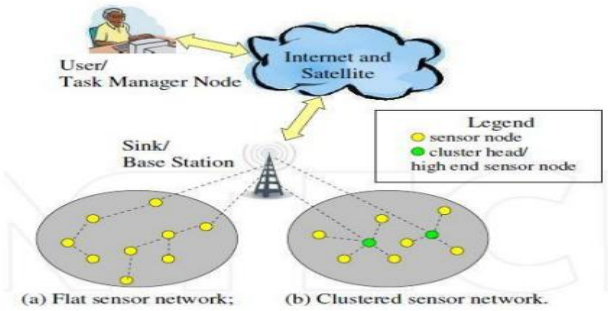

Figure 1: Typical wireless sensor network architecture

In Figure 1, two kinds of network topologies are shown. The sensor nodes either form a flat network topology where sensor nodes also act as routers and transfer data to a sink through multi-hop routing, or a hierarchical network topology where more powerful fixed or mobile relays are used to collect and route the sensor data to a sink.

1.2 Sensor Node Architecture

Typically, a wireless sensor node (or simply sensor node) consists of sensing, computing, communication, actuation, and power components. These components as shown in figure 2 are integrated on a single or multiple boards, and packaged in a few cubic inches. Central unit and communication module are together called as Mote.

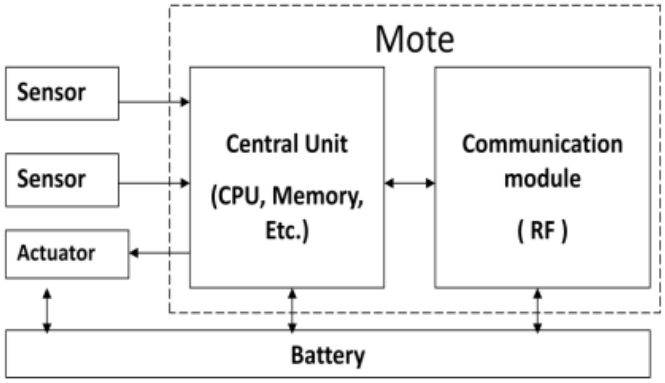

Figure 2: Typical sensor node architecture

1.3 Application Specific units

In addition to the basic units, sensor nodes consist of some additional application specific units such as actuators, location finding systems, mobilizer and power generator. Location finding systems or Global Positioning System (GPS) is used to estimate the geographical position with certain level of accuracy. Some applications require the sensor node to move to carry out the assigned task, in such cases the sensor nodes equipped with mobility unit called mobilizer and actuators to perform the task. The power generator which supplies continuous power to a node has some additional functionality.

1.4 Genetic Algorithm

Genetic Algorithm A genetic algorithm (GA) is a heuristic search technique that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization problems and search engines. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), the solutions to optimization problems using techniques inspired by natural evolution to generate as inheritance, mutation, selection and crossover.

1.5 Introduction to clustering

Clustering is one of the important methods for prolonging the network lifetime in wireless sensor networks (WSNs). It involves grouping of sensor nodes into clusters and electing cluster heads (CHs) for all the clusters. CHs collect the data from respective cluster's nodes and forward the aggregated data to base station. Figure shows on the basis of proposed technique the life time of the Wireless sensor network can be enhanced due to the low energy consumption

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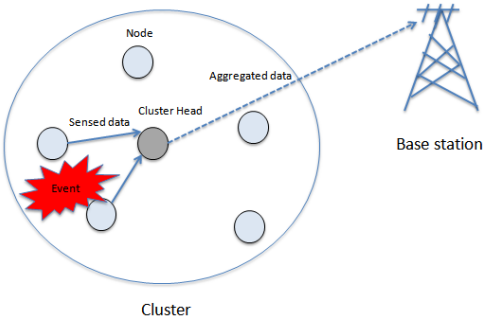


Figure 3: A low energy time based clustering

In figure 4 clustering technique reduces the complexity of communication with the help of maser node and slave node within the cluster. Now, now the Master node has solely responsibility to communicate the base station.

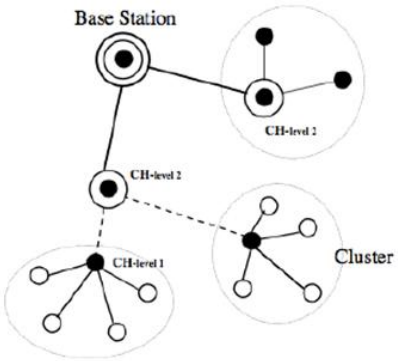


Figure 4: A sample of cluster based WSN.

1.6 WSN Applications

- Military or Border Surveillance Applications
- Environmental Applications
- Health Care Applications
- Environmental Conditions
- Home Intelligence
- Industrial Process Control
- Agriculture
- Structural Monitoring

1.7 Advantage of Wireless Sensor Network

The advantages of WSN include the following

- Network arrangements can be carried out without immovable infrastructure.
- Apt for the non-reachable places like mountains, over the sea, rural areas and deep forests.
- Flexible if there is a casual situation when an additional workstation is required.
- Execution pricing is inexpensive.
- It avoids plenty of wiring.

- It might provide accommodations for the new devices at any time.
- It can be opened by using a centralized monitoring.

II. Authors Reviews

Rezaeipanah et al. (2019), in this paper, during the route of the route a networked approach was developed to reconstruct sensory integration, if needed. The proposed clustering was performed based on three objectives including reducing the distance between sites within the cluster, reducing the distance between cluster head (CH) candidate segments and sink node, and the appropriate online distribution of the locations within each cluster. Advanced analytical algorithms are used to make combinations. In addition, a genetic algorithm (GA) is used as a route algorithm.
Amjad et al. (2017) in this paper, they have proposed a novel approach to high-quality (QoS) -based routing for heterogeneously integrated wireless sensor networks (WSNs). Real-time traffic is transmitted with minimal delays by dedicated routes. To achieve QoS in an agricultural network, using four different power level nodes have different initial capacities. The cost factor (Cv) is employed to achieve maximum integration with each energy level.
Hamidouche et al. (2018), in this paper, they proposed hereditary calculation based methodologies for bunching and steering in WSNs. The goal of this instrument is to draw out lifetime of a sensor and increment the nature of administration. They perform broad reproductions of the proposed calculations and contrast the reenactment results and that of the current calculations.
Kaur et al. (2020), in wireless sensor networks, localization is one of the essential requirements. Most applications are of no use, if location information is not available. Based on cost, localization algorithms can be divided into two categories, namely range-based and range-free. Range-free are cost-effective, but they lack accuracy.
Wang &Xie (2020),the purpose of this is to enhance the exploitation and exploration ability of the algorithm respectively, so as to improve the convergence and optimization precision of the algorithm. In addition, in terms of WSN deployment in 3D surfaces, this paper improves the means of determining the perceived blind zone. Meanwhile, a novel method to calculate the WSNs coverage area of simple and complex 3D surfaces is presented by combining the grid and integral of the 3D surfaces.
Aziz et al. (2020),this paper proposes an Efficient Multi-hop Cluster-based Aggregation scheme using Hybrid CS (EMCA-CS) for IoT based heterogeneous wireless sensor networks (WSNs). EMCA-CS efficiently combines between CS and routing protocols to extend the network lifetime and reduces the reconstruction error.

III. Methodology

WSNs are the application based networks which consist of a number of sensor nodes. WSN is a composition of hundreds of sensor devices which communicate with wireless networks with the help of limited energy consuming routing protocols. Wireless Sensor network share dense wireless networks of small, inexpensive, low-power, distributed autonomous sensors which accumulate and propagate environmental data to facilitate monitoring and controlling of physical environments from remote locations with better accuracy. Generally, it is assumed that each sensor in a network has certain constraints with respect to its energy source, power, memory and computing capabilities. It contains a gateway that provides wireless connectivity back to the wired world and distributed nodes. WSN nodes have constrained battery limit. To build the life expectancy of WSN the usage of vitality in a productive way is a most normal issue. As the utilization of WSN are expanding step by step and has numerous varieties like target following condition observing, air contamination checking and so on. These applications require fast correspondence between sensor nodes. The main goal of this research is to provide the energy efficient routing protocol. These protocols are used to provide efficient data transfer

between sensor and the sink. In the development of the protocol energy consumption is the main concern because the energy resources of sensor nodes are limited.

Wireless Sensor Networks (WSNs) are deployed over a target area to supervise certain phenomena of interest. Each node takes readings from the local environment, processes and transmits a certain number of packets, containing the sensed data, to the sink node. Two common modalities can be used to access the shared medium to communicate the data to the sink node: unscheduled and scheduled-based transmissions.

In a cluster-based architecture, there are two distinct phases:
(1) The cluster formation phase, where all the active nodes transmit a control packet directed to the sink node in order to be part of the cluster. Specifically, the active nodes in the supervised area transmit their control packet with probability τ in each time slot. If there is only one transmission, that is only one node transmits, the control packet is successfully received by the sink node, and the node that successfully transmitted this packet is considered to be already a member of a cluster. As such, this node no longer transmits in the cluster formation phase. The remaining nodes continue this process until all the active nodes successfully transmit their control packet. If there are two or more transmissions in the same time slot, all transmissions are considered to be corrupted, and the control packets involved in this collision have to be retransmitted in future time slots. Hence, when a collision occurs, none of the involved nodes are aggregated to a cluster.

(2) The steady state phase, where all the nodes in the system transmit their data packets to a cluster head (CH), which in turn transmits an aggregated data packet to the sink node.In the cluster formation phase, the active nodes transmit using a random access protocol where the channel is shared among all nodes, and hence, as stated before, collisions are possible. In this work, the slotted Non-Persistent Carrier-Sense Multiple Access (NP-CSMA) scheme is considered due to its superior performance compared to other variations of the Carrier-Sense Multiple Access (CSMA) protocol for WSN applications. On the other hand, in the steady state, CHs assign resources by clarifying which sensor nodes should utilize the channel at any time through a Time Division Multiple Access (TDMA) protocol, thus ensuring a collision-free access to the shared data channel. One important characteristic of this phase is that only the transmitting nodes and their respective CHs are awake while the rest of the nodes go into sleep mode in order to save energy. For the sake of clarity, the packets used to form the clusters are referred to as control packets, while the packets used in the TDMA scheme will be referred to as data packets. Additionally, an adequate selection of the CH nodes can greatly reduce energy consumption. Indeed, a CH should be selected in order to reduce the distance to its cluster members (CMs) in order to also reduce the power transmission required to relay their information in the steady state phase. Therefore, intelligent clustering algorithms can reduce energy consumption by choosing the most appropriate nodes to become CHs or by reducing the average distance among the CMs and their respective CHs. As is shown in this paper, intelligent schemes are based on performing a number of iterations in order to find the most suitable CHs. This procedure also consumes time and energy. As such, in this work, we are interested in clearly identifying the conditions where the use of intelligent CH selection schemes greatly outperforms conventional CH selection schemes, such as the Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol.

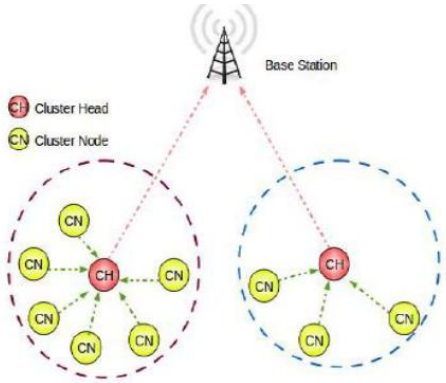
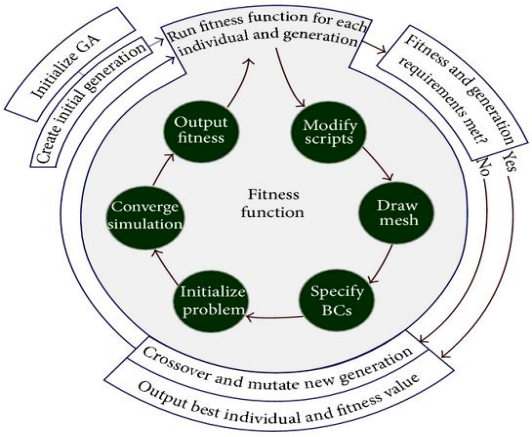


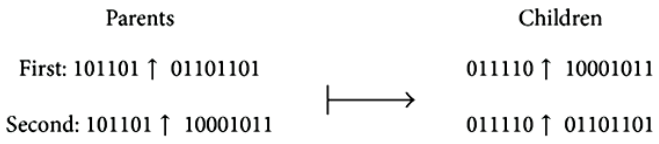
Figure 5: Cluster formation in WSNs

3.1 Overview of Genetic algorithm

Also known as a global heuristic algorithm, a generic algorithm estimates an optimal solution through generating different individual. Focused fitness function is one of procedures of the algorithm. Following section describes the fundamental parts of a generic algorithm. Figure 2(a) indicates the general scheme of Genetic algorithm mechanism.



(a)



(b)

Figure 6: (a) General scheme of GA mechanism. (b) Single point method at random point 6.

3.1.1 Initialization

The Genetic algorithm starts with an elementary population comprised of random chromosomes which includes genes with a sequence of 0 s or 1 s. Afterward, the algorithm leads individuals to achieve an optimum solution by the way of repetitive processes including crossover and selection operators. There are two ways to develop a new population: steady-state GA and generational GA. In the case of the

former, one or two members in the population are replaced and at the same time, the generational GA replaces all the generated individuals of a generation.

3.1.2. Fitness

Under the Genetic algorithm, the fitness function, by definition, is a process for scoring each chromosome based on their qualification. The assigned score is a trait for continuation of further reproduction. Dependence to problem by the fitness function is considerable, so that in case of some problems, it is not possible to define the problem. Naturally, individuals are permitted to go to the new generation based on their fitness score. Therefore, the score dictates the fate of individuals.

3.1.3. Selection

During every successive generation, a new generation is developed through adopting members of the current generation to mate on the bases of their fitness. The individuals with higher fitness score have higher chance for being selected, the process which results in preferential adoption of the best solution. Majority of the functions include a stochastically designed element for adopting small number of less fit individuals for sake of keeping diversity in the population 10. Among the many selection methods, Roulette-Wheel is adopted to differentiate proper individuals with the probability of

$$\mathbf{P_i} = \frac{\mathbf{F_i}}{\sum_{\mathbf{j=1}}^{\mathbf{n}} \mathbf{F_i}}$$

Where p_i fitness chromosome and the size of population, respectively. According to the Roulette-Wheel, each individual is assigned a value between 0 and 1.

3.1.4. Crossover

The crossover or reproduction process constitutes the major step toward production. Indeed, sexual reproductive process by which inherited characteristics are transferred from one generation to the next generation, is simulated. In the reproduction process, crossover process adopts a couple of individuals as the parents through breeding selection process. The process continues to reach the desired size in the new population. Generally, several crossover operations take place, each of which with different aims. The easiest way is single point, where a random point is adopted to divide the role of the patents. One example of mating by two chromosomes in single point way is pictured.

IV. Implementation of Algorithm

Genetic Algorithm- aGenetic algorithm (GA) is a heuristic search technique that mimics the process of natural Genetic. This heuristic is routinely used to generate useful solutions to optimization problems and search engines. Genetic algorithms belong to the larger class of Genetic algorithms (GA), the solutions to optimization problems using techniques inspired by natural Genetic to generate as inheritance, mutation, selection and crossover. In a Genetic algorithm to a population of strings developed (chromosomes), the candidate solutions (fitness value) to encode optimization problem to better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The development usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of each individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Usually, the algorithm terminates when either a maximum number of generations has been produced, or has reached a sufficient condition for the population. If the

algorithm is terminated by a maximum number of generations, a satisfactory solution may or may not be achieved.

A typical Genetic algorithm steps:
1. A Genetic representation of the solution domain,
2. A fitness function to evaluate the solution domain.
Generally the solution is represented as an array of bits. Arrays of other types and structures can be used in essentially the same way. The main property that makes these Genetic representations convenient is that their parts are easily aligned due to their fixed size, which facilitates simple crossover operations. Variable length representations can be used, but in this case of complicated crossover. Tree-like representations are explored in Genetic programming and graphic representations in the form of Genetic algorithm programming. The fitness function is defined over the Genetic representation and measures the quality of the represented solution. The fitness function is always problem dependent. Once the Genetic representation and the fitness function defined, GA is an order (usually random) initialize a population of solutions and then improved it by repeated application of mutation, crossover, inversion and selection of contractors.

In general, the operational stages of WSNs include node placement, network coverage, clustering, data aggregation, and routing. A technical survey was conducted on these operational stages. By finding the drawbacks and optimizing them, ideal parameters of the network were achieved. Finally, using Genetic algorithm, a fitness function with optimum formula was obtained and the present protocols were optimized. The results of simulations in MATLAB were compared with are of the present protocols and optimization of the two parameters confirmed. It is also noticeable that the diagrams obtained from the simulations showed an improvement in energy consumption parameters and lifetime of the network; this means more ideal WSNs. An application based protocol without specific limitation regarding its application suitable for military, medical, and commercial applications will be subject of our future studies. After applying the Genetic algorithm, less energy dissipation in network appears after increasing number of rounds. Proposed work uses Genetic algorithm to improve the network lifetime (dead node) and energy dissipation value of the wireless sensor networks by finding the optimum number of cluster heads and their locations based on minimizing the energy consumption of the sensor nodes. MATLAB simulation results showed that the proposed work is less energy dissipation, less number of dead nodes. After comparing the existing work as with GA, Simple GA. This simulative result found very good result. Moreover, it outperforms the previous protocols in terms of energy dissipation rate, network lifetime and stability period in both homogeneous and heterogeneous cases.

4.1. Simulation and Result

Figure 7 present the first layout of the proposed work constructed in MATLAB 2013. The one button is GA which is executable and run the main code file.

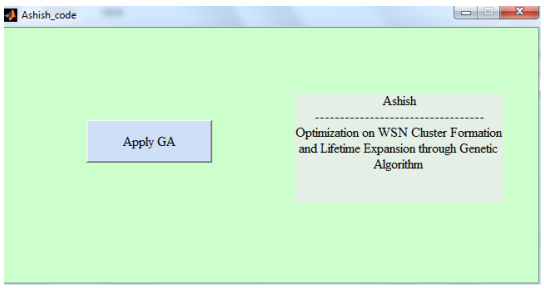


Figure 7: Layout of the proposed work

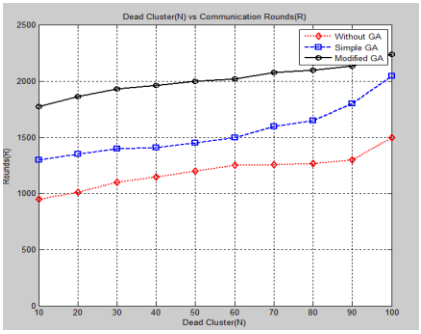


Figure 8: Dead node vs. communication round

Figure 8 shows the relationship between the dead node vs. communication round. It is found that the three line were formed. The first formed without GA, Simple GA and modified GA. The proposed work is modified GA which is above to all line. This figure demonstrate the occurrence of dead node as per communication round increases. The above figure found the modified GA is very good as it has less occurrence of dead as compare to communication round.

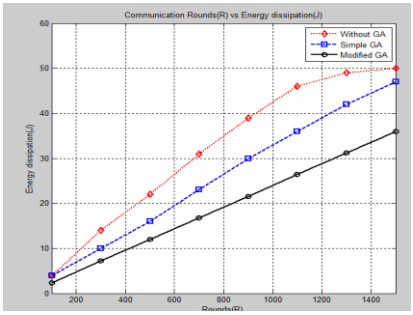


Figure 9: Energy dissipation vs. communication round

Figure 9 shows the relationship between Energy dissipation vs. communication round. It is found that the three line were formed. The first formed without GA, Simple GA and modified GA. The proposed work is modified GA which is below to all line. This figure demonstrate the occurrence of energy dissipation as per communication round increases. The above figure found the modified GA is very good as it has less occurrence of dead as compare to communication round.

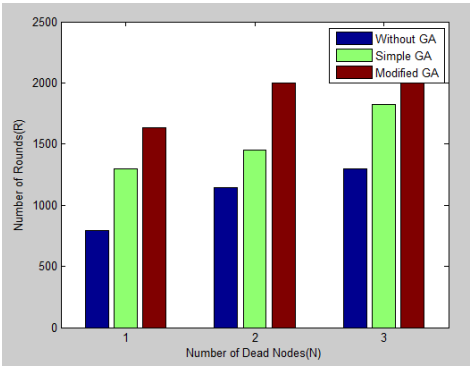


Figure 10: Dead node cluster vs. communication round

Figure 10 shows the relationship between the dead node cluster vs. communication round. It is found that the three line were formed. The first formed without GA, Simple GA and modified GA. The proposed work is modified GA which is presented as bar diagram. This figure demonstrate the occurrence of dead node cluster as per communication round increases. The above figure found the modified GA is very good as it has less occurrence of dead as compare to communication round.

V. Conclusion

Wireless Sensor Network (WSN) is a wireless network to connecting devices in the form of nodes and used to collect data. Every node that is connected has limited energy because it only uses batteries. Currently there are many routing protocols that function to save energy from nodes on the network. On comparing to without GA, Simple GA and Modified GA, the result has been explored on the basis of communication round.

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