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Comprehensive Study on Metaheuristics FADE Based Artificial Bee Colony Optimization Algorithm to Improve Performance of Wireless Networks

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ABSTRACT

Over the last few years, it is been experienced wireless sensor networks technologies are grabbing huge attention in almost every aspect of human lives due to its vast coverage in real-life applications. It has emerged as one of the important and very promising technologies with lots of potential from every section due to its importance in wireless information transmission. WSNs due to their useful characteristics are being considered vulnerable to several possible security attacks which may affect the performance of the system. Among these issues, most challenging issues such as sinkhole which is considered as the most dangerous attack in WSN to reduce network performance. It prevents the base station in the process of gathering complete and unmodified data from its source. This work inspired by the integration of FADE and ABC presents a new variant of the metaheuristics fuzzy adaptive differential evolution based optimization algorithm to improve the performance of a wireless sensor network.

Keywords: Wireless Sensor Networks, FADE, Artificial Bee Colony Optimization, Fuzzy logic-based Clustering Process, Sinkhole.

I. INTRODUCTION

Over the last few years, it is been experienced the lightning speed of technological evolution, in almost every aspect of human lives. Wireless Sensor Networks (WSNs) have been gaining growing interest from researchers and organizations from all over the world and from every section due to their importance in wireless information transmission. Despite their effective usability, promising performance, and quality of operation, WSNs are being considered vulnerable to several possible security attacks. Among these is a sinkhole attack, which is considered as the most dangerous attack in WSN which presents a severe threat to the security lead to reduce network performance [1]. Such attacks in wireless sensor networks are the most vulnerable and dangerous attacks in WSN that prevent the base station in the process of gathering complete and unmodified data from its source. Having security in WSN, data authenticity, confidentiality, integrity, and availability are a few of the important security goals [2].

1.1 Wireless Sensor Networks (WSN)

Wireless Sensor Networks (WSN) is a network with inexpensive and elegant computing devices that plays a very important role nowadays in all the sectors; they are being used for developing smart sensors [3]. These smart sensors are geographically distributed in such a way and embedded to ecological sensors for measuring to monitor and recording the physical conditions of the environment effectively like temperature, sound, pollution levels, humidity, wind, and so on[4]. The sensor nodes can interact among themselves using radio signals. A wireless sensor node is composed of massive, tiny sensing devices and computing devices, radio transceivers, and power components with minimum power, processing, and interaction abilities. The requirement for administration and application of WSN needs a proper protocol and algorithm due to the unwanted task of maximum sensors in diverse fields as it is prone to the sinkhole attacks since it is composed of the specialized interacting patterns. [5].

1.2 Fuzzy Adaptive Differential Evolution Algorithm (FADE)

This research using a new adaptive form of DE having a lower number of search parameters required in this process to be set by the user a priori means without being based on previous experience or observation with adaptive control parameters. The fuzzy adaptive differential evolution algorithm is based on using the functionality of fuzzy logic controllers whose inputs integrated the relative function values and individuals of the succeeding or successive generations to adjust by adapting the search parameters for the crossover operation and the mutation operation. In this mechanism, standard test functions are used to demonstrate. This process brings a new algorithm which results in a faster convergence for these functions [6][7].

1.3 Artificial Bee Colony Optimization (ABCO)

The artificial Bee Colony algorithm is widely being used in the field of WSNs to solve different complex problems [8]. The ABC technique was deployed by Karaboga is that is based on swarm intelligence. Defined as the acceleration of food foraging nature of bees [9]. Here, the food source of the bees is named as a solution. It consists of 3 classes of bees such as the employed bee, the onlooker bees, and the scout bee [10]. The bee colony is having employed and onlooker bees in the same numbers. Employed bees are supposed to find the food source from the available environment for their hive and the relevant data will be saved in their locations. After that Onlooker bee collects the required information of food sources from the employed bees to gather the amount of nectar in the hive which will help in further nectar extraction. Scout bees are responsible for the exploration of new food sources to support those employed bees when the nectar amount in the food source is minimum and whose food source quality cannot improve further than scout bee explores fresh food source in a search space arbitrarily [11].

1.4 Fuzzy logic-based Clustering Process

Clustering is one of the powerful approaches to composing a system into an associated order; load adjusting and enhancing the system lifespan by energy utilization and the system lifetime. The cluster-based network is designed in a way, so cluster head position must be closer to the sink so depletes its energy speedily resulting in hot spot problems [12]. The proposed method is using here a fuzzy-based centralized clustering technique in WSN for energy-efficient routing protocols. In the proposed study clustering technique uses fuzzy logic to elect CHs which are responsible for gathering the data from the nodes and sending it to the sink (base station) and these cluster heads enforce a separation distance among them [13]. The process of calculating separation distance is adaptively based on the number of unfinished or remaining live nodes, the percentage of the desired CHs, and the dimensions of the area covered by these nodes [14].

1.5 Sinkhole

Wireless sensor networks (WSNs) consist of many numbers of nodes, WSNs are vulnerable to a wide class of attacks various routing attacks as it communicating sensor readings to the base stations through other nodes among which sinkhole attack puts serious threats or danger to the security of such networks. From a security point of view in WSN, confidentiality, data authenticity, integrity, and availability are very important security goals. So it is very obvious that a security protocol must be created by focusing on a particular attack in WSN. Some of the renowned attacks in WSN are the Sybil attack, Denial of Service (DoS) attack, Wormhole attack, Selective attack, Sinkhole attack, etc. This study focuses on one of the most challenging and dangerous routing attacks, called the Sinkhole attack. A Sinkhole attack in WSN is one of the sternest routing attacks which are very challenging to deal with as it attracts surrounding other nodes with misleading and fake routing path information to perform data forging or selective forwarding of available data passing through which can cause energy drain on some other nodes and may end up with generating or producing energy holes in WSNs and it can spoil the performance of the network by causing inappropriate and potentially dangerous responses based on false measurements [15].

Need and Significance of the Research

Wireless Sensor Networks (WSNs) making various types of applications available for providing comfortable and smart-economic life. WSNs have significant potential in various applications including agriculture sector health, environmental engineering, and military [16]. Despite their powerful capabilities and potential, the successful development of WSN with higher standards is still a quite challenging task. WSNs are found vulnerable to a very wide range of attacks among which sinkhole is one of the attacks which puts severe and dangerous threats to the security of such networks. The main objective of this research is to investigate a novel approach to detect and mitigate such attacks in WSNs which can considerably increase the network lifespan.

- **Agricultural Sector**: For maintaining wires could be tough in a difficult environment, Irrigation automation is a promising technique which enables more efficient use of water and reduces waste.
- **Military Applications**: Military command, control, intelligence, communications, computing, battlefield surveillance, reconnaissance, and targeting systems.
- **Area Monitoring**: Sensor nodes are deployed over a region for monitoring like heat, pressure, etc and it could be immediately informed to one of the base stations, which then takes appropriate action.
- **Transportation**: Real-time traffic-related data is being collected by WSNs helping in transportation models and alerting drivers of congestion and traffic problems.
- **Health Applications**: Health applications are supporting potentially like interfacing for the disabled, telemonitoring of human physiological data, diagnostics, and helping drug administration in hospitals, and tracking & monitoring doctors or patients in a hospital.
- **Environmental Sensing**: Includes sensing of volcanoes, glaciers oceans, forests, etc. Few other major areas are: Air pollution monitoring, Forest fires detection, Landslide detection, Greenhouse monitoring
- **Structural Monitoring**: To monitor any movement within buildings and infrastructure such as flyovers, bridges, tunnels, etc making engineering practices possible to monitor assets remotely without requiring costly site visits.
- **Industrial Monitoring**: For machinery condition-based maintenance system as it offers significant cost savings and enables new functionalities.

In agriculture WSN used for monitoring, irrigation system, measuring temperature, measuring water supply and so much other automation. WSN is very helping the farmer to produce the quality crop with high quantity and reduce the overall cost of yield. Agriculture gets affected by climatic change, environmental change, and natural disaster. So, this research focuses mainly on low power consumption, at low cost, and is a convenient way to control real-time monitoring for unprotected agriculture and habitat. Moreover, it can also be applied to indoor living monitoring, greenhouse monitoring, climate monitoring, and forest monitoring [18].

II. The Objective of Study

Wireless sensor networks (WSNs) are being under the focus of the researcher's community for so long. The applications of this promising technology, as well as the problems it poses, are many. This study considers using such technology to implement a detection system. Sinkhole attack one of the most destructive and dangerous since it prevents communication among network devices. After studying it is found that existing solutions are somewhere not sufficient and not effective to provide protection and security against sinkhole attack in wireless networks, the research is organized as the background study of other related existing techniques is provided. The sinkhole attack has been investigated in the recent few years by the experts in wireless sensor networks and several diversified solutions were proposed. Fuzzy Adaptive Differential Evolution is a new adaptive form of DE techniques or mechanism having a smaller number of search parameters needed to be placed by the user a priori. The most relevant fuzzy adaptive differential evolution-based technique that can be intelligently used in WSNs to achieve various objectives. The main contributions of this study include:

- Providing a comprehensive study on clustering techniques in WSNs focusing on how to improve properties.
- Reviewing the most optimal solutions used by clustering techniques to achieve the discussed objectives.
- Providing statistical analysis of fuzzy clustering techniques and network properties to enhance by analyzing the direction of the research in this field.
- Compose a network structure that can minimize delays in the processes of data collection of wireless sensor networks which extends the lifespan of the network.
- Efficient management of the energy resources that help in extension of the network lifetime by reducing energy consumption.
- Use of data aggregation to reduce the number of communication messages by adapting WSN-based clustering techniques.
- Studying comprehensively the ABC algorithm which can improve the internal dynamics of the cluster head nodes and sensor nodes in the WSN.
- The proposed algorithm can reduce the energy dissipation of nodes, balance the energy consumption across nodes, and maximize the lifetime of the network.
- Effectively reduce data transmission, save energy, improve network data collection efficiency and reliability, and extend the network lifetime.
- How can be utilized fuzzy sets and fuzzy decision theory in the process of building a cluster routing for path optimization?
- Uses of Standard test functions to develop a new algorithm having results in a faster convergence for these functions.
- Adaptive and self-adaptive mechanisms are evolved mainly focused on mutation and crossover differential evolution operations, but less on population size adaptation.

- Managing energy consumption with optimized speed.

III. Hypothesis

Wireless sensor networks (WSNs) are being under the focus of the researcher's community for so long. The applications of this promising technology, as well as the problems it poses, are many. This study considers using such technology to implement a detection system. Sinkhole attack one of the most destructive and dangerous since it prevents communication among network devices. After studying it is found that existing solutions are somewhere not sufficient and not effective to provide protection and security against sinkhole attack in wireless networks, the research is organized as the background study of other related existing techniques is provided. The sinkhole attack has been investigated in the recent few years by the experts in wireless sensor networks and several diversified solutions were proposed. Fuzzy Adaptive Differential Evolution is a new adaptive form of DE techniques or mechanism having a smaller number of search parameters needed to be placed by the user a priori. The fuzzy differential evolution algorithm uses, a fuzzy system which processes considering the variation of two parameters, namely, many generations and population variations are applied to improve the performance of network system where fuzzy logic controllers whose inputs are being taken or incorporated values of the relative function and individuals of the successive generations so it adapts the search parameters for the operation like mutation and the crossover using a set of standard test functions. Standard test functions are being used for demonstration. This new algorithm results will be faster convergence for these functions. ABC conceptualized on the foraging behaviors of bees in nature. The processes of bees finding food sources are most like the processes of searching candidate solutions for a given problem. Although the ABC algorithm is very effective and promising in various problems, it some complicated situations it is found that it suffers from poor exploitation and slow convergence rates. In this study, a new ABC variant based on FADE strategy and machine learning is presented to enhance the performance of ABC by better solutions being chosen to guide the search.

IV. Review of Literature

This research has reviewed literature by having a focus on exploring and analyzing the existing solutions on some parameters used to detect and identify the sinkhole attack in improves the performance of the wireless sensor network. The analysis is based on Fuzzy Adaptive Differential Evolution Algorithm.

N. Al-Maslamani et al. (2020) proposed mechanism is efficient and robust in detecting sinkhole attack with high detection accuracy rate.

Edith C. H. Ngai et al. (2006) suggested an algorithm that first finds a list of suspected or compromised nodes in the network, and then effectively identifies the intruder where communication and computation overheads are reasonably low for wireless sensor networks.

N. Chandra Sekhar Reddy et al. (2019) SVM can be combined with many other feature extraction techniques for effective intrusion detection.

Junhong Liu et al. (2002) proposes a new adaptive form of DE having a lower number of searches by using fuzzy logic controllers and individuals of the successive or succeeding generations to adapt the search parameters for having the mutation operation and the crossover operation.

Lampinen et al. (2004) proposed a mechanism for optimization problems for a set of standard test functions, outperformed those of the standard differential evolution algorithm.

D. Karaboga et al. (2014) did a survey that's been instrumental for the researchers studying Swarm intelligence (SI), particularly the ABC algorithm.

Ankit Gambhir et al. (2018) did a performance analysis of artificial bee colony optimization-based clustering protocol in various scenarios of WSN.

S. Famila et al. (2020) proposed an Improved Artificial Bee Colony Optimization-Based Clustering Technique for WSNs.

R. Logambigai et al. (2015) proposed an algorithm called fuzzy-based unequal clustering to enhance the execution of the current algorithms.

Dipak R. Pardhi & Akhilesh A.Waoo (2011) suggested an efficient ranking based clustering algorithm.

Hamzah A et al. (2019) proposed an Energy-Efficient Fuzzy-Logic-Based Clustering Technique for Hierarchical Routing Protocols in Wireless Sensor Networks.

M.A. Matin et al. (2012) describes the different applications of the wireless sensor network.

D. D. K. Rathinamet al. (2019) described Agriculture can be done in this modern world using many latest technologies. Here WSN is used for producing a crop with high yield and with low cost.

After reviewing the above papers, this study has composed a new Optimization Algorithm to improve the performance of Wireless Sensor Network that is an artificial bee colony based on the Metaheuristics Fuzzy Adaptive Differential Evolution algorithm. The proposed algorithm involves a clustering process to select the CHs and construct clusters a few input variables. The foraging behavior of bees is being utilized and the local optimal problem of ABC has been resolved by FADE. The proposed methodology requires only a minimum amount of time to identify the compromised node, which leads to minimum packet loss and maximum throughput. This will be helping to increase the productivity of agriculture. The human effort will be reduced by the automatic process and it encourages the farmer to develop the farmland.

V. CONCLUSION

This work inspired by the integration of FADE and ABC presents a new variant of the Differential Evolution Based Optimization Algorithm to improve the performance of Wireless Sensor Network. This algorithm is very efficient in the process of identifying sinkhole nodes by using FADE with the standard ABC algorithm to enhance its working and optimizing the results by balance out the effects of exploration and exploitation processes into the network. This inclusion is making it possible to improve the performance of the overall network by enhancing the performance of the algorithm in terms of convergence speed and global optimum achievement. The foraging behavior of bees is being utilized and the local optimal problem of ABC is being resolved by the inclusion of FADE in a way so this model requires only a minimum amount of time to detect the compromised node, which leads to minimizing packet loss and maximizing throughput. The research contributions made in the proposed scheme can be summarized: A new intrusion detection scheme for the detection of sinkhole attack in a wireless sensor network is being proposed. It is going to be validated through security analysis and also the results obtained through the simulation. Furthermore, the proposed method is also compared with other closely related existing techniques. The conducted comparison demonstrates that the proposed mechanism performs better than other existing techniques. Agriculture generally gets affected by environmental change, climatic change, and natural disasters. The proposed method can be beneficial in agriculture by effective use of WSN implementation for monitoring, measuring temperature, Irrigation system, measuring water supply, and so on leading to produce the crop with high quantity and reduce the cost of yield.

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